Selecting an Effective Leak Detection Strategy

Kevin Webb, Energy Solutions International, Jon Barley, Energy Solutions International

ABSTRACT

The Bar has been Raised

Pipelines operate within the living space and under the watchful eye of both the public and the regulatory agencies. Operating these pipelines in a responsible and safe manner is more and more becoming the essential element of the social contract under which the pipeline industry is permitted to conduct business.

Over the past several years the public's safety expectations and demands have stepped up to a new level. Repair and maintenance programs have been greatly intensified. Inspections and inspection technologies have grown as well as better measurement, monitoring, and communications. Along with these advances, leak detection technologies have also burgeoned.

No matter how careful and well designed a pipeline may be, a potential for leaks will always exist. To responsibly address this potential, systems and plans must be in place to detect and aid in the response to a leak, should one occur. From the vast assortment of technologies available, today's pipeline company must piece together a working family of techniques, operating practices, and business policies that can provide effective, real, and sustainable protection.

The Challenge

Leak Detection cannot be addressed by simply throwing money at the problem. There is not a nice hierarchy of function and functionality. API 1130 states that "Each CPM [*Computational Pipeline Monitoring*] method has its strengths and limitations" and "No one technology has been proven suitable for all pipeline applications. Multiple CPM systems may be employed to provide a CPM that can more broadly cover the pipeline operating conditions."

The technology selected must be tailored to the particulars of the pipeline being protected. There are times when a simple pressure trend will provide better protection than a full scale real-time transient hydraulic simulator. In short, the solution must fit the problem. Pipeline leaks never occur at corporate headquarters or in the engineering offices. They occur in the field, under operating conditions, and involve staff that have additional responsibilities. The field is sometimes sensitive about having technology solutions forced on them that they may not fully endorse. The field may also have keener insights into pitfalls and challenges that should be well considered before implementing a solution strategy.

The challenge of implementing a viable leak detection system, then, is to merge the management skills of the corporate office, the technical skills of the engineer, and the practical hands-on work experience of the field.

A Methodology

A technical solution and approach cannot be dictated. The "Enlightened Despot" of the engineering or IT group may indeed be able to specify a theoretically correct solution. However, a commonly derived solution will be easier to implement and more successful in the end.

The technology cannot be ignored, certainly. The various capabilities and liabilities of each technology must be considered. It is just that this technical wisdom must be imparted, somehow, in a practical manner, to an open decision making forum. All of the shareholders in the organization must come together, and together forge a workable solution.

Drawing from recommendations put forth in API 1130, this paper will outline a methodology for selecting an applicable enterprise-wide leak detection strategy that is complete with management, technology, and field buy-in. A technique will be discussed to gather and present specifics about the pipeline and operations, and how to match that knowledge against expert level assessments regarding the full sweep of the available leak detection technologies.

INTRODUCTION

The Elusive Best Fit

The distributed and unavoidably exposed nature of a pipeline means that the integrity of a pipeline can not be ultimately guaranteed. Excellence and vigilance can reduce the risk of an unintended release but can never eliminate it. Accordingly, pipeline companies, appropriately and responsibly put business and technical processes in place to mitigate the extent and impact of a leak, against the inevitable day that a leak does occur.

Necessity being the mother of invention, a wide assortment of methods, techniques, and technologies has been brought forth. Indeed, pursuit of this goal has engaged some of the best talents and apparently most inventive minds in the pipeline industry. Each technology and method addresses in some unique way a particular set of requirements regarding leak detection. Determining, therefore, for your particular pipeline which technology or technologies can best be employed to protect it against leaks, can be a daunting task.

To further complicate matters, the best fit for your pipeline is not strictly an engineering consideration. Business aspects, team dynamics, and operational considerations must all be considered.

API 1130

As the industry is grappling with these issues, service organizations such as the American Petroleum Institute have offered guidelines and advice: Four particular publications are API 1154, API 1149, API 1160 and API 1130. While all of these publications address themselves to computer based algorithmic systems, the principles and considerations expressed in them, deal with the broader scope of the challenges posed to the pipeline operator in selecting and operating a leak detection.

This paper suggests extending the principles laid out in these publications and employing them to construct a process for addressing the design and specification of a leak detection system, customized for the peculiarities of your pipeline.

API 1130 directs itself towards the application and operation of a Computational Pipeline Monitoring (CPM) leak detection system. The guidelines and concerns expressed in this publication, however, are not confined to CPM type methods and can be used in the contemplation of other leak detection methodologies.

API 1154 directs itself towards ferreting out the distinguishing characteristics of a group of potential vendors. Their various strengths and relatively unique capabilities are gauged and mapped. In a fashion similar to API 1130, we wish to extend these concepts to a broader and more diverse base.

One Size does NOT Fit All

Section 4.2.1 of API 1130 states that "Multiple CPM systems may be employed to provide a CPM that can more broadly cover the pipeline operating conditions".

The 80-20 rule states that 80 percent of your requirements can be provided in a cost effective and simple manner. Closing the gap to get the remaining 20 percent can sometime double or triple your costs and efforts. Meaning, of course, if you can get by with the 80 percent, perhaps it would be good business to go without the 20 percent. Leak detection is not an area where the 80-20 rule may be applied.

There are many vendors - with a wide range of offerings, a wide range of capabilities, and an even wider range of competency and applicable functionality. Yet, among them all, there is not a single "super" product or technique that will address all of your leak detection needs. Certainly, one of these fine products can form the foundational technology upon which a system can be built, but none can do it all. As API 1130 points out, a patch-work of techniques must be applied.

As Simple as Possible, but no Simpler

Einstein once stated that a problem should be approached in as simple a manner as possible – but no simpler. As we stated above, the simplicity of a single method is too simple. However, the solution is not to drown the problem with a plurality of approaches either. Inappropriate complicity merely compounds the difficulties in deployment and use while increasing opportunities for systemic failure. The solution, as any engineer knows, is to let the problem suggest the solution.

Not Everything has a Technical Solution

As pleasant as it would be, not everything has a technical solution. This is not to say that a solution does not exist, however. Sometimes simple operational changes or minor business practice adjustments can be made that would greatly augment or supplement the leak detection and response capability. Conversely, even the best and most robust leak detection product can fail if conflicting operations and business practices are present.

Determining where such non-technical opportunities exist is often best done in other settings and by other corporate entities than those evaluating and perhaps deploying a complex technical solution. Partnerships must be forged both laterally and vertically within the pipeline company to bring the right talents and authority to bear. This requires a careful presentation of not just the technical needs and costs, but also the operational benefits and burdens and a clear understanding of the final value to the corporation in order to garner the full support of all of the necessary participants.

DANGERS AND PIT FALLS

Anyone that has had the opportunity, or perhaps misfortune, of being closely involved in the deployment of a complex, real time, technology based solution on a pipeline of any size is well aware that the endeavor is fraught with peril. A few examples of such perils illustrate this point.

Over Selling the Solution

Perhaps the most common mistake is over selling the solution. When such a system is first proposed within an organization, announcements are made and glowing images of the benefits of modern technology are painted in bight and vibrant colors – for all to see. Each of the affected constituent groups within the company begins to form expectations, both positive and negative, as to how their work and careers will be affected. Sometimes these expectations are not based on realistic assessments of the actual solution being deployed and the stage is set for disappointment, confrontation, or worse.

Modern leak detection systems are responsible and competent tools. They possess certain well specified capabilities and suffer equally well specified limitations and liabilities. This is true of all tools. However the real-world limitations of these tools become blurred the further away from the actual support and deployment team you go. If your management thinks your new leak detection system will catch a 1 barrel leak in 10 minutes when in fact it was only designed to catch a 1,000 barrel leak in 4 hours – disappointment is inevitable. If your pipeline control center thinks the new leak detection system is fully automatic and fully self-supporting, when in fact the controllers will need to daily interact with the system – disappointment is inevitable.

Leaving Money on the Table

The other side of the coin, in this case, is not seeing the full utility and opportunity leak detection systems can have. Leak detection is a necessary and important asset management and public safety requirement. The need to deploy such a system should be justified on these grounds alone. However, the technology brought to the pipeline by these systems can realize additional operational and business benefits. For example, many real-time leak detection systems accomplish liquid batch tracking as a needed requirement. The additional benefit is that batch tracking capability is delivered to pipeline operations. The benefits of leak detection are only realized on the rare occasion that a leak occurs – the side benefit of the associated technology profits the pipeline operations every day.

Once a corporate commitment has been made to deploy or upgrade the leak detection system, the opportunity to garner such additional profitable capabilities should not be ignored.

Crop Dusting with a Jetliner

It is crucial to select a technology and system that is well suited to your situation, pipeline, and organization. The desired benefit of effective leak detection is always balanced against the cost: purchase price, deployment, support, and operational.

Technology systems all have infrastructure demands, usage monitoring, control and support diagnostics, and user interaction requirements. Collectively these demands represent the basis of the ongoing cost and effort of keeping the system active. This cost may not be strictly financial, but it is a cost nevertheless. The more complex the solution - the higher the support cost. For pipelines that require such solutions this is an unavoidable cost of doing business. If the solution over-powers the problem, however, the functional cost can seriously unbalance the value versus benefit ratio. Such systems become more of a curse than a blessing and are eventually abandoned.

As an example of a task that needs different levels of equipment we observe that that when mowing grass, the highway department uses huge tractors with heavy duty cutters. Some have acreage and need a riding lawn mover. Some use a self-propelled mower for their nice sized lawn. Some live in a townhouse and can do the grass with a weed-eater.

Alienating the Support Organization

As we just mentioned, the operation and support of a leak detection system can require considerable corporate involvement. Some of the areas that must be actively involved will be discussed.

❧ Field Infrastructure

Most technology solutions are founded on data measurements obtained from field instrumentation. The availability, precision, accuracy, and stability of these measurements directly drive and define the availability, precision, accuracy, and stability of the leak detection method. As the field instruments are vital, so are the field technicians that keep those instruments on-line. A field technician's time is a limited resource, and as such technicians are always having to make value assessments and prioritizations. If they do not appreciate their impact on the leak detection system or perceive its significance to the pipeline, performance issues can arise.

❧ Communications and SCADA

Next up the data chain is the communications and SCADA systems. Leak detection systems – especially real-time systems – can be very demanding. If not properly implemented, these demands can become a considerable irritant. This is doubly true if the SCADA group has also been saddled with the responsibility of maintaining the leak detection system as well.

◈ **IT and Network Concerns**

Similar to SCADA, the corporate IT and network groups also find themselves in a strategic role. Usage, monitoring, and support methods can sometimes require access and security requirements that are not strictly in line with the normal corporate IT policies.

◈ **Asset Management**

Many leak detection systems must be configured to match or mimic the physical pipeline asset: As the pipeline changes, so must the leak detection system. Sometimes this means gross additions and modifications to the pipeline (new pipe, new valves, or new pumps). Sometimes this just means opening or closing a non-telemetered valve or changes to an instrument. Effort must be made to coordinate with these changes.

◈ **Operations**

The front-line user of a leak detection system is the pipeline operator. Notwithstanding, the operator is the focal point of a storm of potential activities, diagnostic investigation, mandated government reporting, business bookkeeping, not to mention critical operating decisions. A leak detection system should lighten this burden, not add to it. However, if not properly implemented, operation of the system may become too demanding and details will begin to get lost. Another case of too high of a cost for too little benefit.

The cooperation and collaboration of these groups must be secured to insure a successful leak detection system. A highly placed corporate mandate is no substitute for actual team building.

Over Dependence on Technology

Technology solutions carry a certain mystique. People not directly familiar with them are quite likely to believe in almost magical capabilities. And why not? Computer games perform computational acrobatics unthinkable even five years ago. Robots are seen roaming the surface of distant planets. And then there are the sales staffs of the various vendors… All this can give the impression that installing a system will make all the hazards and concerns of leak detection "go away". Exciting stuff, but completely untrue.

All technologies can fail. In an application where failure is unacceptable technology must be monitored, backed up, paralleled, and never-never completed trusted. Leak detection systems are tools that actual humans must wield. Any solution that is deployed without seriously considering the human aspects will certainly fail. People must be made available, people must be trained, and people must be allowed to work on the system.

This seems like a very obvious point, but, over the years, many systems, costing many thousands of dollars and

several staff-years of deployment, have failed because an adequate staff was not provided to operate the system once it was commissioned.

All technologies also have their limitations. Even the best leak detection will possess time and volume thresholds beyond which it is ineffective. Perhaps other methods can be devised and implemented to help lower the effective threshold. These "other methods" must be identified, explored, and specified.

However, when all the best attempts at mitigation have been implemented, leaks can still occur that will not be detected. Disappointing upper management's hopeful naivety in these regards is perhaps a thankless job, but an important one. This is doubly true when it comes to DOT or other government audits and inquiries. Being able to convincingly lay before this audience the realistic potential of the industries best practices is central to doing this effectively.

MANAGING EXPERT OPINIONS

No project engineer facing the task of implementing a leak detection system possesses all of the technical and market knowledge needed to design the system, select a vendor, and execute a successful deployment. No fear – help is readily available. There are many highly qualified independent consultants, and the vendors, too, are more than eager to assist.

Importance of Expert Opinions

Implementing a complex technology system involves a very broad scope of activities and considerations. The difference between a smooth and successful project and a death-march can be found in the advice and judgments of those that have gone before.

Ask the Vendors

Of course the vendor – especially the sales staff – is going to steer you towards their products and capabilities. This is only to be expected. However, their chauvinistic leanings aside, no one knows the concerns and nuances of these technologies more than the vendors that have developed them and are constantly involved in developing and deploying them. A project manager is wise to use this knowledge.

Seek Independent Judgment

But, of course, the vendor IS biased. Furthermore, the vendor may not be well positioned to advise you on changes needed within your pipeline to address non-technical issues and opportunities.

Fortunately there are many independent consultants. Many used to work for the vendors; others have extensive experience on the client side. These consultants may not possess detailed knowledge of the latest development feature of every vendor, but they will have hard won experience on what it REALLY takes to

deploy a successful system. As a guide and advisor they can provide a mature and real-world prospective.

Stay in the Driver's Seat

There is a model of behavior, when confronted with a technically complex process, requiring informed decisions, to find an advisor that you trust and abdicate responsibility to that advisor. This is the model of the trusted physician, the crafty accountant, and the auto mechanic. This affords a sense of security and protection. A false sense of security as it turns out.

Whether you consult a vendor or an independent consultant-or both – the ultimate responsibility remains with the project manager and other corporate authorities. Experts can educate and advise but it is vital that the pipeline staff make the decisions; and educated decisions at that. If something happens - an accident involving a pipeline leak - the responsibility, and perhaps the blame, will rest on the pipeline company and staff, not the advisors and experts.

So the issue is, how do you listen to a cacophony of voices giving widely differing and perhaps even contradictory advice and extract useful direction? Advice and information, if improperly presented, can often cloud the very issues and decisions they are meant to clarify. The expertise and judgments of consultants as well as the various constituent divisions and departments must be collected, organized, and accessed in such a manner as to enhance your own judgment. It is the focus of this presentation to consider how a pipeline organization can utilize external experts, coordinate with all of its internal constituents, and still make well informed and effective decisions.

THE HALLMARK OF A GOOD SYSTEM

Ultimately the goal is to obtain a good leak detection system for your pipeline. Ironically the "best" choice for a pipeline may not be the "best" technology, the "cheapest" roll-out, or the most "timely" delivery. A "good" leak detection system will work well within your organization while detecting leaks of the appropriate size and within the appropriate time frame. Discovering this "good" choice requires careful consideration of the essential elements of a leak detection system. Talent, expertise, experience, and advice that do not address these essential elements are misdirected and may prove to be unfortunate distractions.

The hallmarks of a good leak detection system are effectiveness, usability, and sustainability. There is literature available addressing these considerations, API 1154 and API 1130 are good examples. Sketching out the essential elements is useful in seeing how the overall system can be strategically approached and logically analyzed.

Meaningful and Effective

A leak detection system is a safety system. Its purpose it to mitigate the consequences of a pipeline release by providing timely notification of the event and information helpful to the response teams in a meaningful and believable manner.

This concern is more easily expressed in the negative.

- ☒ A system that is vague and indeterminate is less than usable.
- ☒ A system that requires detailed and time consuming analysis just to know what it is "saying" is next to unusable.
- ☒ A system that is disabled or inoperable for significant periods is unusable.
- ☒ A system that produces so many false alarms that any real alarm is lost in the "noise" is worse than unusable.

Affordable Excellence

Excellence means doing what is required and a little more. Excellence is a performance issue, not a cost issue. An excellent system is one that the pipeline can afford to purchase and deploy. It is one that can be supported and maintained without undue stress, and one that the operations staff can and does use. An excellent system is a system that works – for the whole pipeline.

Safety versus Cost

Safety is not something to which one can attach a price tag. If a pipeline can not afford to operate safely, it can not afford to operate - period. Nevertheless, safety and cost are not necessarily linked together. Just throwing money at a safety issue may make you THINK that you are addressing the issue, but the truth may be otherwise. Safety can be obtained; and in a fiscally responsible manner. Concerns for safety set the vision and determine the goals, but beyond that the implementation requires good business practices and judgments.

Design and Purchase

Cost may not be the issue, but it is a factor. Project requirements to deploy the system can represent a significant effort. Since pipelines do not have unlimited resources, the design and purchase cost and deployment effort must be proportional to the expected benefit to the organization.

Infrastructure and Capital Expenditures

Instrumentation and other infrastructure upgrades are often required when installing a new leak detection system. The particular improvements are driven directly by the choice of technology and methodology. What looks like a great leak detection system may prove to be impossibly difficult to deploy if the infrastructure improvements are too demanding.

Deployment

Deploying a leak detection system represents a significant commitment by a pipeline organization.

Business and operational practices must be adjusted and project and personnel resources mobilized. The disruption and hidden costs of this effort must be realized when choosing which leak detection method to employ. Specific skills and talents are also implied by the choice, and the availability of suitable staff should not be ignored.

Usage

Leak Detection technologies and methods have widely varying usage demands. An affordable leak detection system will integrate well with the pipeline's capabilities, practices, and culture.

Maintenance and Sustainability

Similar to deployment is the need to support and maintain the system. An affordable system can be supporting in-house with limited tether to the vendor.

THE METRICS

Elements

To facilitate analysis and help focus and refine characterization of individual leak detection systems, API 1130 has offered seven key concepts. DOT 195.452 adds one more. Collectively these eight concepts blanket the various essential elements that affect the performance of a system.

⋄ Accuracy

As suggested by API 1130, ACCURANCY is how close to the actual truth are the process-determined predictions regarding the leak parameters that the particular leak detection method produce.

⋄ Precision

Precision is a measure of the error introduced by random or nondeterministic elements in the process. Another way of thinking of this is how much plus-or-minus factor must be applied to any result delivered by the method.

⋄ Stability

Stability gauges the degree to which the leak detection process can be confused or driven to erroneous conclusions, even in the presence of reasonably good input data. Operational patterns and other contributing factors can confuse some methods. Other methods can get "trapped" in non-convergent methods or lost in a jumble of inconclusive logic.

⋄ Robustness

Robustness deals with how easily a leak detection method might be invalidated by the failure of one or more of its data sources or underlying drivers.

⋄ Usability

Usability is a measure of the ultimate utility of the information produced by the leak detection system. This usually bears on the ability of the method to determine the primary leak detection parameters;

- ☑ leak existence,
- ☑ size of the leak,
- ☑ location of the leak,
- ☑ product being released,
- ☑ time of the leak,
- ☑ amount of product already released, and
- ☑ how much MORE product is likely to be lost.

⋄ Believability

Believability is a crucial aspect and deals mainly with the likelihood of a false alarm. However, believability also addresses the possibility of a missed or undetected alarm.

⋄ Sustainability

Sustainability deals with the pragmatic estimation of whether a method can be continuously applied.

⋄ Swiftness

DOT 195.452 introduces the concept of "swiftness". While it is loosely defined, swiftness can, in part, be thought of as the time required to-detect a leak with surety. Early warnings that something MAY be wrong is not a detection. A release detected with surety by a leak detection system requires no further investigation or analysis and triggers an immediate line shut-down or other appropriate response activities.

Swiftness also bears on the accessibility of the response teams to the potential release site. The selected leak detection method may be highly biased by the access time. For example, Believability (likelihood of false alarms) becomes a big issue; as does the desirable utility of the method (i.e. Leak Location etc).

An Example

As an example, consider aerial patrols. The method of spotting leaks from the air has a great deal of precision and accuracy. Coordinates forwarded by the pilot are exact and definitive. Furthermore, the pilot will deliver the same result each and every time. Aerial patrols, however, are not very robust. Weather and darkness easily disable this method, not to mention an utter dependence on a single piece of equipment (the plane). The Utility of the method is also low. The pilot often has no meaningful way of determining the size of the leak, the product being released, when the leak occurred, how much product is on the ground, or how much might be eventually lost. In the affirmative sense aerial patrol is a very believable method. If the pilot sees the leak, it is fairly certain that the leak does exist. In the negative sense, however, it is very non-determinate (un-

Believable). If the pilot didn't spot the leak, does that mean it doesn't exist? Finally, constant aerial patrols are impractical and thus not highly sustainable. Aerial patrols, therefore, would not seem to be a very good leak detection method. So why, then, do almost all pipelines employ this method? The reason bears directly of the focus of this discussion. Aerial patrols are used because, in a narrow application, it can produce highly accurate and timely information. Aerial patrols are used as an effective supplemental method, augmenting other – more primary methods.

Leak Detection Assessment Scores

Similarities with Risk Assessment

A Risk Assessment Score is a single numeric value that encapsulates a broad assortment of dissimilar and mostly unrelated issues, all regarding safety and risk issues of an operating venture, into a simple decision metric. This metric is used to assess and "measure" the risk level of the venture and to gauge the reduction of those risks by the implementation of certain proposed measures. This is precisely the type of methodology and capability that is needed in regards to the selection, evaluation, and improvement of Leak Detection Systems.

What is an Assessment Score?

An Assessment Score is a composite value, computed from different expressions that collectively address all of the areas of concern. Each of these areas is represented by a measured expression of some type, but each measurement may be determined in a completely different manner. The composite measurements are scaled so that they combine in a meaningful manner. The primary requirement of these measurements is that they all represent gradients of quality or performance in a consistent fashion (like small is good – big is bad). Each measurement is then scaled appropriately so that the contribution of each is commensurate with its relative importance to the system.

The actual calculations and their associated scales are, indeed, somewhat arbitrary. Comparisons of an Assessment Score from one venture to another, even in the same industry and similar settings, are meaningless. However, comparisons of Assessment Scores on the same line but driven by adjustments in the input conditions ARE significant. Changes to the Assessment Score both in direction and scale in response to proposed changes provide meaningful insights as the actual improvements that may be achieved.

What an Assessment Score Is Not

Although an Assessment Score can provide meaningful insights, it is NOT a precise measurement. The score is neither smooth nor linear. This is to say that a 100 point change one year does not mean the same as a 100 point change the next year. Also a change of 200 is not necessarily TWICE as good as a change of 100.

Assessment Scores should never be used to drive specific goals ("…get the score down to 1264") or specific comparisons over time ("…but we are committed to dropping the Assessment Score by 10% each year for the next 5 years").

The assessment expressions and weighting values greatly affect the outcome of the score. Adjustments to these elements should be done with care. Assessment Scores are a knowledge tool to help drive correct decisions. They will be only as valuable to your organization as you permit it to be.

What do we Assess?

The eight concepts described above that are used to define or characterize a leak detection methodology are also the key performance metrics for a leak detection methodology. As such they lend themselves naturally to use as part of an assessment. However, these performance metrics do not tell the whole story and we need to consider metrics from other areas such as Operations and Asset Management to provide a clear and unbiased assessment score for a defined leak detection methodology.

Operational characteristics such as high or low flow rates, highly transient conditions, slack line conditions, etc. are used to describe the operating environment or circumstances under which we want a leak detection methodology to operate. Similarly, Asset Management considerations such as the installation cost, installation support cost, running cost, etc. should also be employed.

These characteristics lend themselves to definition of metric and hence an assessment score. Once we have identified all of the characteristics that should be considered, we can define a measure for each and generate an assessment score.

In general, we must involve every aspect of a leak detection methodology when generating an assessment score: from the accuracy to the change in operations needed to get the best out of a strategy.

Assessment Expressions

A generic formulation

Once we have decided on the set of aspects or metrics that we are going to use to generate our assessment score we find that that many of the aspects are dependent on operational parameters. Consider the aerial patrol example cited above. The swiftness of the method depends on how many flights there are past each point of the pipeline in a given timeframe. If the patrol happens once a day, then the maximum detection time is 24 hours – two patrols a day will give you a

detection time of 12 hours, and so on.

A functional relationship exists between the aspects of a leak detection methodology and the set of operational parameters. The functions themselves may not be clear and may vary from one vendors implementation of a given methodology to another. The set of operational parameters, themselves, may well be different for each methodology – patrol frequency has no bearing on a model based leak detection system: SCADA refresh rate has no impact on aerial patrols. However, the complete set of parameters should always be considered.

Exploitation of the functional relationship between the methodology aspects and operational parameters can provide much more than just a desired contribution to the assessment score. They can help determine how to best improve an incumbent leak detection strategy, which parameters are the most sensitive (thus providing input into the maintenance program), and how operational changes will affect the system.

To help illustrate the concepts we will use a fairly simple, if somewhat contrived, example – we will consider the following three performance aspects of a leak detection methodology: Location Accuracy, Swiftness and Believability.

Once a set of aspects has been determined, the parameters affecting these aspects can be determined and a functional relationship between the aspects and parameters constructed. This function might be constructed through some analytical methodology or it may be that experience has provided a set of "rules of thumb" that can be employed; in any case a functional relationship can be determined. It is assumed that the function is sufficiently continuous and sufficiently differentiable (except at isolated points, perhaps) to ensure the following analysis is reasonable. If it is not, then we can use an approximation to the function that is.

Define $\mathbf{p}$ to be the vector of parameters that affect the aspects of a leak detection methodology. Then, for a specific aspect q_i then we can write

$$q_i = f^m{}_i(\mathbf{p})$$

where the superscript on the function indicates that the function is appropriate for leak detection methodology m.

Consider again our example: we may have determined that these performance aspects depend only on two parameters:

p_1 -   Number of measurements

p_2 -   Interval between scans

Experimentation, experience, direct calculation or some

curve fit has provided the following functional form to express the aspects in terms of the parameters:

Swiftness: $q_1 = f_1^m(\mathbf{p}) = 120 * \dfrac{p_1}{p_2}$

Accuracy: $q_2 = f^m{}_2(\mathbf{p}) = 1 - e^{-\frac{p_1}{100}}$

Reliability: $q_1 = f_1^m(\mathbf{p}) = 0.98\sin^2(p_1/100)$

These functions are fictitious and are used only to illustrate the methodology. It is worth noting that our "Swiftness" function is actually a "Slowness" function – it gives the reciprocal of the time to detect – this is because, ultimately, we want to maximize our functions and therefore we want to maximize the reciprocal of the time to detect, not the time to detect.

The range of the parameters is important. In many cases this will be some hard and fast physical limit. In the example limitations are prescribed as the maximum update frequency is 1 update per second and the maximum number of instruments is 250.

The key point here is that there is a functional relationship (or one can be derived through data fitting) and that the function is smooth and well behaved in the range of dependence - or can be made to be.

Per Aspect Optimality and Sensitivity

For an aspect q_i we can determine the optimal set of operating parameters – this is the maximum value for the function. This occurs at either a turning point or at the parameter range boundaries:

Find p_i such that $\dfrac{\partial f_i^m}{\partial p_i} = 0$ or $p_i = p_L$ or $p_i = p_u$

where p_L and p_U are the lower and upper range values of p_i respectively.

Simultaneous solution of each of these gives us the optimal point for the quality.

The optimum value can be used to scale the function so that the function range is [0,1]. This allows a set of weights to be applied to the functions to define an assessment score where the weight is a measure of perceived importance of the method aspect under consideration and controls the final assessment score.

For the example, swiftness is optimum at the endpoint values of 250 instruments and a 1 second update time (a "swiftness" of 30,000); accuracy is optimum at the

endpoint of 250 instruments (an "accuracy" of 0.918) and reliability is optimum at its maximum turning point at 157 instruments (with a "reliability" of 0.98).

It is clear that different sets of optimal parameters exist for each method aspect. In general this is true and in itself this provides no real information to us. However, the sensitivity of the method aspects to the parameters is meaningful as it tells us how quickly the aspect deteriorates away from the optimum point or from any other point in the parameter range. The sensitivity here can be defined as the derivate of the function in the neighborhood of the current set of parameters.

In selecting a methodology the optimum parameter points should be used to provide an assessment score on a per aspect basis. However, the sensitivity in the neighborhood of the optimum should be taken into consideration as it is more than likely that, with the best will in the world, the leak detection methodology optimum operating conditions will never be met.

If we are assessing an incumbent leak detection system the aspect functions may be evaluated at the existing parameter set values to provide an estimate as to how far from the optimum value the parameters are and the sensitivity to parameter changes at that point. With each parameter change there is an associated cost which can be described in a functional form. Therefore, the cost associated with a change in the parameters leading to a change in the aspect function value can be calculated.

Assessment Score, its Optimum and Sensitivity

An assessment score for a leak detection methodology can be written as a simple linear weighted combination of all the aspect functions. With a prescribed set of weights, w_i, such that $0 \le w_i \le 1$ and $\sum w_i = 1$ we can write the assessment score as

$$s = \mathbf{w}.\mathbf{q} = \mathbf{w}.\mathbf{f}(\mathbf{p})$$

Where $\mathbf{w}$ is the vector of weights and $\mathbf{f}$ is the vector of method aspect functions (suitably scaled).

The weights can be referred to as "significance" as they will be determined by asking the end user how important each quality is to the overall system performance.

Using the above we can determine the optimal assessment score $s = \mathbf{w}.\mathbf{f}(\overline{\mathbf{p}})$ where $\overline{\mathbf{p}}$ is the set of parameters that maximize the function s from either

$$\frac{\partial s}{\partial p_i} = \sum w_i \frac{\partial q_i}{\partial p_i} = 0$$ or from range boundary values.

Extending the example by defining the significance weights (after consultation with our selection committee):

$$w_1 = 0.25, w_2 = 0.25, w_3 = 0.5$$

we have our overall assessment score function as

$$s = 0.001 * \frac{p_1}{p_2} + 0.272 * \left(1 - e^{-\frac{p_1}{100}}\right) + 0.5 \sin^2(p_1/100)$$

It so happens that the optimal score is when we have 172 instruments and an update frequency of 1 second. This gives us an optimum assessment score of 0.884.

Lets us assume that we have an incumbent system that with only 100 instruments and an update frequency of 16 second. This would give us an assessment score of 0.532. If we had a fixed amount of expenditure for enhancing the system that would either allow us to buy up to 10 more instruments or increase the SCADA update frequency up to 8 seconds we can use the assessment to help drive this decision: buying 10 more instruments would provide the biggest improvement to the assessment score.

Method Selection:

When determining which methodology best fits the pipeline requirements, some of the method aspect assessment scores may be determined by a function that is suitable for all implementations of the method. If no suitable method can be determined, a fixed value assessment score may be assigned.

For each method aspect a required score q_i^r will have already been determined by the selection committee and therefore a total (or target) assessment score value will have been determined. The single most appropriate method can determined by calculating the sum of the differences (capped below at zero) from the method scores and the required score for each aspect:

$$\sum q_i^s = \sum \max(0, q_i^r - q_i)$$

This is the "shortfall" score for the method with the shortfall for each quality being given as

$$q_i^s = \max(0, q_i^r - q_i)$$

Obviously we would need to consider the range of each of the method aspect assessment scores which can be calculated by consideration of the range of the operating parameters that affect each of the scores. The optimum method aspect assessment should be used in determining the shortfall score, but the range should also be used to help identify if moving away from the optimum score leads to a shortfall.

Method Combinations:

To mitigate the effects of shortfall we need to consider combining methods. For each method, j, we denote the aspect assessment score for aspect i, as $q_{j,i}$ and an associated shortfall of

$$q_{j,i}^s = \max(0, q_i^r - q_{j,i})$$

The problem of how best to determine the best combination of shortfalls does not fall neatly into any combinatorial optimization framework. However, one approach to selecting a suitable combination of methodologies is to determine the best single methodology and then remove from consideration the methodology aspects for which the best method gives a zero shortfall score for. The remaining methods are then compared with a reduced set of required aspect assessment scores. This will yield a second level "best" method.

Combining the "best" and "next best" methods is a matter of "overlaying" the two methods aspect assessment functions to produce a combined function. The combined method can then be put back into the assessment scheme, replacing both of the individual methods, and again shortfall scores should be calculated for the full set of method aspects. The combined method will be the "best" method, but, if not all shortfall scores are zero for this method, will lead the way to a selection of yet a further method for combination.

A "Simple" Example

A Simple Assessment Expression

A simple assessment expression is shown below.

$$I * S = A$$

Where

$I, InputEstimate$ is the measured aspect of the environment, pipeline asset, or operation

$S, Significance$ is the significance of the input measurement to the assessment consideration

$A, Assessment$ is a numerical value estimating the compliance or satisfaction of the concern

Since there are multiple input estimates and assessment concerns the expression becomes

$$\sum_{n=N} I_n * S_{n,m} = A_m$$

Where

N is the number of Input Estimates

M is the number of Assessment Concerns

There are two types of assessments that must be considered,

☑ The Requirements of the Pipeline and

☑ The Capability of the Leak Detection Methods.

These assessments are related to the Score by

$$\sum_{m=M} MIN(AR_m, AC_m) = Score$$

(Simple 1)

Where

M is the number of Assessment Concerns

AR_m is the Assessment for Requirement "m"

AC_m is the Assessment for Capability "m"

S is the composite Assessment Score

The minimum value is employed along the lines of "Enough is as Good as a Feast". If the pipeline only has a modest need for a particular capability, the assessment score should not be over-balanced for methods whose capabilities far exceed those needs. For example, if a pipeline very rarely (if ever) experiences slack line conditions; the ability of the leak detection method to support slack flow should not be unduly credited.

In addition these assessments provide an Opportunity Score. ··simple 0

$$\sum_{m=M} AR_m - MIN(AR_m, AC_m) = Opportunity$$

(Simple 2)

The individual terms of the Opportunity Score are helpful in that they indicate WHERE improvements can be made. They also help indicate how multiple methods may be combined to create improved hybrid systems. The total score indicates how close your particular pipeline is to fully utilizing the available technologies.

Input Parameters

Assume that there are only five key input parameters,

1. Pipeline Length,
2. Meter Accuracy,
3. Scan Rate,
4. Pumps, and
    ··simple 1
5. HCA Encroachment.

Assessment Considerations

Assume that there are only six key assessment considerations,

1. Flexibility,
2. Robustness,
3. Swiftness,
4. Diagnostic Content,
5. Transparency, and
6. Weight.

Methods

Assume there are only three Leak Detection methods available,

1. Method 1,
2. Method 2, and
3. Method 3.

Matrix

The terms and values of equation "simple 1" define a simple linear matrix, the terms of which represent the weighting terms of each Input variable to each Assessment Consideration variable. The input parameters define a vector which is then multiplied with the assessment matrix to obtain the assessment score.

Four Assessments

Four assessments must be made in the evaluation of this example.

Pipeline Requirement Assessment (1)

The requirements of the pipeline are determined using an assessment calculation. The weighting terms are determined to estimate the leak detection features most critical to the pipeline based on its geometry, environment, and operations.

Pipeline Requirement Assessment

		Flexibility	Robustness	Swiftness	Diagnostic	Transparency	Weight	
Length	35	75	66	50	85	35	40	
Meter Acc	22	50	40	60	25	85	70	
Scan Rate	75	60	50	25	25	85	70	
Pumps	75	80	50	60	75	30	70	
HCA	15	50	50	80	50	50	80	
		14975	11440	10645	11775	12470	14640	75945

Leak Detection Method Assessments (3)

There are also assessments made for each of the three Leak Detection methods.

Method 1 Requirement Assessment

Length	35	25	45	55	72	42	15	
Meter Acc	22	32	40	45	25	35	50	
Scan Rate	75	55	35	45	25	70	45	
Pumps	75	75	45	65	70	40	55	
HCA	15	40	33	72	38	45	68	
		11929	8950	12245	10765	11165	10145	65199
Limited by P/L Req		11929	8950	**10645**	10765	11165	10145	63599

Method 2 Requirement Assessment

Length	35	45	72	55	75	40	65	
Meter Acc	22	45	35	65	30	75	65	
Scan Rate	75	55	50	30	15	75	65	
Pumps	75	37	55	55	60	44	65	
HCA	15	45	45	70	40	54	67	
		10140	11840	10780	9510	12785	14460	69515
Limited by P/L Req		10140	**11440**	**10645**	9510	**12470**	14460	68665

Method 3 Requirement Assessment

Length	35	65	50	60	60	40	35	
Meter Acc	22	65	45	55	55	70	85	
Scan Rate	75	55	45	35	30	45	50	
Pumps	75	85	35	50	65	35	65	
HCA	15	74	25	70	60	40	65	
		15315	9115	10735	11335	9540	12695	68735
Limited by P/L Req		**14975**	9115	**10645**	11335	9540	12695	68305

Tapping Corporate Knowledge

Constituents

The Knowledge needed to select the Leak Detection strategy that best fits your pipeline is scattered throughout the body corporate. Pipeline controllers, field technicians, engineers, and division supervisors all have information and perspective to bring to the decision table. Unfortunately there is not enough room at that table for all of these people, nor could all of their perspectives be efficiently brought to a consensus in such an open forum. However, a consensus is precisely the objective.

The Questionnaire

The challenge is to obtain the needed information and opinion from each of the constituents with a minimum of controversy and haggling. One way to obtain this information is to determine a relatively small collection of simple questions that target the particular skills and experience possessed by each constituent. The answers to these questions then comprise the body of information that a smaller and more efficient group can use to forge a comprehensive strategy.

Phrasing the Questions to Obtain Usable Answers

The trick in using questions is to obtain responses that can be used in a meaningful and methodical fashion. One method to accomplish this is to phrase questions that are answered by a value range. For example "*In a range of 0 to 10, with 0 being not at all and 10 being all of the time, how often does you pipeline experience slack flow conditions?*" Some considerations may be actual measurements, like alarm counts or historical examination of SCADA values. A few guidelines might be used when defining your questions. The Questions and Questionnaire should

- ☑ Require a numeric response,
- ☑ Not require extensive research,
- ☑ Not use techno-babble,
- ☑ Not require extensive measurements,
- ☑ Use "Gut Feel" as much as possible,
- ☑ Be Kept simple,

☑ Be Kept to the point, and
☑ Be Kept short.

Mapping Responses to Input Considerations

So now you have a collection of 100 or so numerical responses. How do you convert these responses into the needed Input Parameters? One method is a simple weighting system where by the contribution of each response is expressed. The Input Parameter is thus obtained by simple multiplication of each response and weight and summed across the whole collection.

$$Input_p = \sum_n \left(Answer_n * Weight_{n,p}\right)$$

Where

N, n : Number of Questions

P, p : Number of Input Parameters

$Input_p$: Value for Input Parameter "p"

$Answer_n$: Response to Question "n"

$Weight_{n,p}$: Weighting of Response "n" to Parameter "p"

The weights assigned to each response must be balanced to each parameter so that the overall assemblage produces a result sensitive to variations in each of the input values. Obviously the selection of the weighting value must also reflect the realities and concerns of the Leak Detection methods in general. For example a question about the SCADA scan rate should map to the speed and sensitivity of an instrument based method. However, since the assessment scoring system is not intended to be quantitative, the precise weighting and balance of one question to the next is not absolutely critical.

Obtaining Expert Opinions

Capturing the "essence" of the relationship of the Input Parameters to the generic considerations of Leak Detection is central to the success of this technique. Inappropriate weights can skew the inputs or even completely invalidate them. Furthermore, one of the goals of this approach is to import industry expertise into the decision process. Accordingly, we recommend that these weighting factors be obtained by consulting with multiple industry "experts".

The proposed questions in the Questionnaire can be vetted to a group of experts of your choosing that can provide their estimation of the appropriate weighting for that question to the desired Input Parameters. The response of each can then be compiled and averaged. Stragglers or out-layers can be discarded as deemed necessary.

These expert-suggested weights, along with the credentials of each "expert" should be recorded as they represent part of a formal validation of the process.

Targeting Your Audience

Similar to obtaining weighting values from industry experts, which corporate members are selected to complete the Questionnaires is an important issue. Each individual should represent a significant experience or responsibility asset of your corporation. Their qualifications and resumes should be recorded. They also represent part of a formal validation of the process.

Vetting Your Data

In this process the actual data that you are carefully collecting should not be consider sacrosanct. Data is data, and THIS data must mesh well with all of its various sources. Accordingly, responses or expert weights from any source can be scaled or excluded as desired.

However, for the data to retain any validation or supportive qualities, any changes should be well documented as to the nature and reason for the change.

Processing and Presenting the Data

The final set of documents should include the following elements.

☑ Credentials of Industry Experts
☑ Resumes and Positions of Corporate Responders
☑ Copy of the Questionnaire
☑ Response Weightings
☑ Leak Detection Weights
☑ Weighting or Questionnaire Adjustments
☑ Resulting Input Parameters
☑ Leak Detection Weights and/or Mapping Inputs
☑ Assessments for ALL Leak Detection Methods
☑ Details of Any Hybrid Strategies
☑ Selected Leak Detection Strategy
☑ Leak Detection Concerns
☑ Implementation Plans
☑ Base Assessment

Decision Making

DOT 195.452 and Integrity Management Protocol #6

Protocol 6 outlines several recommendations regarding the decision making process that is to be employed in selecting your Leak Detection System. Some of these recommendations are

☑ Utilize Input from All Relevant Parts of the Organization
☑ Employ a Systematic Process
☑ Provide a Well Defined Basis for Decisions
☑ Review and Record All Potential Choices
☑ Determine a Base Assessment
☑ Estimate Departures from Base on Periodic Basis

The establishment of a Leak Detection Assessment scoring system as described in this paper supports well the process suggested by the DOT.

Gathering Consistent Data across the Organization

The Questionnaire provides a simple and efficient means for polling crucial individuals within the pipeline organization without undue disruption or interference. The Questionnaire process while subjective is nevertheless unbiased and should be fairly repeatable. If different individuals complete the Questionnaire, similar results should be obtained.

The compiled responses to the Questionnaire are weighted by the predetermined factors to produce the Input Parameters. Thus the Input Parameters can be retrieved more-or-less directly from within the organization in a simple and repeatable fashion. As the Questionnaires are completed periodically, each new evaluation is closely related in scope and weight to the ones before. In other words, the foundational Input Parameters can be collected in a consistent and repeatable fashion and reflects input from all of the relevant portions of the pipeline.

Base Assessments and Departures

As described earlier, the Input Parameters are transformed by the mapping functions into Leak Detection Assessment values upon which the selection decisions can be made. These mapping functions are developed outside the decision process and translate the inherently consistent pipeline evaluations of the Questionnaires into consistent performance assessment numbers. Changes in the operating environment, pipeline asset, or business practice will be reflected in changes to the decision framework underlying the choice of Leak Detection methods employed. Each assessment cycle will thus produce a set of values that forms the base assessment against which the next cycle will be judged. Changes in the organization that bear of the original choice will be easily visible. Personnel and organizational changes should not affect the accuracy and utility of this comparison. What is produced is a stable, repeatable, and unbiased assessment metric.

Record All Candidate Choices

One benefit of the assessment process is that ALL of the candidate technologies can be simply evaluated in a consistent and even fashion. The opportunities and liabilities of the various potential solutions are communicated to the decision committee and can be easily recorded.

Committee Based Decisions

The actual selection of a Leak Detection method or methods will be made by a committee of key individuals. Decisions made by the committee are guided by the tacit organizational knowledge of these individuals as well as by their professional experience and judgment. This skill and talent is focused on the state of the pipeline and the available technologies as described by the Input Parameters and Assessment values and produces a decision.

It is important to note that the Decision Basis, not the DECISION itself is methodically extracted from the Questionnaire and Assessment processes. The actual decision is still made by the common sense and professional wisdom of the committee.

Re-Evaluations

Reexamination of the selection can be made by reexamination of the assessment values that formed the basis of the decision. This reexamination can be made by simply requiring the Questionnaires and feeding the results back into the assessment calculations. This does not require reconvening the committee unless a departure of significant magnitude occurs. As the numeric values of the assessment scores should not be taken as quantitatively significant, a human should review the reevaluation scores to determine if the committee needs to reconvene.

Team Roles and Responsibilities

As with most business endeavors the key to success is the team assembled to implement the strategy. This technique envisions an active corporate team that coordinates and shepherds the activities needed to utilize it. The roles and responsibilities of these envisioned individuals help define the nature and purpose of the organizational team.

Execution Leader

The Execution Leader is the highest placed management individual whose responsibility includes the successful selection of a Leak Detection system on the Pipeline. This individual can insure that the other personnel assignments are properly staffed. The execution activities, such as completing the Questionnaire and participating in the Committee, are enforced by the corporate authority of the Execution Leader.

Technical Lead

The Technical Lead actually coordinates and implements all aspects of the process. Obtaining the expert options and making the assessment evaluations are prime responsibilities. Preparing and facilitating the Committee meeting(s) is also a key function.

Corporate Consultants

Corporate Consultants complete the Questionnaire and communicates as needed with the Committee or any of ifs representatives.

Expert Consultants

The Technical Lead will contact and secure the services of a set of industry experts. These may be independent consultants (preferred) or vendor talent. These "experts" represent the Expert Consultants. The duties of these consultants are limited to completing questionnaires or weighting matrixes. The Committee may contact them as deemed necessary.

Divisional Leaders

The Divisional Leaders are the corporate managers and responsible persons that directly control or operate the pipeline. All of the assessment, evaluation, and implementation activities will be executed within the supervision and under the authority of these individuals. The buy-in of these individuals are critical and the success of the process must be directly tied to their corporate expectations.

Implementation Leaders

The Divisional Leaders will, in general, not be able to be directly engaged with the selection process to any great extent. Accordingly, the Implementation Leaders act as their representatives and under their authority to insure that the requirements of the selection process are met.

About the Committee

This process envisions as system in which the required evaluations, assessments, data gathering, and analysis is gathered as a preparation for a cumulated decision point. While it is unreasonable for highly placed corporate staff to be engaged in the daily activities and extended preparations of this process, the selection meeting itself MUST include the prime owners of the risks and the individuals authorized to make the key decisions that will be predicated.

The committee MUST have the corporate authority to plan and implement any decision that may be made. The process of subsequent "approval" by an oversight individual or group of individuals compromises the decision. Any adjustments or modification to the plan by this "higher" authority compromises the validity of the selection.

In other words, the corporate decision makers MUST be on the committee.

Obtaining and Measuring Success

The true measure of a process or system is how well it works. Each pipeline and pipeline organization is different and any process deployed will encounter differing degrees of acceptance and success. Accordingly, the process should be fluid enough to accommodate the personality of your pipeline.

First, factors crucial to the success of the methodology must be recognized. This is to insure that these elements are accommodated. Second, identifiable actions or behaviors can be anticipated. These expected success "signposts" can either assure you that the system is working or guide you into areas where improvements may be considered.

Some of the factors critical to the success of the methodology are listed below along with some "signpost" measures.

Critical Success Factors

- ☑ The Questionnaire and Input Parameters cover all concerns regarding your Pipeline
- ☑ The Required Responses are Clear and Unambiguous
- ☑ Each Leak Detection Method is properly ranked and fairly represented.
- ☑ The Process is not Biased towards a Particular Method
- ☑ The Process Facilitates Discussion and Consensus Building
- ☑ The Resulting Decision withstands External Scrutiny

Measures of Success

- ☑ How often do Questions (on the Questionnaire) have to be Clarified?
- ☑ How often are Questions added to the Questionnaire?
- ☑ Resulting Recommendations are Reasonable and in Keeping with the team's subjective assessment.
- ☑ Workable and Acceptable Methods are not artificially Excluded
- ☑ Controversy or Disagreement with the Selection and Recommendations within the team is minimal.
- ☑ Controversy or Disagreement with the Selection and Recommendations from External Sources NEVER occurs.

Conclusions

Deceptive Simplicity

When we first began thinking about these issues we thought that it was a fairly straight-forward problem. A few clever recording techniques and the job is done. However, as we dug deeper this subject has proven to be surprisingly complex and encompasses a rich and potentially powerful set of technical capabilities.

Loss of Exclusive Ownership

The selection and deployment of safety related issues is no longer a private issue of the pipeline company. Public and legal parties have inserted themselves into the process and want to be assured reasonable and responsible decisions. It is not that pipeline companies have been unreasonable or irresponsible in the past. But they have been opaque. Decisions previously made in the private considerations of a single person or small group of persons must now be opened to public scrutiny.

Need for a Defendable Process

Unfortunately this public interest is not strictly "friendly". Transparency in the process must unavoidably lead to challenge and potential controversy. Regulations are demanding a clear and methodical process, each step of which can be gauged against best industry practices.

The Best Fit is NOT a Sales Issue

Defining the best Leak Detection technology for a pipeline is in everyone's best interest. Individual vendors may, and should, be able to review the weighting and assessment values to correct any omissions or skewed values. However, the choice of technology is not a sales choice.

Utilizing Burgeoning Technologies

Technologies grow over time – even explode. Keeping abreast of these technologies, to the level of expertise needed, is very difficult. Additionally, widely varying technologies and methodologies will involve different pockets of technical expertise. Someone "in-the-know" about one method may not be proficient in others. The technique proposed in this talk has been primarily driven in an attempt to allow the collection of widely different expert opinions into a single-source repository.

Producing Transparent Technologies

The choice of a technology and Leak Detection strategy involves mobilization of considerable corporate resources and requires appropriate authorization. Accordingly the decision must be made by individuals positioned to make these commitments.

Such decisions must employ the industry's best practices and most fruitful technologies; delivered in such a manner as to not cloud the thought process with detail but rather expose the essential nature of their capabilities and benefits.

The selection decision must not be a political, financial, or personal choice. It must be the RIGHT choice; made using the right information and for the right reasons.

References

API 1130 - Computational Pipeline Monitoring for Liquids Pipelines
American Petroleum Institute
01-Nov-2002

API 1149 - Pipeline Variable Uncertainties and Their Effects on Leak Detectability
American Petroleum Institute
01-Nov-1993

API 1155 - Evaluation Methodology for Software Based Leak Detection Systems
American Petroleum Institute
01-Feb-1995

API 1160 - Managing System Integrity for Hazardous Liquid Pipelines
American Petroleum Institute
01-Nov-2001

Protocol 6 - Preventive and Mitigative Measures
US Department of Transportation

Code of Federal Regulations, Title 49
US Department of Transportation

Biographies

Kevin F Webb
Lead Designer
Energy Solutions International

Kevin rejoined ESI (formerly LICEnergy, formerly SSI) in September 2004 after a seven year stint working for Koch Pipeline Company where he worked as an engineering consultant and software developer in their pipeline operations group. In his previous role with ESI he worked on the development and support of their off-line engineering simulators. During his time with Koch Pipeline he worked on several operational systems as well as authoring corporate guidelines and processes surrounding the selection, operation, and enhancement of their leak detection systems.

He is currently involved in the development and deployment of their liquid batch transport products.

Education

BS Mathematics, University of Houston, 1978

Current Technical Interests

Technical interests include the interconnectivity of hydraulic modeling capabilities with crucial corporate and business requirements, application of modern software techniques and platforms to expose technology to a wider audience, and the application of numerical techniques to the business processes and decision-making system used in today's pipeline industry.

Jonathan J Barley
Principal Simulation Specialist
Energy Solutions International

Jon joined ESI (formerly LICEnergy, formerly SSI) in November 1992 as a Consultant after leaving BP Research where he worked as an Applied Mathematician in the High Speed Computing group. During his time with ESI he has worked on the development, integration, implementation and support of many Real-Time On-Line Pipeline Modelling Systems and Off-Line Pipeline Modeling Applications.

He is currently a Principal Simulation Specialist within ESI UK and is responsible for the development of PipelineStudio.

Education

BSc Mathematics, University of York, 1985

PhD Computational Fluid Dynamics, University of Reading, 1989.

He has published various papers on various subjects over the twenty years – some of them relevant to the pipeline industry.

Current Technical Interests

Technical interests include the numerical modeling of gas, liquid and multiphase pipeline networks, application of modern software techniques to problems in the oil and gas industry, visualization and code optimization.