Uberlytics approach to criticality analysis and the Criticality Analyzer™

Uberlytics offers a unique approach to system criticality analysis, applicable to any complex facility or system. The Uberlytics approach has consistently identified significant unrecognized risks and quantified in dollars the risk potential. It is an invaluable tool and approach when risk mitigation, whether for down-time or safety or environmental compliance, is vital to assure overall success balanced against the reality of limited capital and maintenance dollars. This prime constraint is most commonly known as the **Level of Service versus Cost to Maintain** equation.

Three key aspects of the Uberlytics approach to criticality analysis will be demonstrated in the following case studies:

- **A functional system approach instead of a discrete asset focus** allows for a more efficient process and delivers more meaningful results.
- **Inclusion of 100 percent of systems and assets** ensures identification of previously unrecognized critical assets and sub-components, often with surprising findings.
- **Flexibility to include evaluation categories important and unique to the client** results in an analysis truly reflective of the client's values and constraints.

In each case study, the Uberlytics approach and Criticality Analyzer identified previously unknown significant system risks.

The case studies presented here involve a ground water remediation site, a large municipal system, and an industrial water treatment system within a refinery. Each study had a unique set of evaluation criteria determined by the client's values and the unique performance, contractual, and regulatory issues affecting the facilities. In each case study, the Uberlytics approach and Criticality Analyzer identified previously unknown significant system risks, allowing the client to take specific action to mitigate those risks. Due to confidentiality considerations, specific names and the actual numerical data have been removed.

Case One
Ground Water Remediation System

Situation

A major refining operation in southern California includes a ground water remediation process consisting of extraction wells, a fluidized bed activated-media treatment process with filtration, and internal re-use of the treated water. This groundwater treatment process is heavily regulated and closely monitored by state regulatory agencies. The system design incorporates a small amount of excess capacity to help meet the annual target but given the annual turnaround requirements each year there is very little room for down-time outside the refinery schedule, making up-time a key performance metric.

In mid 2004 a sequence of unusual, but not extraordinary, events led to an extended shutdown, jeopardizing the ability of the system to meet the annual treatment targets before the year was half over. This placed the owner at considerable risk for regulatory actions and fines.

Because the process is relatively robust and reliable, such a situation had not been anticipated even though excellent engineering and operational management had been in place. It became clear that conventional approaches through process reviews, HAZOPs, and an aggressive maintenance program, were not adequate and the need to find the true risks in the system was paramount.

Leveraging the functional system approach rather than a discrete asset approach resulted in not only a more efficient process, but also more meaningful results.

Response

The owner's engineering staff worked to engineer out repeat future occurrences of similar events. However, they quickly found that what caused the shutdown was mostly an odd combination of circumstances and otherwise quite random and normally inconsequential failures. **In short, they could not find what to fix.**

The owner requested assistance in the evaluation of the overall process to identify the as yet hidden risks and related potential issues in order to prevent future similar and unforeseen occurrences. The Uberlytics criticality analysis approach (in development for a few years already) and an early version of Criticality Analyzer™ were brought and applied in a workshop environment where the owner's system experts including engineers and operators were brought together with a criticality analysis expert facilitator. Inclusion of 100% of the overall process units in this functional area of the refinery and inclusion of pipes and valves as a separate group asset proved essential. The registry comprised in excess of 30 main functional systems and in excess of 200 discrete main assets. Against this backdrop of a comprehensive asset registry, leveraging the functional system approach rather than a discrete asset approach resulted in not only a more efficient process, but also more meaningful results.

Given the relatively limited scope of the system as compared to a plant wide analysis, a few hours of preparation and a day of workshops accomplished an analysis of the complete remediation system, and produced remarkable and surprising results.

The owner was focused on treatment capacity concerns, but thorough analysis revealed that an important spill/ overflow requirement could easily be violated at high probability.

Results

While the owner's focus was primarily on preventing recurrence of the recent event, a full analysis of the system revealed several key aspects that led to a more comprehensive understanding of the process and associated risks. Specific improvement opportunities were identified that would immensely reduce risk with remarkably little effort and expense. Some of these are:

Final Filter – The client system experts initially suggested ignoring a treated water filter that had been merely an annoyance to them in order to save time in the analysis. The filter had been added to the process as an afterthought in order to treat minor and rare fluctuations in quality that had since been worked out. However, once analyzed, it was found that this filter posed the highest risk within the entire process. The owner representatives had been focusing on treatment capacity concerns, but thorough analysis revealed that an important spill/overflow requirement could easily be violated at high probability due to the filter. Merely addressing the failure modes or simply removing the filter from service would increase reliability of the overall process immensely. Potential losses here could reach well into the hundreds of thousands of dollars (larger investigations, cleanup, local and State fines) at a fairly high degree of probability.

Fluidizing Recirculation – The central treatment aspect in the process is a biologically active media fluidized bed reactor. Analysis revealed that many potential failures throughout the process led to the consequence of loss of fluidizing flow in the reactor, leading to congealing of the bed, which in turn required its replacement at great cost and loss of production. It was recognized that the system could be quickly, easily, and cheaply modified to provide the capability to re-circulate fluidizing flow, which would prevent congealing the bed. This one simple change, consisting of adding a short length of pipe and a valve, eliminated or significantly reduced the consequences of numerous potential failures throughout the process and eliminated a majority of the risk associated with treatment capacity and the consent decree treatment limits. Failure to meet treatment limits are fined at over $1MM per day.

Level Controls – Sometime after the process was designed and installed, an equalization tank was added at the inlet into the process. Controls were included to operate the pumps to manage the level in the tank. However, the added functions of “equalization” and the associated components had not been sufficiently evaluated in respect to the overall process. Analysis revealed many potential failures that would result in the equalization tank either going dry or overflowing. To complicate matters, an overflow, while contained, would be considered equal to an actual environmental discharge, and thus deemed unacceptable by the client (see next item). There were no backup or failure controls such as high and low alarms and interlocks installed in the tank and integrated into the process controls. Simply adding these simple controls would eliminate a large number of potential failures and significantly reduce overall system risk. Costs associated with these events range from a few thousand to tens of thousands of dollars (investigations and crew lost time).

Containment – The analysis revealed that treatment capacity, which had been the complete focus of the owner, was not the only regulatory requirement that applied or was at risk. In fact, the severity of spilling untreated or partially treated groundwater was at least as high, if not higher, than treatment capacity objectives. Analysis revealed the majority of potential failures resulted in spills and overflows, violating this regulatory requirement. When the facility was constructed, an area with a simple six inch concrete berm was used for containment. Existence of the berm was assumed to be adequate for containment. However, analysis revealed that numerous potential failures could lead to overflow of containment. By raising the berm and extending it to include the entire process, the majority of these potential failures would be eliminated or their consequences significantly reduced. Potential losses here could reach well into the hundreds of thousands of dollars (larger investigations, cleanup, local and State fines).

Summary

Not only did the Uberlytics criticality analysis approach pinpoint the issues behind the major occurrence, but it also found numerous other risks, as well as providing simple and cost effective solutions that immensely reduced the risk profile for the entire process in all risk areas. Further, what was thought to be an inconspicuous and apparently insignificant process component was actually of major importance. Conventional analysis and evaluation of what had happened failed to reveal meaningful ways to address the situation and prevent recurrence in the future. The investment effort and cost to perform criticality analysis using the methodology that Criticality Analyzer is designed to support were insignificant in comparison to the value gained.

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Case Two
Public Utility, Pacific Northwest

Situation

A public works department of a major US city decided to begin doing infrastructure asset management on their systems. They began by using their wastewater plant as a testing and development area to build integrated asset management systems and processes. The program needed to identify the criticality ranking of every system within the overall facility service area. In short, what were the weak links in the chain that would upset the client mandated 'Level of Service' to the customers and in what priority should resources in general be allocated?

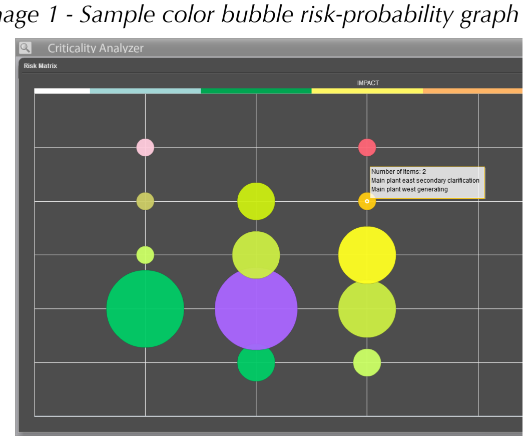
Inclusion of 100 percent of the systems and assets ensured identification of previously unrecognized critical assets and sub-components.

Response

In 2006 the work began in performing a criticality analysis using the methodology developed by Uberlytics and an early version of the Criticality Analyzer™. Central to the overall success was the flexibility of the analysis to include evaluation categories important to the local client, such as safety, environmental risk, stakeholders, as well as capacity. The result was an analysis truly reflective of the client's local values.

The treatment plant was evaluated and a hierarchy of components developed. Workshops with engineers, operations, and maintenance representatives from the city were facilitated by experts in the criticality analysis methodology that Criticality Analyzer was designed to support. The facility was broken into tens of functional systems, each designed to deliver a specific function, each comprising of hundreds of individual assets, such as pumps, MCC panels, pipe and valve collections, monitoring equipment, gas turbines, power generation, etc. This detailed approach using 100 percent coverage ensured identification of not only the critical systems but also the critical assets and sub-components in those systems to efficiently drill down to the items of concern.

Image 1 - Sample color bubble risk-probability graph



Results

The analysis yielded some surprising results in addition to the anticipated areas of risk. Accurate rankings for all equipment yielded immediate returns by prioritizing for areas like engineering evaluation, maintenance and capital investment, operational attention, etc. Efficiency and payback gains were immediate and observable. Image 1 is a sample risk-probability graph of typical analysis results. Each bubble represents a collection of systems in that risk ranking. The entire analysis is represented within all the bubbles. Position represents overall risk ranking, color represents relative risk on the iso-risk line, and size represents the number of assets in that risk ranking. Four results of note are briefly discussed.

Gas Conditioning - A recent upgrade of the cogeneration plant brought particular focus to that part of the operation. More so, given that certain financial incentives and disincentives were put in place related to its service up-time, the overall importance of this system was deemed the most critical system. Upstream of the cogeneration plant, the gas-conditioning system cleans the gas and removes moisture to provide a gas quality nearly equal to distribution line natural gas. The gas conditioning system achieved a high ranking because of its collateral damage potential. Further, it had several points of failure, many of which would inhibit or stop the flow of gas to the cogeneration plant. The lead time for the key vulnerable component was 12-16 weeks.

The financial penalties associated with a failure here were prohibitive, and merely having a shelf spare of the blower mitigated this risk.

Substation Transformer - This identified system was a surprise to all participants. The transformer had been grandfathered into the treatment plant assets long ago from the electrical utility company. It had gone unnoticed by local management, had no record of inspection or condition, was historically assumed 'outside the fence', and was in fact unrecognized as part of the electrical transmission service to the plant. This substation was actually a single power feed to the old and lower portion of the plant receiving more than 4.8 million gallons of sewage per day by gravity. Failure of this substation would potentially result in 5 million gallons per day of raw sewage to the Columbia River. To exacerbate matters, a failure of the substation would likely damage the building next door that housed the emergency backup power breaker, effectively negating the use of backup power.

Fines associated with this event could be extremely high (hundreds of thousands of dollars) in addition to the negative public perception. A simple solution was not only to monitor and maintain the transformer, but also to arrange for a 24 hour replacement unit.

Failure of a single front end loader would stop solids flow and quickly backlog the system. Vehicles had never been thought of as treatment process components.

Service Vehicle - Because the entire process and all functions of the treatment plant were included in the analysis, vehicles were included and evaluated for criticality. The analysis revealed that a single front end loader constituted multiple links in the flow of solids produced from the treatment process. Failure of the loader would stop solids flow, which would quickly backlog and impact the liquid treatment process significantly affecting effluent quality and capacity. This had not been identified as a risk area because vehicles had never been thought of as treatment process components.

The analysis revealed and quantified the requirements the loader was actually fulfilling. This provided all of the information and specifications needed to develop an alternative, which a simple advance agreement with a local rental vendor would adequately meet: a virtually no-cost mitigation to an otherwise major risk that previously had not been identified.

Telecom - Critical systems with a slightly lower risk ranking, but still surprisingly high, were main plant telecom and telephone systems due to their integration in call out and emergency response systems, and one of the main treatment process units.

The comprehensive approach to criticality analysis far surpassed the original goal by identifying serious risks that had been overlooked.

Summary

Criticality analysis, and the comprehensive approach developed, far surpassed the original goal by identifying several areas of risk that had not been previously captured or recognized. Each had the potential to seriously affect the overall mission statement of the city's utility as well as result in costly fines and political fallout. Further, each was managed with relatively simple and low cost alternatives to reduce or eliminate the risks.

To meet the original goal, the analysis provided the ranking of all facility systems by priority; necessary to enable two things. The phased implementation of the larger asset management program, and the ongoing allocation of work and resources to proceed with maximum efficiency and efficacy.

Case Three
Refinery Boiler Feed Pretreatment System

Situation

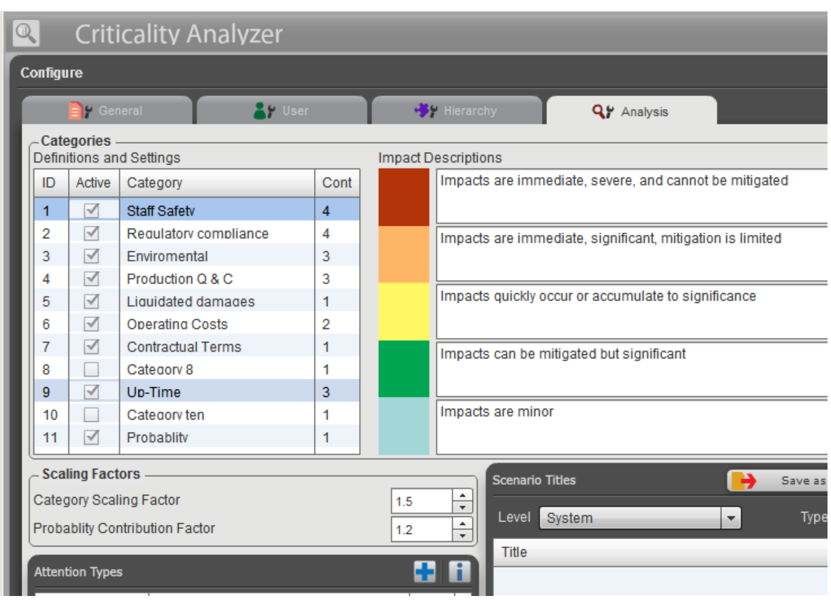
A boiler feed water pretreatment system was due for an expansion and had undergone several design reviews, two HAZOP reviews, and several construction reviews. However, given the importance of this system within the refinery operation as well as being a key part of the refinery overall water reuse initiative, the refinery elected to commission a criticality analysis on the plant boiler feed water pretreatment system. The decision to perform a criticality analysis was also based, in part, on the success of the previous review methodology. However, since the system had also undergone some annual refurbishments and after 18 years of operation was thought to be fully 'known', there were decreased expectations that any previously unidentified issues would surface. This assumption proved to be false.

The success of this analysis hinged on the flexibility to include not only areas such as safety, environmental, capacity, and up-time, but also commercial terms, liquidated damages, and contract terms.

Response

As in the previous example, the success of this analysis again hinged on the flexibility to include not only areas such as safety, environmental, capacity, and up-time, but also commercial terms, liquidated damages, and contract terms. This proved to be a truly unique analysis with results reflective of more than just a process view, revealing the unique situation this system's risk profile posed within the larger context of the client operation. See Category section of Image 2.

Image 2 - Detail from Criticality Analyzer™ analysis customizable set-up and definitions page



The same steps were conducted as above, except in this case an asset registry had previously been generated as part of a HAZOP review. The database was imported for the analysis. Again, a team comprising various client experts was assembled with a criticality analysis expert facilitator. Inclusion of 100% of the overall process units in this functional area of the refinery again proved essential, as did leveraging the functional system approach rather than a discrete asset perspective. This enabled a more efficient means of identifying the critical systems and associated assets, saving time and money.

The analysis showed that the failure of a $10K brine recharge system would bring the whole treatment facility to a full shut-down in *less than a shift with no alternative or backup.*

Results

The analysis did clarify and further define the generally known critical areas central to the overall mission. However, once again the analysis brought to the surface as yet uncovered risks inherent to the system. While the system was thought to be fully understood, neither the ranking of critical risk systems was as expected, nor was the discovery of the most critical systems. One system was a particular surprise to the investigating team and two other systems were elevated to a higher criticality than previously thought given the potential for overall system failure.

Brine System - Previous thinking had placed the highest risk on the actual softener units that had internal corrosion issues, valued at almost $1MM, which would impair capacity. However, the analysis showed that the failure of a $10K brine recharge system would bring the whole treatment facility to a full shut-down in less than a shift with no alternative or backup. This event would have a serious impact to the refinery operational cost, even possible reduction of boiler capacity, in addition to triggering contractual damages as a service provider to the refinery. The lead time to replace the system was four weeks and so any unexpected downtime of the brine system would have been clearly unacceptable. The potential cost of the risk was hundreds of times that of the brine pump system cost.

As a consequence the pump system was evaluated for condition and severity of service load. The decision was made quickly to replace the pump with a new and more robust one.

Waste Lines Blockage – The waste lines had always been assumed a secondary consideration of the system as they were operated at low or ambient pressure, and thus had little attention focused on them. However, given the system configuration it was discovered that any potential blockage, via several mechanisms, outside the operational boundary area would result in a serious process upset and possible blowout of the main RO units, in addition to fouling of the membranes. Aside from the cost to repair and clean the membranes, the down time would be unacceptable to the refinery. The solution was again simple and inexpensive - enhanced monitoring and inexpensive relief valves - compared to the potential cost of the risk (over $100K).

Plant Air – A system that often went unnoticed, especially just outside the battery limit of the process unit, was the plant compressed air supply. Several of the key water conditioning and support backwash and cleaning operations are controlled by air operated valves. Even partial failure of the air system via low pressure in this system could again severely impair the operation of the overall system, even to complete process failure. Once again the solution to reduce the risk profile was low cost versus the risk of a shut down, simply by adding additional inspection to the rounds and a simple pressure alarm.

Summary

Even though the system and its associated risks were thought to be fully understood, inclusion of contractual and commercial evaluation parameters highlighted the relationship between process and commercial risks that had previously gone unnoticed. A true cost could then be assigned to those risks for a more comprehensive business risk evaluation. As part of the exercise, it was also easy to identify low cost and tangible solutions to mitigate those risks at a fraction of the risk cost, significantly reducing the cost to maintain, efficiently targeting capital and maintenance dollars.

Conclusion

It is clear from these three sample case studies where this methodology has been applied, that a carefully planned and well executed criticality analysis has tremendous benefits. The Uberlytics approach to criticality analysis consistently identifies previously undiscovered system risks. The Criticality Analyzer™ is a sophisticated and invaluable decision making software tool specifically and uniquely designed to deliver those specific analysis tools to your facility's management. In today's economic climate, far more than pen and paper, or even an Excel spread sheet, is needed to effectively and efficiently meet the objectives of any serious comprehensive asset management and capital planning/implementation program. A sophisticated yet efficient approach is required to identify hidden risks in a cost effective way that also lends itself to solution identification. The Uberlytics approach consistently meets and exceeds that objective.

Ignorance of risk is not absence of risk.

We look forward to assisting you in your upcoming criticality analysis. Uberlytics will help you capture those as yet unidentified system risks.

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__Tacoma Zach__, P.Eng (Ontario and Alberta) is a Certified Reliability Leader ™ and CEO of Uberlytics, experts in criticality analysis. With over two decades in operations under his belt, he now helps organizations discover what's most critical to their mission and use that information to optimize their asset management.
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