FALCONEER Solution

1.**Solutions for Information Overload from Process Control Systems:**
Engineers and operators today have access to enormous amounts of information from their control systems. In most cases, they experience information overload or just don't have the time and resources to use all of this information effectively, if at all. Specifically, the control systems and data historians of today's plants generate enormous quantities of data from the process instrumentation that needs to be interpreted at multiple levels within an organization. At the lowest level this raw sensor data is used to directly operate and control the given process in a plant. At the higher levels, this information is used to monitor operations so that they can be optimized at the overall highest or enterprise level. Ultimately, the reasons for collecting and analyzing this information are to improve the plant's profitability and safety.

Young engineers coming into the industry need to be exposed to and to develop the skills and tools to work effectively in this environment. A critical responsibility for new engineers and plant engineers is daily operations assessment, planning, adjustment and, too often, troubleshooting or “fire fighting”. Information overload is also often a routine experience that goes with this responsibility.

Falconeer offers a a continuous performance monitor system that can help to assess the performance within a plant in real-time identifying areas (instrumentation, control loops, equipment, unit operations, etc.) that are both underperforming and performing properly essentially sifting through the information overload to find the business “gems” or benefits. The key benefits of a performance monitoring system are a more efficient plant, improved reliability & safety, and increased profitability. The most immediate benefit comes from predictive and preventative actions based on performance monitoring results. Identifying non-optimal conditions as they begin to occur or faults and failures as they are about to happen will allow for rapid corrective

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2.A statistical process control (SPC) based package for improving plants (Ex: chemical process plants) which run on continuous process.
Statistical Process Control (SPC) is a tool used to assess whether a process is currently under or out of control. Various techniques exist for doing this analysis depending upon the nature of the process being monitored. In continuous processes (as opposed to the manufacture of discrete, individual units), process data collected at a particular moment in time is not completely independent of its previous data. This is especially applicable for chemical process plants, water /waste water treatment plants , paper and pulp manufacturing plants. This phenomenon is referred to as auto-correlation

between the data. SPC techniques for continuous single point samples that handle auto-correlation in the data include Cumulative-Sum (CUSUM) as well as EWMA. These techniques can better handle the effects of auto-correlation and allow small but statistically significant shifts in an observed variable's value to be readily detected. With this process monitoring suite, the EWMA calculation is the preferred method because of its ability to not only monitor current process operations but to forecast where the process is headed.

3.Package for generation of realistic alarm by providing better fault detection :

The process condition monitoring system provided by Falconeer demonstrated in a couple of installations that when the sensors are reading properly and are validated, real swings or disturbances in the process can be tolerated by this software and will not trigger failure or fault detection alarms - just out of control alerts or alarms as should be expected.

4.Cost reduction- Reducing operational expenditure: The package contributes in two ways to effect operations cost reduction.

a.Capturing process knowledge to reduce operational expenditure: One of the intended cost benefits of increased automation is the resultant ability to reduce manpower. An often overlooked loss that is difficult to value is the loss of process knowledge and experience that this cost “savings” generates. The software design helps to minimize this loss by providing a means to capture and document process knowledge. This knowledge is contained within the customized user's guide and within the readily retrievable Access, MSDE2000 or SQL database. Since the beginning of development and implementation of FALCONEER at FMC, the number of process/production support personnel decreased by about 50%, in part due to advanced automation and in part due to cost reduction initiatives, and with that all the combined knowledge (operators, process/mfg/control engineers & maintenance engineers) of the process. The plant remains well controlled with higher productivity due to the increased automation while capturing the otherwise lost process knowledge and information.

b.Cost reduction due to reduced plant down time: The package provides an opportunity cost to improve reliability/reduce downtime: In one of the installations, for a 14-month period during which information was provided, the total unscheduled downtime at the plant for the monitored process was over 500 Hours. It was estimated that the unscheduled downtime issues that may have been potentially predicted by this process monitoring & alerting software accounted for about half the total downtime. Therefore, the potential cost savings by early detection of the sensor failures, equipment failures and/or control issues and preventing or eliminating the

unscheduled downtime (by coordinating the required maintenance with scheduled outages) is estimated to be **several hundred thousand dollars.** This value also does not include the cost of the waste material associated with start-up or general process operation, which was estimated to **be tens of thousands of dollars,** nor does it include process inefficiencies (energy, raw material usage, etc.) from non-optimal process control associated with startup or general process operation. By predicting just **15%-20%** of the causes with enough time for the operators, engineers, or maintenance workers to take corrective action, would realize a **PAYBACK of 1 to 2 years** using this software tool investment. The payback would be even better if the plant had been at capacity production levels or a higher percentage of diagnostics were correctly acted upon in a timely fashion.

5.REAL-TIME AUTO-GENERATING PROCESS MONITORING SUITE

FALCONEER Technologies FALCONEERTM IV Real-Time Process Monitoring Suite (FALCONEER) includes sensor and process condition validation, continuous statistical process control monitoring, and predictive fault analysis. This software suite thus provides a single source means for complete, high level monitoring and analyzing all manufacturing & environmental process data in real time to predict future process performance and optimize current process performance to help improve reliability, yield and quality, avoid failures and accidents, and reduce costs. A patent-pending innovation designed into this technology is the ability to be essentially self-creating and self-maintaining. This feature significantly reduces the cost, time, and resource commitment to implement and to maintain.

The Process Monitoring Suite consists of several software modules with display screens. These include the State Identification **(State ID)** module, the **S**ensor **V**alidation and **P**redictive **F**ault Analysis **(SV&PFA)** module, the Virtual **S**tatistical **P**rocess **C**ontrol **(VSPC)** module and a configuration interface. This application can operate as a standalone system or run as Web service with alarm screens and information screens as Web clients with the capability of OPC messaging to notify pagers, cell phones, etc. Below is a summary of the purpose and operation of the different modules that add intelligence to the control systems and instrumentation.

A.**State ID:** The software program first determines whether the process is operating within standard conditions or not. This is accomplished with the State Identification (State ID) Module. FALCONEER is idle if the process is not operating. The program begins its analysis of sensor measurements once startup is complete. It continues this analysis until the process is shutdown and then is idle again until the next startup completes. The process condition monitoring suite thus runs continuously and adjusts its analysis to current process operations accordingly.

State ID variables are any sensor measurements used by the program to determine if the process is running. These variables tend to monitor either key process feeds or process configuration states. They generate green alerts (used to denote normal operation) when the process is operating and each of these variables is either within its associated standard operating conditions (SOC's) or its normal state. If outside their SOC's but within their interlock limits, these variables generate yellow alerts. In either case, the program status is “In Production Mode” and “Not Expecting Interlocks”. If outside their interlock limits or normal configuration, these variables generate red alerts and the rest of FALCONEER's analysis is preempted. In this situation the program status becomes “Not in Production Mode” and “Interlock Expected”. It stays in this mode until the next startup is completed.

B. **SV&PFA: The Sensor Validation and Predictive Fault Analysis (SV&PFA) and alarm management:** The software module monitors current process sensor measurements to determine if they are either valid or incorrect. It also determines if certain processing faults (leaks, pump failures, controller malfunctions, etc.) are occurring or not. It does this by evaluating engineering models that describe normal process operation. Briefly, when the process system is operating normally (i.e., fault free), the engineering models describing normal process operation should all close. When they don't this is evidence that something is going wrong in the process system. By looking at the patterns of all this evidence it is possible to infer the underlying fault(s) in the process that could cause such behavior. These results are then given as alerts to the users. If not found to be faulty, the sensor measurements are considered validated (i.e., trustworthy).

It is very common that the SV&PFA module reports more than one plausible fault at the same time, i.e., many alerts occur simultaneously. This is referred to as the diagnostic resolution of the analysis. In those cases all alerts need to be checked out further to identify the actual process problem occurring. In other words, although each alert given is a plausible explanation of the current process situation, it still needs to be verified as actually occurring or not by the user. Thus, alerts are meant to identify all the possible operating problems that can explain the process behavior currently being encountered. These alerts are continuously updated as process conditions warrant.

Besides determining single fault alerts, the SV&PFA module also determines many plausible pairs of fault hypotheses, i.e., multiple faults. However, this is not an exhaustive list of all plausible multiple faults. Furthermore, just like single fault alerts, multiple fault alerts also need to be further confirmed by the process operator. Since in reality multiple faults tend to occur much less frequently than single faults, single fault

alerts should always be fully checked out prior to checking out the multiple fault alerts.

The evidence determined by evaluating the engineering models is combined together using a Fuzzy Logic calculation. This calculation determines a certainty factor associated with each fault hypothesis. These certainty factors can range from 0 (at least some evidence does not support that fault hypothesis) to 1.0 (that fault hypothesis is a highly plausible explanation of the current process behavior). Alarm generation and display components are used to flag alerts to the users. The package has a **comprehensive alarm management** system linked to analysis modules for generating appropriate alarms based on the alerts generated. Appropriate alerts are given if these certainty factors exceed the chosen alert thresholds as described below.

Alerts are given priority by this module according to the following color scheme. If the certainty factor associated with the fault hypothesis is greater than 0.97, a red alert (highest priority alarm managed by alarm management system) is given. In this case process conditions are definitely abnormal and it is highly likely that this process fault may actually be occurring. If the certainty factor is less than 0.97 but greater than 0.92, a yellow alert (warning or caution) is given. This indicates that process operations are no longer considered to be normal and the identified fault may be the reason why. Else a green alert (validation) is given. These alerts indicate that the corresponding variable is valid (i.e., either the indicated sensor measurement is correct or the assumed value for an unmeasured variable is correct). These threshold values, which are configurable, were chosen to be highly certain that those associated alerts are real. They make the SV&PFA module results conservative by not alerting until process conditions are well outside their normal operating ranges. The SV&PFA module should thus give few false alarms.

C**: VSPC:** The **V**irtual **S**tatistical **P**rocess **C**ontrol (**VSPC**) software module augments the SV&PFA module, providing an independent but complementary analysis of sensor measurements. The VSPC module uses Exponentially Weighted Moving Averages (EWMA's) to determine in real-time if individual process sensors and process conditions are in control, are going out of control, or are definitely out of control. It directly flags out of control sensors and process conditions in real-time rather than after-the-fact. These alerts can also occur at levels that may allow the process operators to take appropriate control actions to reduce or eliminate disruptions to process operations or product quality. This method is considered virtual because the analysis is done automatically without the need for the operators to collect and chart any process sensor readings.

Statistical Process Control (SPC) is a tool used to assess whether a process is currently under or out of control. Various techniques exist for doing this analysis depending upon the nature of the process being monitored. In continuous processes (as opposed to the manufacture of discrete, individual units), process data collected at a particular moment in time is not completely independent of its previous data. This phenomenon is referred to as auto-correlation between the data. SPC techniques for continuous single point samples that handle auto-correlation in the data include Cumulative-Sum (CUSUM) as well as EWMA. These techniques can better handle the effects of auto-correlation and allow small but statistically significant shifts in an observed variable's value to be readily detected. With this process monitoring suite, the EWMA calculation is the preferred method because of its ability to not only monitor current process operations but to forecast where the process is headed. There are two classes of sensor variables that can be used by this module: sensors that are being directly controlled and those that are not.
Since this analysis is based solely on statistical calculations, false alarms are possible. Measurements may be identified as out of control and then rapidly determined to be in control once again. Such spurious alerts can be minimized by choosing update times for the analysis that are close to one time constant for the process being monitored. However, they cannot be totally eliminated. Therefore, VSPC alerts also need to be further confirmed by the users before any _____

6.Package ensues quality data to asset management software: Many maintenance and asset management initiatives are driving instrumentation self-diagnostics and equipment condition monitoring investments, both hardware and software. These solutions are inherently designed to perform at the lowest level, i.e. the individual sensor or equipment level. These include Hart Diagnostics, Foundation Fieldbus and Prefabs, Smart Sensor Technology, and software such as Emerson's AMS. However, these solutions can be very expensive for processes with an existing installed base of instrumentation that does not have access to these new diagnostic technologies. There are also large gaps in these low-level diagnostic capabilities. The new diagnostic solutions only cover about a fifth to a third of potential faults, failures, or abnormal situations.

FALCONEER™ IV addresses these cost and capability gaps with its high level, process centered approach and design.

- Our validation & fault diagnostic technology is based on a combination of models that are already being used to design and operate the process, i.e. unimpeachable sources of plant knowledge.

- We couple this model-based approach with normal plant operations obtained from any control system data historian. This combination allows for detection of

any and all deviations from normal, rather than only those deviations that have already been identified and built into the diagnostics. We don't have to “learn” or “train” like the other model-based approaches. It's all built into how our patent-pending diagnostic methodology works.

Compared to other approaches, ours is more fundamental with easily configurable and understandable equations and logic, according to FMC. A former Foxboro manager appreciates our approach as: ***being rigorous enough to identify the problems without being too complex or expensive, combined with being easy enough to configure and maintain.*** Basically, our approach only requires the existing process =knowledge about normal operation (in the form of equations and models) and simple statistical analysis of normal operating data. Our program automatically generates additional diagnostic models, all possible single and multiple fault rules and virtual control charts. This feature greatly reduces the configuration and startup time and any on-going maintenance requirements, making this patent-pending technology essentially autogenerating and self-maintaining.