Profitable Safety – Improving Real Time Operational Safety to Jumpstart the Profit Engine

by Peter Martin and Steve Elliott

Executive summary

Traditionally safety and profitability have appeared to be diametrically opposed concepts for many manufacturing and production operations. Since the primary objective for a manufacturing or production business is to drive profitability, protecting the safety of the plant's people, assets and environment have often been viewed as somewhat necessary evils. As such, industrial EH&S teams have typically been viewed as adjunct organizations that are not part of the mainstream business. And that has made their job more and unnecessarily challenging. It is a bold idea to go in a different direction? Not with new state-of-the-art control theory.

It is now understood that the safety of the operation can have a direct, positive impact on the operational profitability of the plant. EH&S can now be viewed not just as a cost center, but as a profit center, and new levels of both safety and profitability can result.

Real-time safe profitability is no longer a dream—it is a reality!

Real-time profita-ble safety

1. Background

Safety of people, equipment, facilities and the environment is becoming increasingly important in industrial operations. This is not just because of highly publicized accidents or even for altruistic reasons. Rather, it has become evident that the safety of an operation is directly linked to profitability of the operation. Although industrial executives are always very concerned about the safety of their operations, the potential for increased operational profitability that can be realized through more effective safety management is really starting to turn heads, and it is truly bringing safety and environmental integrity into the mainstream of industrial business processes.

For decades industrial professionals have recognized that the cost of unexpected events, such as fires and explosions, can be very high in terms, resulting in injury, death, equipment damage, facility damage, environmental damage, business interruption, and skyrocketing insurance premiums. Industry has responded to this by implementing functional safety programs, such as installing safety-instrumented systems that detect pending unsafe conditions and automatically take the corrective actions. These systems have helped effectively avoid predefined unsafe events and are a huge step forward. But avoiding the costs of unexpected events is just a small piece of the overall potential operational profitability improvements an effective safety control solution can produce.

Because all executives have a keen interest in profitability, they are almost always willing to invest in approaches that measurably improve financial performance. What might not be totally clear to them is the impact functional safety control can have on operational profitability, even in the absence of costly events. It has often been difficult for Environmental, Health and Safety (EH&S) leaders to get funding for the capital projects they propose because the "payback" is not obvious, even though the ROI for a systematic approach to operational safety management and control can be huge. Industry needs to think differently about measuring and improving the safety of their operations to show that safety can be a profit center, not a cost center.

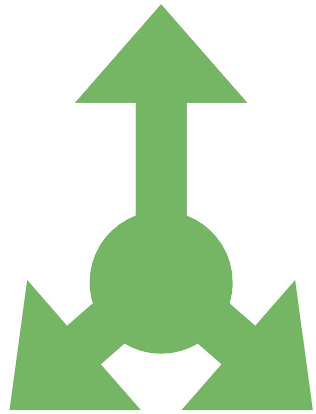
2. Real-time variability and profitability

In order to fully understand the impact of safety on profitability it is important to first recognize a key business driving force that is currently impacting industrial operations. This driving force is the transition from the highly stable business variables over long time periods to the frequently fluctuating business variables of today. This transition is having a huge impact on the profitability of even well-run operations as the business of industry has started to experience dynamic fluctuations that are almost as "real time" as those of production processes. For example, with the opening of competition on the power grids, electricity prices, which had been constant for months on end just a few years ago, have started to change every 15 minutes in the U.S. and even more frequently in other countries. This has had a domino effect on other business variables, such as other energy prices, feedstock prices, and even the production value of the products being produced. Industrial companies have become used to measuring and reporting their key business variables on a monthly basis, which appeared to be reasonable when those variables did not change within monthly boundaries. Today, companies that measure these variables monthly, weekly, daily, or even hourly will find themselves in a situation in which the profitability of their business is out of control even when their plant operations are in control.

Not all components of profitability are experiencing real-time fluctuation. For example, labor cost still tends to be fairly stable over a monthly time period. But a number of key components of the profitability of an operation, such as production value, energy cost, and material cost, are fluctuating more frequently with time. These three variables can be considered the real-time components of profitability (**Figure 1**). The primary object would be to maximize the production value of the operations while simultaneously reducing the energy and material costs by as much as possible.

Figure 1

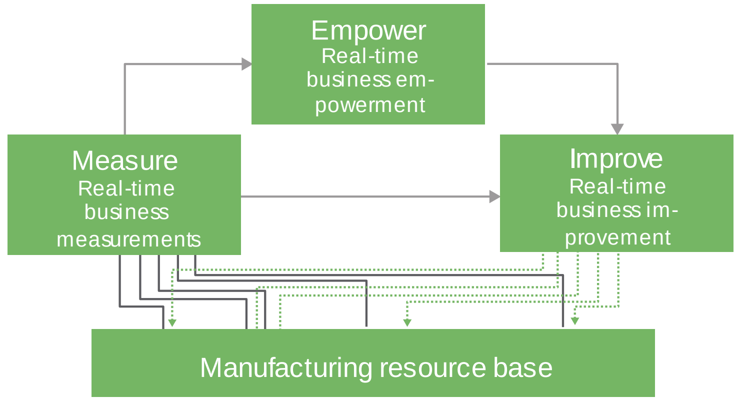
Real-time profit control.



Balancing these three variables to continually maximize the profitability of the operation is a fairly classic control problem, which is why it is referred to as real-time profit control. To solve such a control problem requires a classic control approach. In this instance the application of a simple feedback control loop to the real-time profitability variables is an effective starting point (**Figure 2**). The first component of the loop is measuring the business variables in real time. Schneider Electric has developed a patented approach called Dynamic Performance Measures to model the measurements of these variables from process sensor data in real time. Once the variables are measured in the necessary time frame the resulting information can be provided to the operator who impacts the business variable through a scorecard or dashboard. This is the empowerment component of the loop. Empowering profit-impacting operational personnel in this manner enables them to make better decisions that drive profitability. This essentially provides a manual control strategy for profitability. Experience has shown that over time even front-line operators with moderate education levels learn to drive significant profitability improvement. The third component of the loop is the ongoing improvements that can be implemented to incrementally improve the profitability of the operation, such as changing fuels or optimizing set points. Using this approach on each of the real-time business variables can start to bring those variables under control and help drive profitability improvements.

Figure 2

Real-time profitability control loop.



3. The impact of safety on real-time profitability

The vector diagram representing real-time profitability is incomplete. There are constraints on the profitability that limit the length of the vectors and the overall profitability of the process. For example, the installed manufacturing equipment itself will provide some limits, such as the capacity of a pump, the size of a vessel or pipe, and the efficiency of a unit. Most of those constraints are fairly easy to identify and are fixed. But there is one constraint, made up of multiple constraint functions, that tends to fluctuate in real time in a similar manner as real-time profitability. That constraint is safety (people, process, environmental). The actual real-time profitability model should include the safety constraint (**Figure 3**). This model clearly shows the tight relationship between operational safety and real-time profitability.

Figure 3

Constrained real-time profitability model

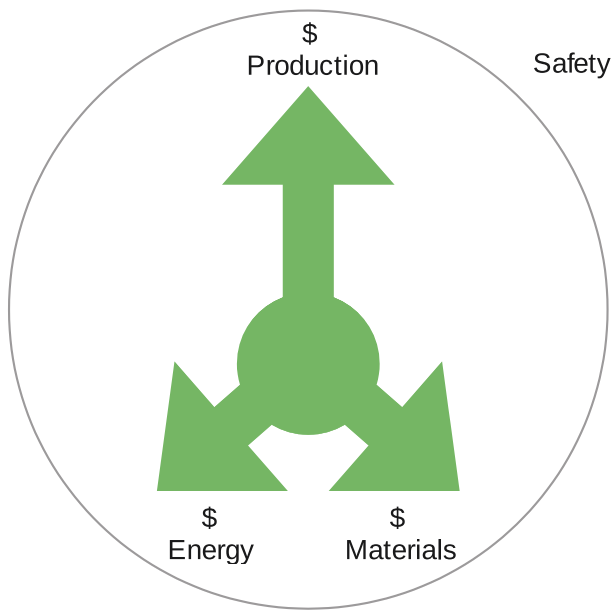
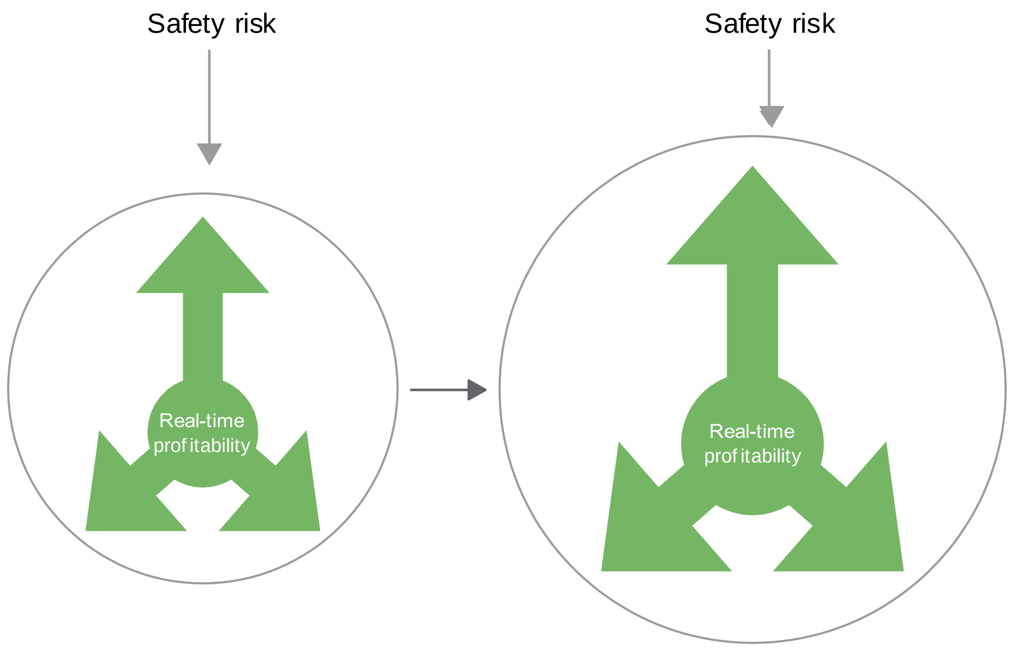


Figure 4 attempts to demonstrate the relationship between the safety constraint and the real-time profitability of an industrial operation. If the real-time profitability model on the left represents the current operation of the plant, it is clear that the current profitability is constrained by the current safety risk. In other words, for the plant operations staff to improve the profitability they would significantly increase the safety risk to unacceptable levels. On the other hand, if the safety risk constraint could be opened up a bit, then the profitability could be improved within acceptable safety limits. This, of course, is assuming that other fixed constraints, such as equipment constraints, are not more constraining than safety. The key to being able to improve the profitability of the operations, therefore, is the opening of the safety constraint on the profitability.

Figure 4

Impact of real-time profitable safety.



Since some of the critical components of safety fluctuate in real time they present a similar control problem to that of profitability. Once these components can be effectively measured in an ongoing real-time manner the appropriate control approach, whether automatic or manual, can be implemented. The challenge is measuring safety risk in a manner that will enable the control system to be developed. Before looking into an effective way to measure safety risk, it might be important to pause and use the constrained vector model to demonstrate the relationship between real-time safety and real-time profitability.

4. Opening the safety constraint

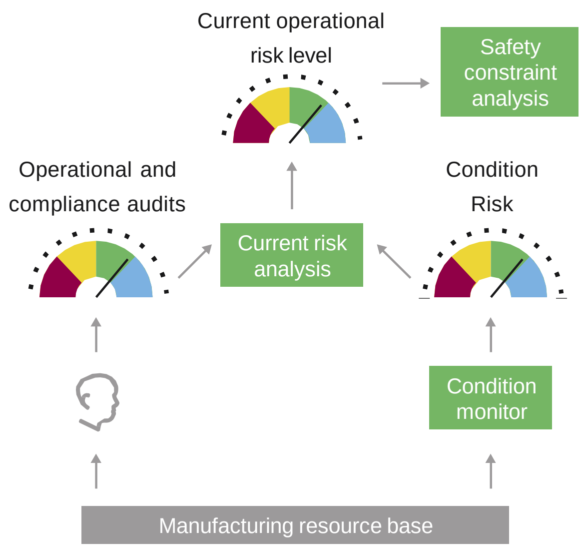
The key to being able to determine where the safety constraint truly is and how to free it up is to accurately measure the safety risk of a piece of equipment, process unit, plant area, or plant in a real-time, continuous manner. With ongoing real-time measures of safety risk, plant operators can determine how hard they can safely drive the plant. Today, without an accurate measure of real-time safety risk, it is typically assumed to be at some level that has been established through engineering analysis, often done years ago, and is typically based on a worst-case scenario. This means that the risk is assumed to be worse than it really is and that the assumed risk imposes tighter constraints on the process and profitability than truly exists. This assumed risk tends to reduce profitability well below the actual safe potential. Even worse, without the real-time safety risk measures, when circumstances around the operation combine to increase the safety risk, that increased risk often goes unnoticed. This results in not only a less profitable operation, but also a less safe operation.

The challenge therefore is the development of continuous, real-time safety risk measures. This can be accomplished by developing a dual view of safety risk and combining this dual view into composite safety risk measures. The first view of safety risk, operational, and compliance safety risk, involves following the processes and procedures with respect to inspections, audits, and reviews determined during the design of the plant. These audits should be accomplished on a defined schedule to ensure that the operational and compliance risks are as low as possible. History has demonstrated that operations that follow the compliance audits judiciously tend to have much lower safety risk.

Unfortunately, following the operational and compliance procedures with great rigor does not eliminate the safety risk. Unexpected events and conditions that cannot be discerned during an inspection can develop and drive up safety risk. Therefore the second view of safety risk involves online condition monitoring and measuring. This is referred to as the conditional safety risk. The information necessary to discern increases in the probability of an unexpected, unsafe event should be readily available for any plant with a reasonable operational history. The aspects of the conditions that might lead to an event can be monitored to detect any suspicious changes. Automatic workflows can be triggered that further assess the situation, increase the conditional safety risk measure according to the probability and severity of a potential event, and advise the operating personnel.

Figure 5

Impact of real-time profitable safety.



Since having two separate safety risk views and corresponding measures increases the operational difficulty of assessing the actual safety risk and could lead to confusion, a composite safety risk measure for the operation should be developed. This composite

measure should take the operational and compliance safety risk measure and conditional safety risk measure as inputs (Figure 5) and perform appropriate analytics on the two measures to establish the actual current safety risk. Clearly, the composite measure should be heavily weighted to the higher of the two input safety risk components. It might be easy to merely take the higher of the two component risk factors, but this approach may be too simplistic for complex production operations.

Some operations will require an analysis of both component measures against each other to develop the composite safety risk measure of the operation. With this real-time safety risk factor for every operation in the plant and for the plant as a whole, the operating personnel can make decisions that improve plant profitability while understanding the impact of their decisions on the safety risk in the plant.

5. Real-time safety risk control

Applying feedback control to safety risk can be accomplished by utilizing the control model of **Figure 3** for the composite safety risk measurement. For operational and compliance safety risk issues the controls can be applied by keeping the operational safety risk measurement visible to the leaders of the EH&S team responsible for the safety compliance audits and, if significant violations of expected processes are encountered, automatically notifying plant management of any violations. Automatically triggered workflows can also be developed in the system that trigger workflows to notify and guide the compliance processes and to keep management in the loop both when the processes are correctly followed and when there may be an issue. This level of feedback sets up a manually operational and compliance safety risk control system that will certainly help in reducing the safety risk of a plant.

A similar approach can be taken to the conditional safety risk of the operation, although conditional risk is typically less dependent on human processes than it is on unexpected failures and other unanticipated events. For the conditional safety risk a predictive conditional safety system can be developed using automatic workflow to monitor for a potential safety condition, identify the condition, and take the appropriate corrective action. All three components of this conditional safety risk control system can be set up for automatic operation. Setting up the correct safety conditions monitor involves a detailed understanding of the history of operation of the plant and of other similar plants. A team must analyze the historical data to identify the lead indicators of an unexpected event and must set up the safety condition monitor to trigger from these lead indicators. The safety condition identification function must be set up to monitor combinations of factors to try to focus on the potential unsafe conditions that may be triggering the indicator. The corrective action function must be set up to take various corrective actions based on the circumstances identified for the potential event. This is not unlike the approach to safety taken with traditional batch service logic for decades, but this perspective must be taken for the plant as a whole. One other consideration that is also similar to batch service logic is that the identified condition may need to be contextualized to the operating state of the plant in order to truly determine the potential situation's significance.

Once a control system is developed to effectively control the safety risks within the other process constraints, a similar approach to controlling the real-time profitability of the operation can be employed.

6. Real-time profitability control

Loosening the safety constraints on a production operation does not, by itself, lead to increased profitability. It merely means that there could be potential to increase profitability safely. Actually driving increased profitability requires the application of control theory to the three vectors of the real-time profitability model presented in **Figure 1**. As displayed in **Figure 2**, this can be accomplished through a manual feedback control system based on prioritized operator score card showing the real-time business variables. As the operators perform the traditional actions expected, such as changing set points, managing alarm conditions, and activating advanced control strategies, they can monitor the impact that the changes are having on the key business measures presented on the dashboard. Over time the operators will learn how their actions impact the real-time profitability of the operation and can tune their actions to maximize the profitability. When this is accomplished, specific improvement actions may be considered for the operation, such as the implementation of advanced control strategies that might further drive the profitability of the operation. Since the impact on the operation of these incremental improvement activities is visible to the operations staff, they will be less likely to turn them off if they are actually having the desired impact.

The issue of tying the safety risk measure and the profitability controls together is, at least initially, as simple as providing a real-time safety risk indicator on the operation dashboard. This visible real-time safety risk value will provide immediate feedback to the operators of the increased or reduced safety risk resulting from an action, enabling the operators to take appropriate profitability improving actions while also mediating the safety risk to the operation. In a sense, simultaneously balancing safety risk, production value, energy cost, and material cost is tantamount to solving a multiple-objective optimization problem. Mathematically solving this type of problem is very challenging and time consuming, but experience has demonstrated that an operator with a moderate educational level and reasonable experience can learn to solve such a problem quite effectively over time.

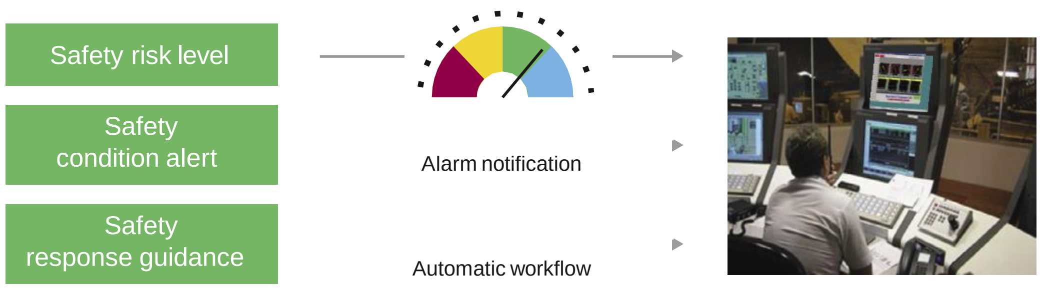


Figure 6

Profitable safety control.

Over time, with enough experience and historical information about the relationships between the safety risk and profitability of an operation, the relationships between the critical variables may be able to be quantified and modeled. Once this is possible, automatic control models and algorithms for the operation may be able to be developed for the automatic safe control of real-time profitability. This is certainly a future challenge. The manual control and optimization systems prescribed herein should be able to help production companies experience a considerable portion of the potential profitability improvements that can be realized in their operations while also creating a safer operational condition for the plant and the environment.

About the author

Dr. Peter Martin is a recognized leader and innovator in automation and control. He has been a practitioner in the field for over 37 years; has authored three books, coauthored two, and been a contributing author for three more; and has published dozens of articles and papers in these disciplines. He holds or has pending multiple patents in the areas of real-time business measurement and control. He was recognized by Fortune as a Hero of U.S. Manufacturing, by InTech as one of the Fifty Most Influential Innovators in Control, and by Control as a member of the Automation Hall of Fame; he has also received ISA's Life Achievement Award. Peter Martin has a B.A. and an M.S. in Mathematics, an M.A. in Administration and Management, and a Ph.D. in Industrial Engineering, as well as a Master's and a Doctorate in Biblical studies.

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- Igniting the Industrial Profit Engine – White Paper
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