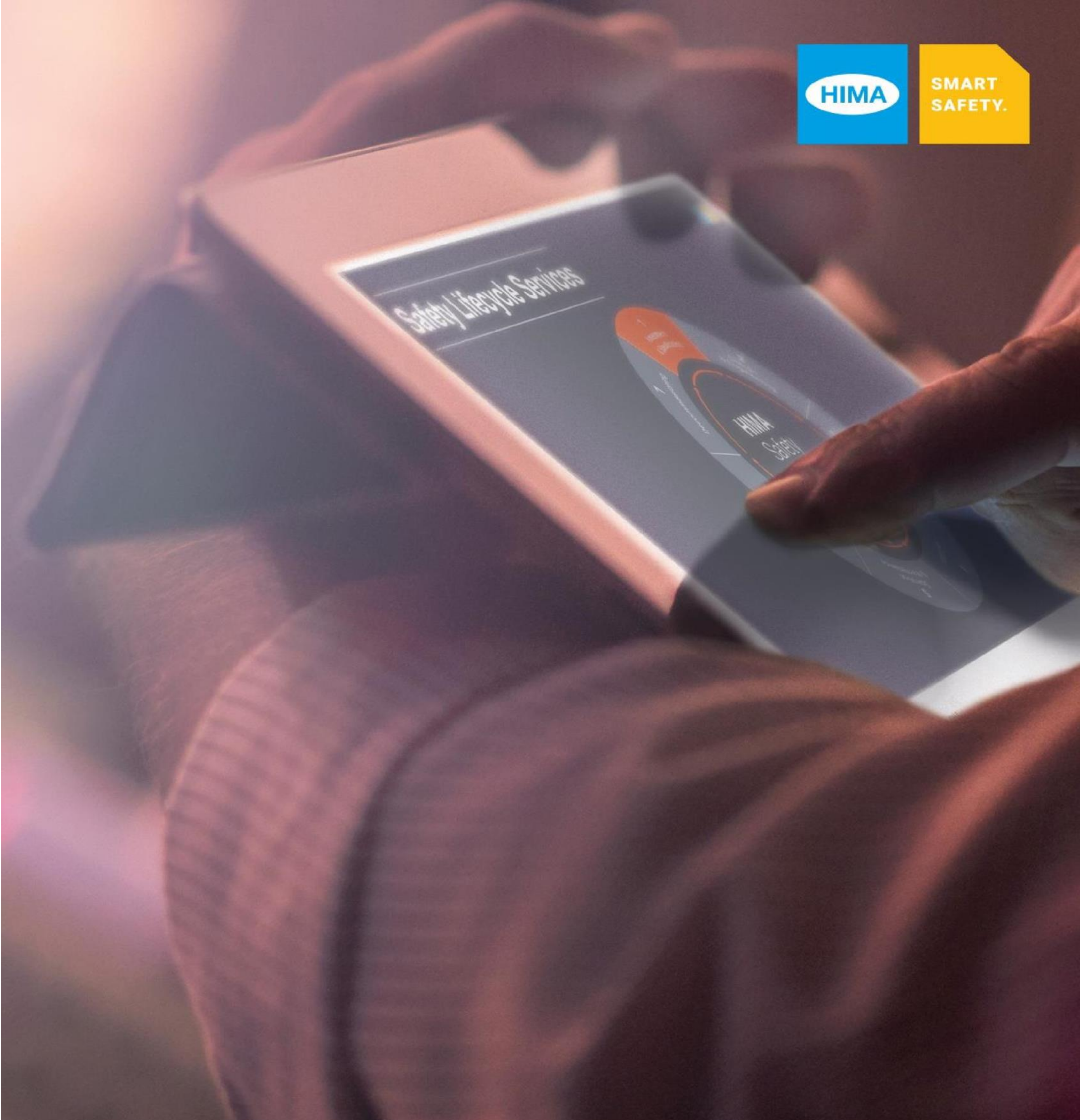

Justifying Investment in a Safety Lifecycle Management SLM® Platform

Safety Lifecycle Manager

Conformance to IEC61511

MANGAN Software Solutions

MANGAN
Software Solutions

Justifying Investment in a Safety Lifecycle Management (SLM) Platform

SLM®
Safety Lifecycle Manager

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1 Introduction

You have seen the SLM® demonstration and are impressed. Every process safety, safety engineering and operations challenge that you threw at the demonstration team has been answered. The software has a well-designed and user friendly solution for every problem except one: How do you sell this to your management? Your management has limited funds available. The decision to purchase SLM® competes with other priorities such as installing a new pump or replacing that corroded piping. You know you need this software and that it would save a lot of time and money, but how do you communicate that?

This paper discusses how safety lifecycle software purchases may be effectively justified to your senior management through both business and safety case studies from actual customer experiences. Your numbers will likely differ from the numbers used in these case studies, but this paper should help you understand where to look.

What economists and sociologists call the Principal-Agent Problem occurs when an agent is expected to be working for his principal's best interests but is in fact working for his own. This occurs when the principals' and the agents' incentives are not fully aligned.

For process industries, process safety principals include the managers and executives who are responsible for process safety performance and their agents are the many engineers, technicians, contractors, operators and others who are expected to manage risks. Agents may be disincentivized to adequately managed risks because their bonuses are rewarded based on conflicting performance standards such as keeping costs low or meeting production targets. One of the primary reasons for the incentive gap is that project cost and schedule and production rates are easy to measure and incentivize but risk management is not. You can control only what you can measure.

Mangan SLM® equips process safety principals to resolve the Principal-Agent Problem by making process risk information visible so they can correct incentive misalignment between themselves and their agents and to progress from “I think I am safe” to “I know I am safe”.

Another central SLM® concept is to provide leading risk indicators such as overdue testing or the increased use of bypasses so that organizations can easily recognize when risks are increasing and take action before an incident occurs. SLM® collects such information automatically and makes it easily accessible and understood.

Depending on your business needs, SLM® offers benefits in the following focus areas:

- Cost savings from instant access to Process Safety Information (PSI)
- Risk Analysis Solutions
- Assuring Adequate Protection Layers are installed
- Preventing Systematic Errors
- Keeping protective layers online
- Capital Project Execution

This document will outline the business justification for each of these key focus areas.

2 Cost Savings from Instant Access to Process Safety Information

Overview:

Accessing Process Safety Information (PSI) (PHA/LOPA/SIS/IPL) within the SLM® platform drastically reduces the amount of time it takes to secure necessary and relevant information. According to one evaluation conducted by a major operating company, use of the platform achieved a 92% reduction in duration of information searches. With Process Safety Information interconnected between the SLM® platform's modules, information is easily accessible, evergreen and relevant.

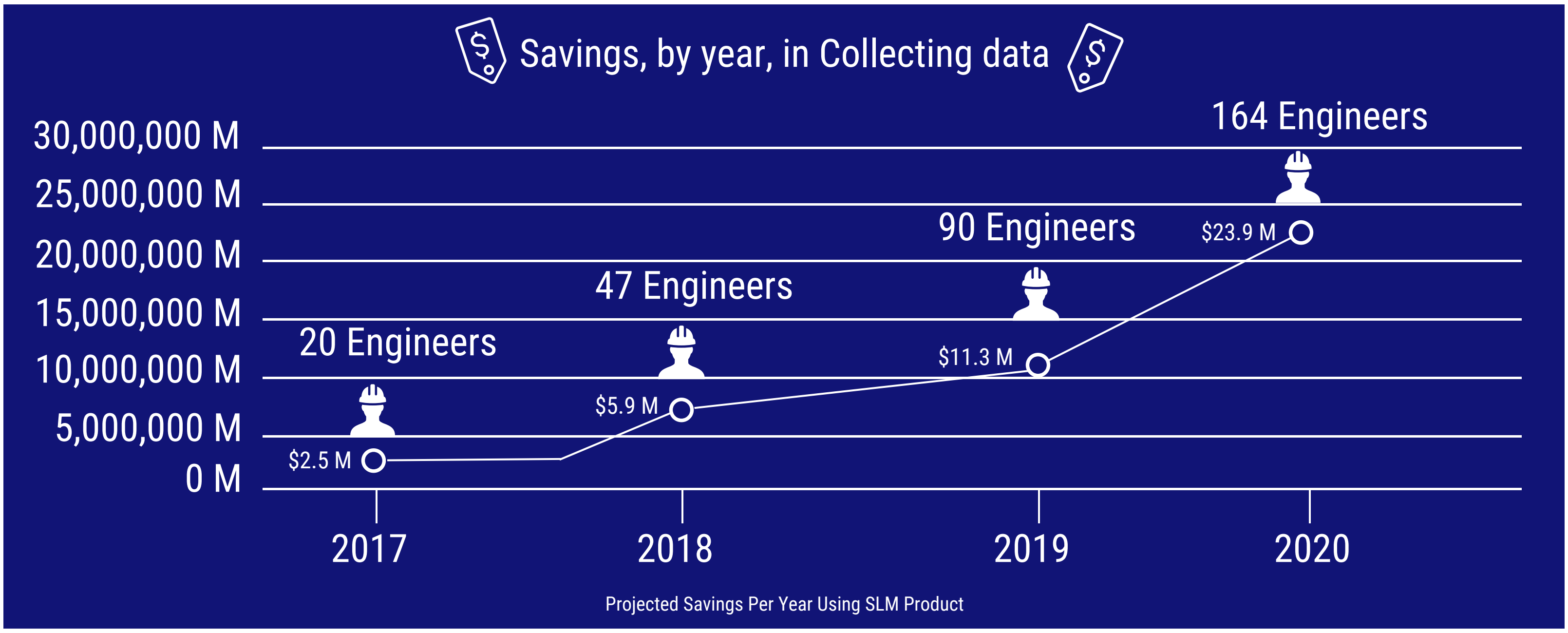
2.1 PSI Case Study #1: Process Safety Information Gathering

Challenge:
Major multi-national operating company finds its process safety and functional safety engineers were spending much of their time searching, retrieving and analyzing Process Safety Information (PSI) in preparation for assessments, risk studies and managing changes. This was time they were not able to spend actually performing value added activities.

Before SLM®:
Prior to the implementation of SLM® software, engineers would have to search up to 38 different information sources to understand a particular risk taking an average 22 minutes to collect the information. Using SLM®, engineers were able to reduce that search time to 2 minutes.

Result:
The operating company plans to have 164 engineers by 2021 using SLM® saving the company $23.9 million dollars per year in data searches alone, freeing up those engineers to focus on value added activities including improving production and reducing process safety risks.

PSI Case Study #1 Figure:



Initial Cost Savings per year for PSI searches:

Maintenance/Reliability Team	Existing Methods	With SLM®
Time to access relevant process safety information (mins per search)	22	2
Process Safety Information Searches per year	78,000	78,000
Total Duration of Searches-Hours	28,600	2,600
Total Cost	$2,574,000	$234,000
Total Annual Savings	$2,340,000	

SIS Engineer	Existing Methods	With SLM®
Time to access relevant process safety information (mins)	22	2
Process Safety Information Searches per year	6500	6500
Total Duration of Searches-Hours	1516	217
Total Cost	$318,360	$45,570
Total Savings	$272,790	

Total Annual Savings	$2,612,790

2.2 PSI Case Study #2: Corporate Key Performance Indicators (KPIs)

Overview:
SLM® v2 instant reports and KPIs can automate reporting around Process Safety and SIS KPIs enabling users to reduce the amount of time it takes to generate reports saving money and ensuring the data is accurate and evergreen.

Challenge:
Multi-national operating company experiences a series of costly process safety incidences despite indicators showing a good safety record prior to the incidences. Company realizes that the safety performance indicators were all focused on personal safety and not on process safety. Company realizes that project and operating company personnel were often dis-incentivized from focusing on process safety because the company payed bonuses based on meeting project cost and schedule targets and by meeting production targets and not on based on compliance with process safety related requirements. Company creates new rules requiring reporting of specific process safety Key Performance Indicators (KPIs) and creates incentives for compliance.

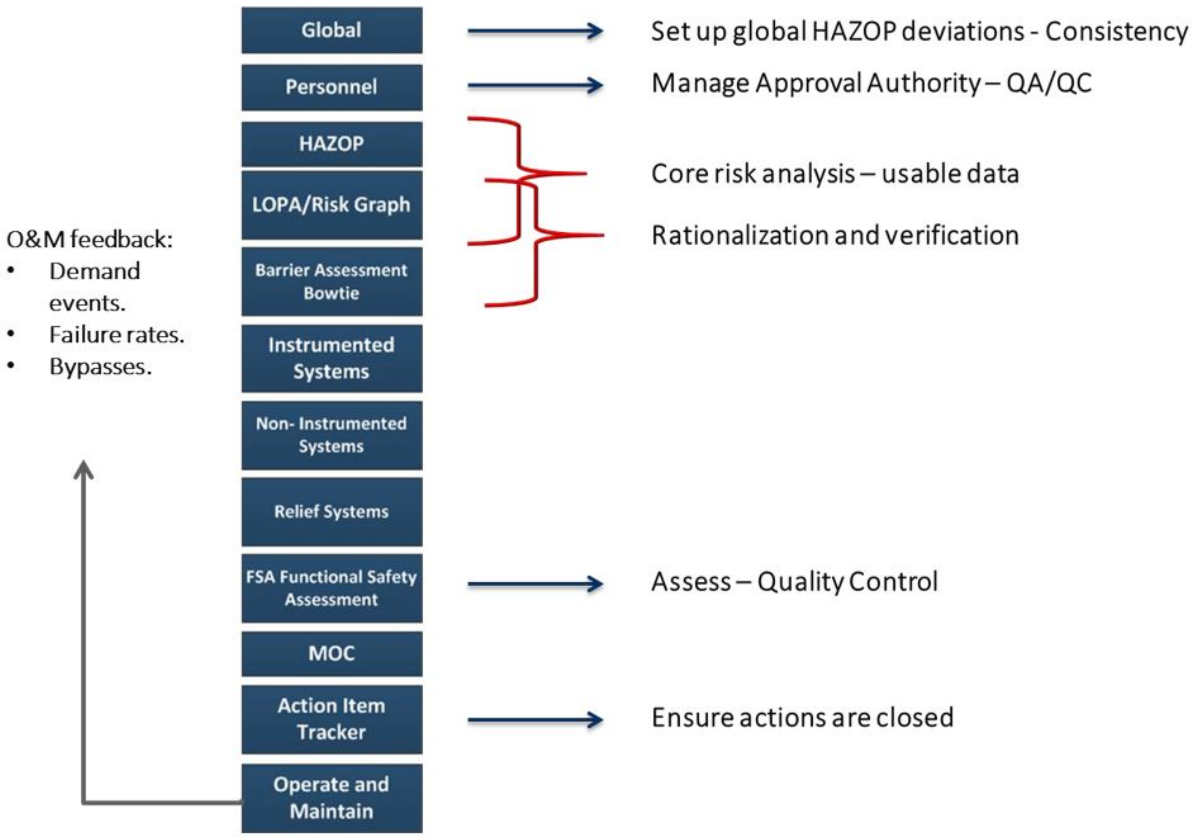
Before SLM®:
Facilities and projects find that gathering and analyzing the data needed to produce the KPIs using manual methods is very expensive and time consuming.

Data Points:
The engineers responsible reported that it took some 25% of their time per month to gather the data and create the reports for each facility.

Result:
Company begins piloting Mangan Software's SLM® as a solution to significantly reduce KPI gathering and processing costs, improving data quality and managing other aspects of the functional safety lifecycle.

	Existing Methods	With SLM®
Time to compile and analyze process safety information and produce KPI reports per facility per year (hours)	520	50
Total Cost	$83,200	$8,000
Total Annual Savings	$75,200	

3 Risk Analysis Solutions



3.1 Risk Analysis Case Study #1: Tier 3 KPIs

Overview:
SLM® v2 transforms Tier 3 metrics into leading indicators, giving business leaders at our client sites unprecedented visibility and assurance that process risks controls are being effectively managed, before incidents occur.

This gives operating companies the opportunity to avoid major incidents, improve plant availability, and optimize operating conditions. The SLM® system offers unprecedented visibility around the performance of the barriers protecting against a hazardous scenario.

Challenge:
Efficiently and effectively gather, analyze and visualize process safety information and automate reporting of the selected Tier 3 KPIs.

Before SLM®:
Legacy systems struggle to report lagging indicators-failures and incidents. Current data collection methods are cumbersome, resource-intensive and rely on open-field data entry. Critical information is in disparate systems, documents and spreadsheets.

Data Points:

- A pilot program was launched at the key Refinery utilizing the IPL Safety Lifecycle Management software SLM® v2 as the information management system to gather, analyze and visualize process safety information and automate reporting of the selected Tier 3 KPIs
- Data Migration: Process Safety Information in LOPA, IPL lists, SRS
- Leverage Existing data collection systems: DCS, Historian, Impact, SAP
- Data Entry: Tier 3 metric process safety events recorded through SLM® workflows
- Data Validation: Analysis of systems, PSI, event data
- Communication analysis, Identification of risk

Result:
The operating company was able to efficiently gather and analyze Tier 3 metrics for each IPL including:

- A management Report on Tier 3 metrics by unit
- Top Five SIF "Bad Actors"
- View Tier 3 Metrics by Equipment
- ID hazardous scenarios and effectiveness of IPLs
- Visualize performance of protection barriers and their effectiveness
- View an accurate and evergreen IPL list
- Execute procedures in accordance with IEC 61511 clause 5.2.5.3 to "compare the demand rate on the SIF during actual operation with the assumptions made during risk assessment when the SIL requirements were determined."

The deployment of a Tier 3 Metric program using SLM® v2 gave the operating company the opportunity to achieve operational excellence and continuous improvement in safety through:

• Informed Risk Mitigation Strategies:

Confidently **deploy** resources towards **high-risk scenarios** and ineffective prevention barriers

•Reduced cost structure:

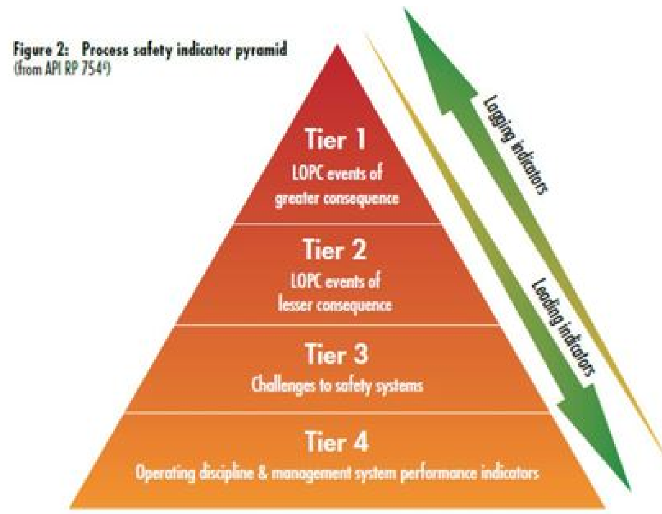
Collect **meaningful** performance information cost effectively through integrated automatic data collection and analytics

•Performance Monitoring:

Evaluate the performance of each SIS/SIF against its safety requirements

•Safety Lifecycle Management:

Ensuring that Instrumented IPLs are Managed Effectively and Efficiently



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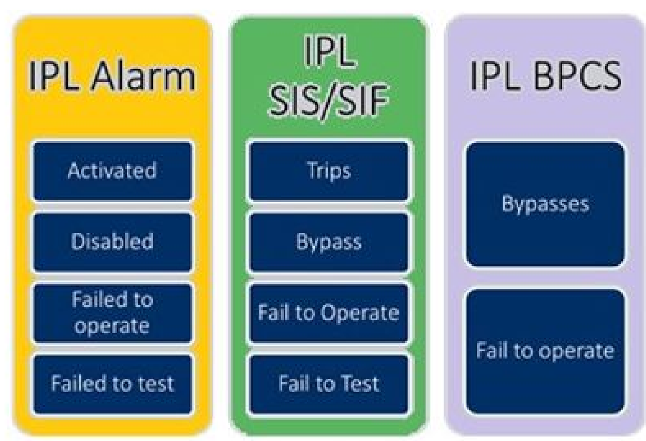
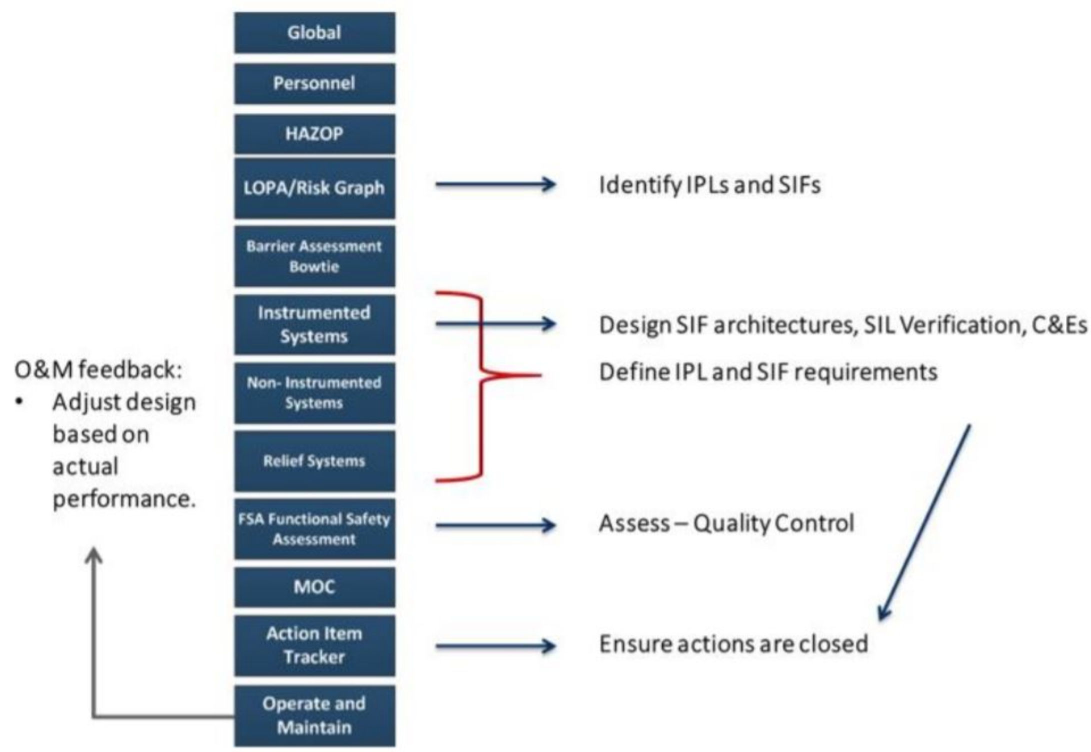


4 Assuring Adequate Protection Layers Are Installed



Current Practices Across The Industry		With SLM®	
Manual	• Time consuming process to capture and analyze data • Adverse impact on productivity and subject to human error	Automated	• Automatic population of HAZOP/LOPA data • Evergreen and instant reporting and tracking
Costly	• Data capture conducted by engineering resources • Duplication of efforts have an impact on productivity	Efficient	• IPL Registers / Risk Gap Reports automatically created • SRS templates and tools reduce outsourcing costs
Inconsistent	• Different LOPA methodologies may impact operational efficiencies • Attachments missing, hard to find or out of date	Alignment	• Reports and dashboards highlight IPL gaps • Analyze risk reduction strategies and efficiency
Uncertainty	• No Single Source of Truth for Process Safety Data • LOPA recommendations rarely prioritized by risk level	Visibility	• Authorized users have access to LOPA and HAZOP data • Reporting tools allow users to prioritize risk gap closure

4.1 Protection Layers Case Study #1: Internally Developed Tools

Challenge:
Multinational operating company used internally developed solutions with limited functionality and high support costs. With costs increasing, the application needed to be replaced.

Challenge Before SLM:
Multinational operating company internally developed a corporate Safety Requirements Specification (SRS) database and distributed to facilities and projects requiring them to use it to document Safety Instrumented Function (SIF) and other Independent Protection Layer (IPL) technical and maintenance requirements to comply with IEC61511 functional safety standard requirements. Corporate functional safety engineer and SRS developer become overloaded supporting the SRS database globally. The company hired a contract engineer and developer to support the SRS database full time at a cost of about $300,000 per year. In addition, the company sites and business units developed their own custom built process data management systems to support company required process safety Tier 3 KPI data reporting. Such systems proved to be inconsistent, expensive, unverifiable and difficult to maintain. Some sites spent over $2 million developing such systems.

Data Points:
Management and Subject Matter Experts became concerned that the internally tools are not cost effective and at risk of failure because of dependence on a small group of specialized staff.

Result:
To reduce costs, improve data accessibility and reduce risks of lost data, the company selected Mangan SLM® to replace all their internally developed systems for all sites. In addition, the company contracted Mangan MSS services group to help develop a data migration plan and map and import existing data into SLM®.

4.2 Protection Layers Case Study #2: Internally Developed Tools

Challenge:
Multinational operating company used internally developed solutions with limited functionality and high support costs. With costs increasing, the application needed to be replaced.

Challenge Before SLM:
A multinational operating company internally developed corporate safety lifecycle software to gather and calculate failure rates, design safety functions, perform SIL verification calculations and document SIF technical requirements.

4.3 Protection Layers Case Study #3: Developing IPL Registers

Data Points:
Though generally successful for gathering failure rates and designing safety functions, the operating company found that their software solution was limited in scope as it did not include functionality such as:

- PHA and LOPA studies
- KPIs
- Bypass management
- Enterprise integration

The company struggled with supporting and using the internally developed software. Only highly skilled and high cost corporate SMEs familiar with the software are able to support and use it at over $220 dollars per hour each person.

Result:
Company selects Mangan SLM® as the preferred solution to replace their internally developed system. Easy to use workflows and interface, coupled with cloud access, enabled the organization to increase the user base and achieve 33% more efficiency. Using commercially available SLM® software freed up expensive and highly skilled internal resources allowing them to focus on more valuable activities than software support.

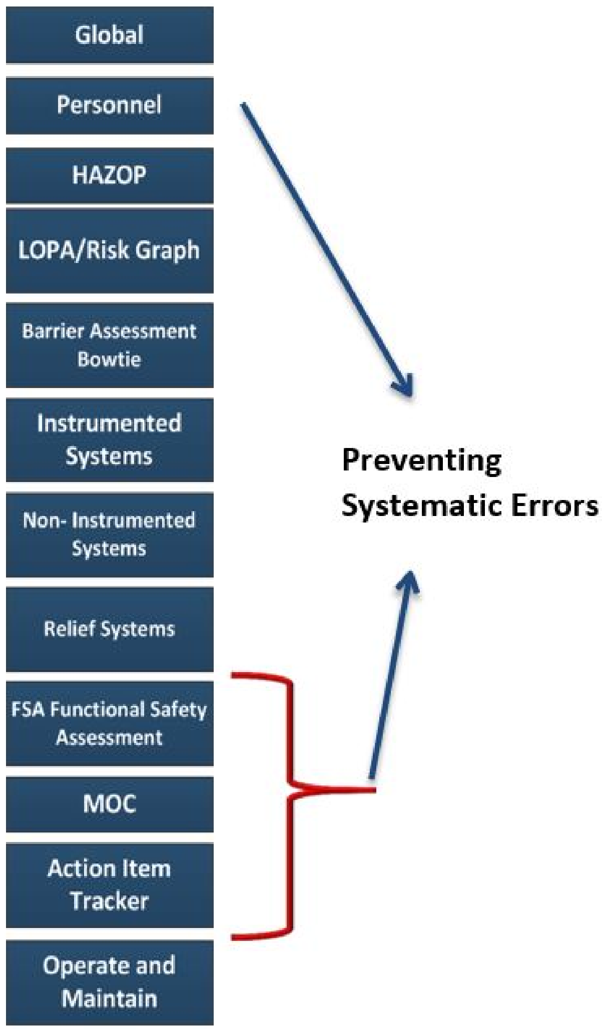
Challenge:
After a major modernization project, a refinery was looking to update and maintain IPL registers for the facility in order to execute IPL Assessments, ensure accessibility and maintainability of integrity and LOPA gaps.

Before SLM:
Spreadsheets were used with PHA-Pro outputs, which were impossible to maintain in an evergreen status.

Data Points:
MSS and refinery process safety superintendent co-designed an IPL register for the facility, which was completed within 3 weeks.

Results:
LOPA and SIL gaps were visible, enabling leadership to develop risk mitigation strategies over the next five years to close gaps. In addition, the PSM team was able to disperse critical and meaningful data to operations, enabling them to use the IPL register and risk registers when making decisions around bypasses.

5 Preventing Systematic Errors



5.1 Preventing Systematic Errors Case Study #1: Functional Safety Assessments

Overview:
Systematic errors are human errors usually caused by a failing to follow procedures or not fully understanding the requirements.

Challenge:
Functional Safety Assessments (FSAs) are required per IEC-61511/ISA 84 functional safety standards to ensure that systematic human errors are identified and corrected before an incident occurs. FSAs are traditionally expensive requiring extensive travel, data gathering efforts and access to senior personnel.

Before SLM:
An operating company directed that FSA be completed throughout the enterprise with some facilities forecasting over 30 FSAs per year to keep up with ongoing projects. FSA costs and resources became a major concern. To overcome internal resource constraints, the company outsourced functional safety assessments to SME Engineering Service Providers at an average of $75K per FSA.

SMEs typically imposed their own FSA protocols on the site, making standardization and ensuring accuracy all but impossible.

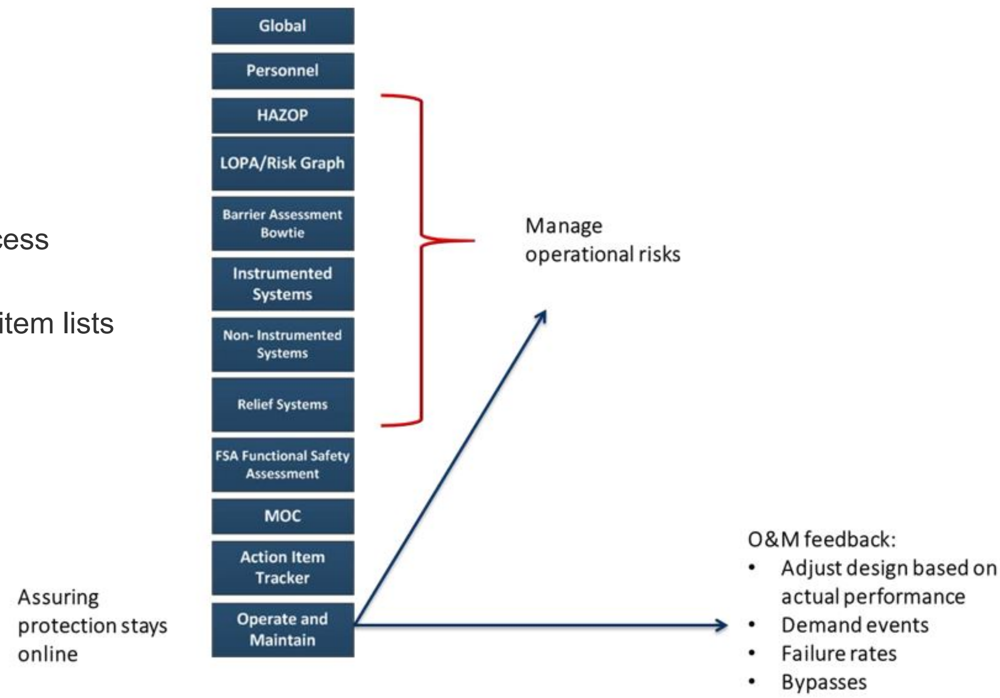
Data Points:
Assessment SMEs would typically divide FSAs into the following tasks, averaging around $19K per task:

• Adjust spreadsheet used to conduct the assessment to site FSA protocol
• Gather and collect data, process safety information
• Interview operations, maintenance, process safety, engineering staff members
• Create and develop reports and action item lists

Results:
SLM's FSA workflow standardized the FSA process, automating final reports and eliminating costly 3rd party consultant deliverables. Conformance Scoring and help features within the solution offered a virtual SIS SME for sites, increasing the safety culture of the sites, ensuring standardization across the enterprise and offering the operating company the chance to internally source these projects and reduce costs.

• FSA projects costs dropped 66% to $25,000 using automated reporting
• Increased SIS/FSA competency; company able to transition to internally sourcing FSA chairperson
• Conformance Assessment Scores provided leadership with visibility into site performance.
• Engineers were able to track action items and justify conformance gap closure to leadership, leading to a safer facility.
• Process Safety Information quick links to SIS/LOPA data shortened duration of FSA sessions by 44%

6 Operations and Maintenance (O&M) Opportunities



Companies invest tens of millions of dollars into adding protective layers to their processes only to find that many of them are offline due to uncontrolled bypasses or poor maintenance. Fortunate companies discover this through careful auditing and less fortunate ones through incident investigations. Though operating facilities are expected to keep their protective layers online, they find justifying the staff required to do so difficult because they do not have the data to justify their staffing requirements.

Mangan SLM® closes the loop between management expectations, engineering and operations and maintenance with integration with control system historians and Computerized Maintenance Management Systems to feedback actual maintenance performance, failure rates, demand events and bypasses into the automatic data analytics and KPI generation functionality.

By integrating data rather than documents, SLM® greatly decreases the amount of time operations people spend in finding and analyzing process safety information allowing them to focus on value added tasks.

6.1 O&M Case Study #1: Maintenance Effectiveness

Challenge:
Major oil and gas onshore facility tests safety instrumentation based on regional, prescriptive safety regulations. Cost of meeting prescriptive maintenance requirements is high and safety performance is low because some devices are tested more frequently then needed to maintain integrity and others are tested not at all. Government agrees to waive prescriptive requirements and allow operating company to test based on risk and performance requirements providing that the company can prove that they collect and manage failure data and have the ability to test according to risk requirements.

Before SLM:
Company is unable to provide evidence of maintenance and risk performance using conventional tools.

Data Points:
Company purchases SLM® to address data management deficiencies, to focus maintenance based on protection layer performance and risk and to provide the evidence to regulators needed to waive expensive and inefficient prescriptive maintenance for efficient, lower cost and more effective risk and performance based maintenance.

Results:
Company was be able to extend turnaround frequencies by moving to risk and performance based testing for a unit that had to be shut down annually for regulatory testing. Much of the facility had to operate at reduced rates to accommodate this testing at high costs. With SLM® the facility was able to see:
• Total tangible cost saving more than $10 million per year.
• Intangible savings include reduced safety risk and improved maintenance as technicians were freed up to focus on repairing and improving critical instrument installations.

6.2 O&M Case Study #2: Bypass Effectiveness

Challenge:
Understanding bypass related risks and tracking bypass activations to manage bypasses in a risk management and cost effective way.

Before SLM:
Major oil and gas onshore facility creates a bypass management program to address near misses and elevated risks associated with uncontrolled bypassing of safety functions. New program consists of a combination of a paper based analysis with an approval process and automatic tracking and reporting of active safety function bypasses. Facility personnel developed and maintained their own database system for tracking active bypasses.

Data Points:
Facility experienced the following issues with their bypass management system:

• Bypass tracking system was expensive, requiring a highly skilled individual to develop and maintain it. The facility became totally dependent on that one person to maintain the bypass system as only he knew how it worked.
• Bypasses were actually authorized without the required risk assessment and documented risk management studies because such studies were too time consuming due to the fact that:
  o Old HAZOP studies were available as scanned PDF documents but were unsearchable and made it extremely difficult to associate safety functions with specific risks.
  o Available information did not make it clear what other protective layers could be used to supplement the bypassed function.
  o Finding the applicable risk studies was a time consuming process.
  o Those involved in the risk analysis did not have the skills to correctly assess the risks and mitigation measures given the limited information available.

Results:
Facility selected Mangan SLM® to manage bypasses and to achieve the following benefits:

• No longer dependent on the single staff developer to maintain the tracking system.
• Tracking system developer had more time available to focus on control system optimization activities.
• Bypass data used to track overall SIF availability and availability of safety functions related to specific process equipment became available.
• Bypass related risks and associated additional protection layers became easily identifiable. Risk mitigation procedures could include verifying the effectiveness of the associated protection layers before initiating a bypass.
• Bypass approvals coordinated using SLM® reducing the time and effort involved.
• Bypass approval forms and bypass activation records are stored by SLM® and visible to anyone in the company who has been granted access making people accountable and making audits more effective and efficient.

Cost Savings:

	Existing Methods	With SLM
Time to conduct risk assessment, record bypasses and evaluate time in bypass (hours)	3	.25
Number of Bypasses	300	300
Total Hours per year	900	75
Total Cost	$72,900	$6,075
Total Annual Savings	$66,825	

6.3 O&M Case Study #3: Proven In Use/Prior Use

Challenge:
A refinery IEC61511 compliance program was facing high costs for meeting SIL requirements due to high theoretical dangerous failure rates based on generic industry solenoid valve failure rate data. The generic and overly conservative data led to the requirement for costly redundant solenoid valves.

The facility suspected that the AC powered solenoids that they used would experience much lower than industry generic dangerous failure rates as that design would be less prone to solenoid sticking.

Before SLM:
The facility had been collecting failure rates and modes for several years through a time consuming manual process. The data allowed the facility to establish actual (Proven In Use) dangerous failure rates for the facility solenoid valves and found that the Proven In Use failure rates where much lower than industry generic data.

Data Points:
The facility adjusted their final element designs based on the Proven In Use data and found that they could reduce the number of redundant solenoid valves, reduce project costs, reduce maintenance costs and improve production rates. Production rates were improved by reducing the number of solenoid valves that could fail.

Results:
Realizing the benefits to efficiently collecting actual failure rate data for all installed safety instruments and final elements and types, the company selected Mangan SLM®.

Installation Cost Benefits Analysis for a Medium Sized Facility Utilizing SLM® Proven In Use Data Management

Item Description	Quantity
Number of Safety Instrumented Functions (SIFs)	600
Average number of devices per SIF	5
Total number of SIF devices	3000
Cost of design, installation, configuration, commissioning each device	$10,000 each
Reduction of SIF devices using Proven In Use data	15%
Number of devices reduced	450
Project Cost savings	**$4,500,000**

Ownership Cost Benefits Analysis for a Medium Sized Facility

Item Description	Quantity
Number of devices reduced	450
Cost per year of testing and inspection per device saved	$180
Total cost of testing and inspection saved	**$81,000**
Number of devices replaced per year if they had been installed	22
Cost of replacing each device (average)	$2000
Replacement cost per year saved	**$44,000**
Maintenance savings per year	**$125,000**

6.4 O&M Case Study #4: Failure and Demand Tracking

Challenge:
Major refinery was looking to develop failure and demand tracking capabilities and improve SIS performance by implementing a tracking program and providing reports to the leadership team on SIS/SIF performance. Existing tools lacked the capabilities needed to document and track these data points.

Before SLM:
Spreadsheets were the primary tool, using output from IMPACT CMMS software and data historians.

Data Points:
Working with plant SIS engineering authorities, MSS Solutions Analysts built a profile of the facility with the following data points:

.

- 15 processing units at the facility
- 300+ SIFs
- 5 SIS/I&C engineer users who would access the system 25 times per week with an average "true cost of the employer" hourly rate of $81.25

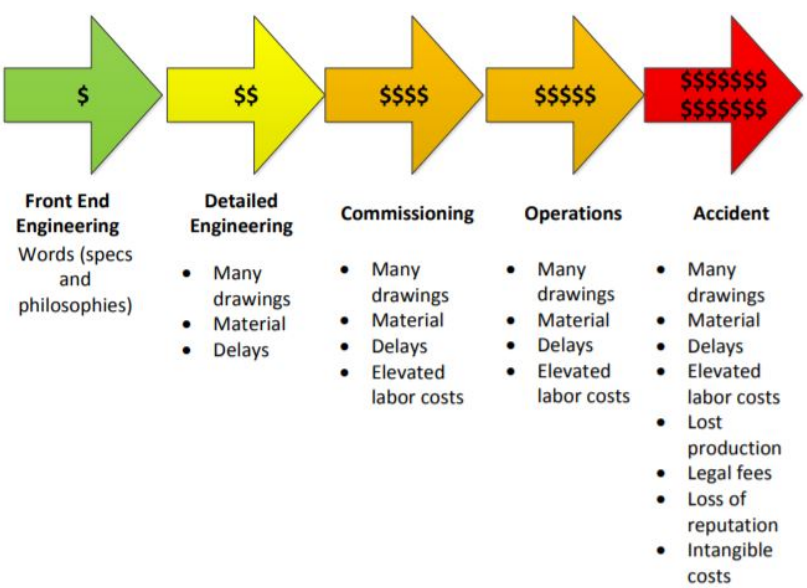
Results:
See figure Below.

Demand Tracking and Documentation	Existing Methods	With SLM
Time to collect, collate and evaluate plant demand data at one operating unit per month (hours)	8	1
Annual Duration	98	12
Number of Units	15	15
Total Hours	1470	180
Total Cost	$119,437	$14,625
Total Savings per year	$105,000	
Fault/Failure and Documentation	Existing Methods	With SLM
Time to collect, collate and evaluate plant failure data at one operating unit per month (hours)	15	1
Annual Duration	180	12
Number of Units	15	15
Total Hours	2700	180
Total Cost	$219,375	$14,625
Total Savings per year	$204,750	

7 Capital Project Opportunities

Late emerging process safety issues have to be addressed so process safety related changes are particularly troublesome and expensive. Major capital projects frequently experience significant cost overruns associated with process safety issues resulting from late changes. The further into the project lifecycle that a process safety deficiency is discovered, the more it costs to correct the problem.

Costs of Discovering Process Safety Design Issues Per Phase



Causes for project process safety related poor performance vary but can be frequently attributed to:

Lack of Involvement of Process Safety and Functional Safety Subject Matter Experts (SMEs):

Access to project information by corporate or contract SMEs has been limited. When they are finally introduced to the project through an assessment/auditing process, significant project changes occur in order to bring the project into compliance with process safety requirements.

Leaving Process Safety Design to the Process Hazard Analysis (PHA) Team:

Projects have become too dependent on the PHA to determine process safety design requirements. By the time enough information is available to perform an effective PHA, the design is well along and changes are expensive or less optimal solutions are accepted to reduce costs. This often leads to a design that is far from inherently safe and depends on a many complex instrument alarms and trips to close safety gaps.

Poor Quality Cause and Effect (C&E) Drawings:

High quality project C&E drawings are critical for effective process safety management and SIS configuration and remain critical documents throughout the life of the facility but are more often than not of poor quality. The primary reasons are as follows:

1. Engineering Procurement and Consulting (EPC) companies do not place a high priority on C&E development so they assign inexperienced engineers without operations experience. EPCs are focused on procurement as that is where the greatest project risks are found. C&E documents do not affect procurement so they are low priority.

2. C&E development is started too soon because of a perceived need that they are needed for the PHA. In reality, C&Es are not needed for a PHA for grassroots projects. How the junior C&E engineer thinks safety functions should work doesn't matter to the experienced PHA team.

3. C&Es functions are not grouped. Every cause and effect is listed individually in every case resulting in overly complex documents, overly complex SIS programs and confused operators trying to figure out how to restart a tripped facility. Functions should be grouped by equipment and every trip that trips that equipment activates the equipment group.

Unverified Layers of Protection Analysis (LOPAs):

The LOPA process was always intended as an engineering activity to be performed by a qualified individual and not by a committee as its purpose was to overcome the subjective limitations of a group environment common to HAZOP studies. Unfortunately, the current industry practice is to combine LOPA and HAZOP studies into a single series of meetings. These studies are expensive because the participants are senior people and senior people come with high billing rates and have many other responsibilities. Meetings involving expensive, senior people need to be as short as possible to control costs resulting in rushed LOPA studies with the following deficiencies:

1. Combined consequences and confused or unresolved solutions. Consequences need to be singular in order to find effective LOPA solutions.

2. Accepted Independent Protection Layers (IPLs) that are not effective. Mistakes are often made in accepting relief valves for liquid relief scenarios, not considering process safety times and IPLs that re not independent.

3. Too many IPLs because each LOPA scenario is considered individually. For example, the first scenario may accept a SIL1 and an alarm and a following scenario credits the same safety function as SIL2. Rationalization would remove that alarm as an IPL reducing costs over the life of the facility.

4. Recommendation actions are issued to the project prior to LOPA rationalization and verification resulting in unnecessary changes and the design of ineffective solutions.

Safety Requirements Specification (SRS) Non-Compliance

Engineers, designers and SIS programmers prefer to be creative and would often rather design their own solutions then read, understand and comply with the SRS. Designing solutions directly integrated with SRS requirements, easily accessible SRS data and efficient Functional Safety Assessment (FSA) tools can correct this problem.

> *"Without having Mangan's software as the tool to complete this project, I don't believe we could have met our schedule or delivered it in a format that the client would have been as happy with." Noel Ann Wright, Project Lead S&B Engineers*

7.1 Project Case Study #1: Capital Project Process Safety Costs and Performance

Challenge:
Major multinational company experiences frequent large capital project process safety failures including:

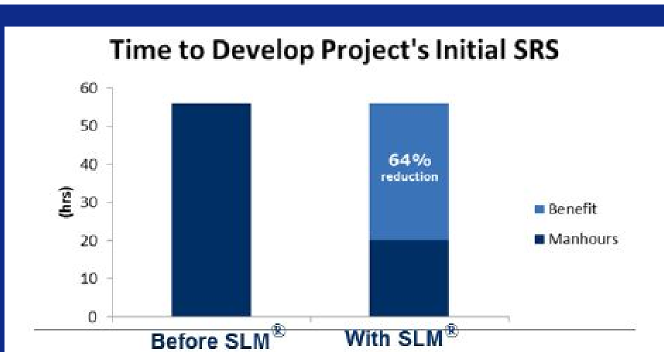
- Commissioning startup equipment destruction and near safety misses attributed to poor project functional safety performance.
- Major mobilization of functional safety resources to site to fix functional safety deficiencies in order to secure regulatory approvals for startup. High field labor costs, overtime and expenses resulted in significant cost overruns.
- Major process safety related design inconsistencies between similar type facilities leading to difficulty supporting and maintaining facilities with uncertain safety performance.
- Overly complex instrumented solutions and large numbers of safety related instrumentation and functions installed in most facilities because of late consideration of functional safety requirements made inherently safe design impractical. Large number of instruments and functions led to burdensome maintenance costs and facility reliability and availability issues.
- Large numbers of high impact spurious trips due to lack of spurious trip prevention fault tolerance led to significant loss of production costs.
- Corporate functional safety and integrity assessments proved to be expensive requiring frequent global site trips, inefficient because of poor access to data and disruptive because of the large number of negative findings

Results:

Company began evaluating lifecycle software solution to address these issues. After a comprehensive evaluation cycle, the company chose Mangan SLM®.

After deployment of SLM® to several of the facilities, the company experienced significant reductions to process safety failures:

- Using SLM® design templates resulted in consistent and high quality process safety solutions at lower costs.
- Visibility of data at corporate Subject Matter Expert (SME) levels allowed experts to remotely assess and guide projects early in the lifecycle before the costs of change became prohibitive.
- The availability of SLM® data reduced travel costs by allowing many assessment activities to be performed from the assessor's office.
- SLM® use of templates, design data visibility and remote assessments allowed corporate SIS SMEs to ensure that safety function designs include fault tolerance to prevent high impact spurious trips.



7.2 Project Case Study #2: Heater Accident Prevention

Challenge:
Major refiner designs and builds a new unit for making a new product. New unit includes a large fired heater.

Before SLM:
Project uses conventional local documents to manage process and functional safety. Documents are only available to the project team and contractor.

Data Points:
Project fails to design a startup purge timer Safety Instrumented Function (SIF). A purge SIF keeps the fuel gas valves closed and disables the ignitor until a purge sequence is completed ensuring the firebox is free of an explosive mixture before ignition is attempted. As a result, the following events occur:

- Project fails to install fire-eye fuel gas trips that close the fuel gas isolation valves on loss of flame.
- SIS design deficiency goes unnoticed by SMEs due to lack access to design data. During commissioning, the control system excessively opens the fuel gas valve in response to increasing load resulting in a flameout due to an overly rich air-fuel mixture.
- SIS fails to trip the fuel gas isolation valves because there are no fire-eyes that can detect flameout on rich mixture.
- Electrical spark ignitor is not disabled because there is no purge sequence SIF configured that would normally inhibit ignition except for a short period after the purge has been completed.
- Operator pushes ignition button after he detected flameout via local monitoring of the heater.
- Explosive concentration of air and fuel in proximity to the ignitor ignites and explodes.
- Side of heater explodes outwards. Fortunately the fragments pass over the operator with no injuries.

Tangible costs of incident include:

• Delayed startup of unit extended project costs and delayed production returns.
• Replacement costs of destroyed equipment.
• Investigation costs.

Total tangible cost of incident = $20 million

Intangible costs:

• Fired senior employees including the plant manager resulted in loss of investment in training, development and loss of knowledge.
• Decreased morale reducing employee effectiveness.
• Decrease in organizations safety reputation making retention, hiring and partnerships more expensive.

How SLM® could have prevented this $20 million Loss:

1. Corporation builds standard heater design templates in SLM® with standard Safety Instrumented Functions (SIFs) that includes purge sequences with ignition lock out and fire-eye flameout detection with fuel gas isolation. Project copies the heater design template SIFs that include purge and fire-eye functionality. Incident is avoided and $20 million is saved.

2. Corporate SME reviews the heater SIF designs against corporate standards and good practice using SLM® and notices that the heater design is out of compliance. The SME promptly documents an action to correct the problem in SLM® action tracker. The action is closed when the design problem is corrected. Incident is avoided.

3. Consultant performs Stage 2 (Design) Functional Safety Assessment (FSA) using the SLM® FSA module and notices the design deficiency by asking FSA prepopulated questions. The consultant creates an action in SLM® Action Item Tracker and the deficiency is corrected. Incident avoided and $20 million is saved.

4. SIS SME defines project approvers in the SLM® Personnel module ensuring that a heater safety SME is included in the approval cycle. The heater SME notices the design deficiency when he is notified by SLM® that the design is ready for approval. The SME notifies the project that he will not approve the design until the deficiency is corrected. The project corrects the deficiency and the SME approves. Incident avoided and $20 million saved.