# Product Assurance Statement

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|---|---|---|---|---|
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# Table of Contents

## 1. Purpose

The purpose of this document is to provide an overview of the Quality Assurance journey taken by Safe Influx Limited while developing the Automated Well Control System.

## 2. Executive Summary

The Safe Influx Automated Well Control system is a bespoke technology that automates the well shut-in sequence providing automated secondary well control. The technology almost eliminates the human factors in well control events therefore minimizing the influx size and preventing blowouts.

The technology and Minimum Viable Product (MVP) have been extensively tested in a simulated environment and tested twice on actual test land drilling rigs in October 2019 and March 2021 (see *Section 4.2*). The MVP is at a Technology Readiness Level (TRL) 8 (i.e., system completed and qualified) and is ready for deployment on an operational rig.

The Automated Well Control system has been qualified by Lloyds Register and comes with a Lloyds Technology Qualification Certificate for both cyber and traditional rig applications. The qualification process included a detailed Failure Mode Effect Analysis (FMEA), Factory Acceptance Test (FAT) and Site Acceptance Test (SAT). The SAT was performed as part of the 2019 test performed on a land drilling rig in Aberdeen, Scotland (see *Section 4.2*).

The Automated Well Control System has been extensively tested on both simulators and (to date) on three operational test rigs

The Automated Well Control system was granted a UK patent in January 2021. Patents are pending in the US (expected award: Q4 2022) and Europe, Canada, and Australia (expected award: 2024).

## 3. System Description

The Safe Influx Automated Well Control system consists of two modules and is outfitted with high quality up to date components as shown in *Figure 1* below:


**PLC Cabinet**


**HMI Screen**

*Figure 1 System Overview*

- PLC Cabinet (approx. 800x1200x500mm w x h x d).
- High availability and Safety Siemens S7/412 FH CPU x 2 (or Equivalent).
- Ethernet or equivalent communications modules.
- Power Supply with UPS (providing up to 2hrs of power) and Ethernet or Equivalent switches.
- IS Barriers for interfacing with HMI.
- Siemens 19" ATEX touch screen IPC Operator Console (approx. 1000x1000x300mm w x h x d).
- Safe Influx Limited proprietary software.
- Digital I/O, if required.

The Automated Well Control system continuously monitors well flow out together with selected drilling and well control equipment I/O data through its PLC server.

When the system identifies and confirms a self-sustained influx, a message appears on the drillers HMI screen indicating that an automated shut-in procedure is initiated. This prompts the driller to adopt a verification role based on the operation being conducted whilst the system automatically performs the necessary sequence of operations with the rig equipment to safely shut in the well

Safe Influx Automated Well Control Procedure:

1. The system receives a kick indicator signal.
2. The system initiates an audible alarm signal
3. The system sends a warning message to the driller "Auto Well Control Initiated".
4. The system takes control of the assigned rig equipment and performs the following automated sequence:
    a. Continues pumping and rotating whilst picking up the drill string using the draw works to the first available safe space out location.
    b. Stop mud pumps and top drive rotary motion.
    c. Monitor flow from well. If flow continues, shut in the well.
    d. Activate BOP to shut in the well following company prescribed procedure.

## 4. Technology Assurance

As an innovative product intended to be deployed to ensure enhanced safety and performance in well control operations, the Safe Influx Automated Well Control system has been designed and manufactured with product assurance as the key qualifier.

Documented assurance measures have been executed during the development of the product as shown in *Figure 2*:

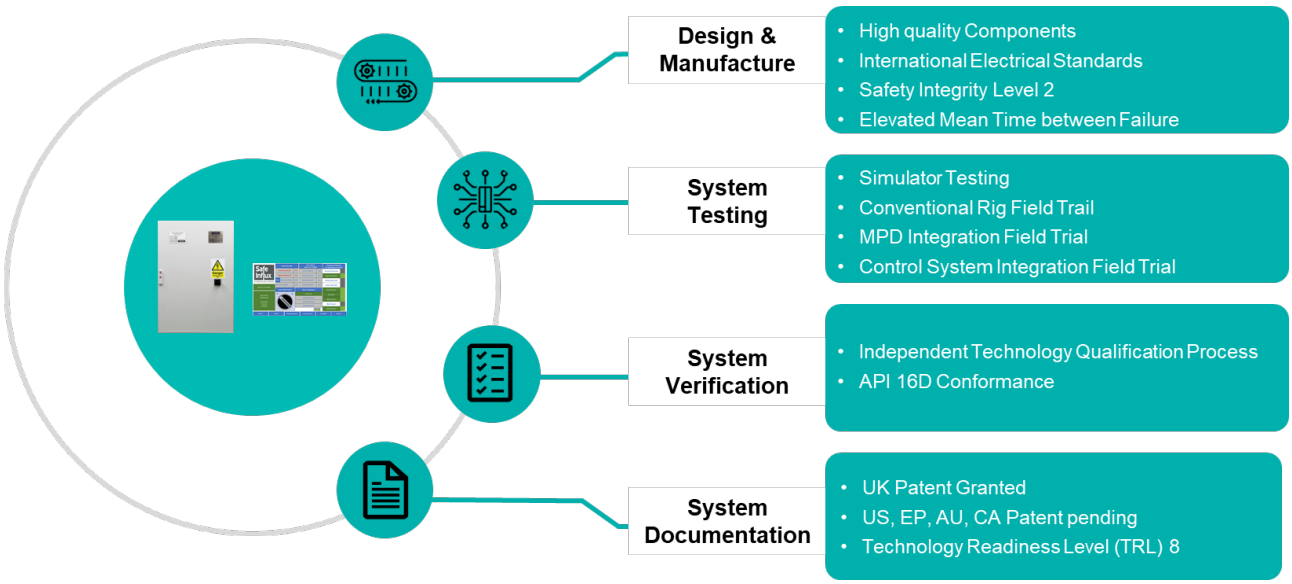


*Figure 2 Technology Assurance*

## 4.1. Design and Manufacture

### 4.1.1. Equipment and Manufacturing Quality

All equipment used in the Safe Influx Automated Well Control system is designed such that the quality and reliability equals (or often exceeds) the quality and reliability of the connected equipment (refer to *Table 1*).

| Component | |
|---|---|
| PLC Control System | Siemens PLC offers high availability (seamless switchover between master and slave), dual redundancy and has a proven record in several applications including rig controls. |
| Power Supply(s) | The power supply is filtered to protect electronic componentry and incorporates a UPS battery power supply to ensure power availability for a minimum of 2 hours in accordance with API 16D. |
| IS barriers | To protect HMI and other digital interfaces. |
| HMI Screen | ATEX certified with a 19” Zone 1 touchscreen. |
| Software | Commonly used open-source software SCADA. |

*Table 1 System Components*

### 4.1.2. International Electrical Standards

The design and equipment conform, where applicable, to the International Standards as shown in *Table 2* below. The system is CE marked as self-declared by the manufacturer to be compliant to these standards.

| Standard | Description |
|---|---|
| BS 7671 – 2018 | IEE Wiring Regulations |
| BS EN 60204 – 1 | Safety of Machines – Electrical Equipment |
| IEC 62061 | Safety of Machines – Functional Safety |
| BS EN 13849-1 | Safety of Machines – Safety Related Parts of Control System |
| IEC 60079-11 | ATEX – Intrinsically Safe Equipment |
| IEC 61508-3 | Functional Safety - Software |

*Table 2 Electrical Standards*

### 4.1.3. Safety Integrity Level (SIL)

The International Electrotechnical Commission's (IEC) standard IEC 61508 defines SIL using requirements grouped into two broad categories: hardware safety integrity and systematic safety integrity. A device or system must meet the requirements for *both* categories to achieve a given SIL.

The SIL requirements for hardware safety integrity are based on a probabilistic analysis of the device. To achieve a given SIL, the device must meet targets for the maximum probability of dangerous failure and a minimum risk reduction factor, both in continuous and 'on demand' use.

The Safe Influx Automated Well Control system has been manufactured using high quality components in compliance with the Safety Integrity Level 2 classification as detailed in *Table 3* and *Table 4*

| Probability of Dangerous Failure | Risk Reduction Factor |
|---|---|
| 0.01 – 0.001 | 100-1000 |

*Table 3 SIL 2 Compliance for demand use*

| Probability of Dangerous Failure per hour | Risk Reduction Factor |
|---|---|
| 0.000001 – 0.0000001 | 1,000,000 – 10,000,000 |

*Table 4 SIL 2 Compliance for continuous operation*

In most cases the SIL classification of the Safe Influx equipment exceeds the SIL classification of both the input and output phases of the rig's control system(s), meaning that the Automated Well Control System cannot be considered as the weakest link in the chain.

### 4.1.4. System Components – Mean Time between Failure (MTBF)

All components used in the manufacture of the Safe Influx Automated Well Control System have been selected with quality and reliability in mind. A measure of reliability is Mean Time Between Failure (MTBF), as quoted by the manufacturer, and a full system detail is summarised in *Table 5*

| Item | Minimum MTBF |
|---|---|
| Control Panel | 90.3 years |
| HMI Display | 7.99 years at 25 °C |

*Table 5 Minimum MTBF*

## 4.2. System Testing

### 4.2.1. Simulator Testing

To ensure that the operation of the Automated Well Control system could be thoroughly evaluated in a benign environment, Safe Influx commissioned the compilation of an interface 'patch' to ensure effective and reliable data communications between the Automated Well Control system and a Drilling Systems DS6000 Simulator.

This integration allowed several test scenarios to be run as follows:

a) To ensure that improved influx detection and reaction time was achieved by automation.
b) By using a formal HAZOP process, to ensure a number of fault finding and user error scenarios could be recognised, documented and if applicable incorporated into future upgrades to the system.

In addition, the simulator testing allowed effective comparison between human and automated well control response, by running several exercises with an operational drill crew. The exercises consisted of a variety of well control snapshots, run using both human and automated responses. The exercises showed that influx volumes could be consistently reduced by 50% - 70% with automation (see *Table 6* below).

| | Influx Size |
|---|---|
| Human Well Control Response | 10-30 bbl. |
| Automated Well Control Response | 2-5 bbl. |

*Table 6 Influx Detection*

### 4.2.2. Rig Trial 1 – Test Land Rig – Bridge of Don, Aberdeen, UK

Following the various simulator tests, a field trial of the Automated Well Control system was performed at the Weatherford test rig at Bridge of Don in October 2019. On 8th October 2019 the first successful field demonstration of an Automated Well Control device identifying and conducting the automated executive actions to safely shut in a well with no human interaction was demonstrated.

The field trial objectives were fully met and exceeded the expectations of the team pre-mobilisation. The field trial was supported by the UK Oil & Gas Technology Centre (OGTC) and was witnessed by Lloyds Register as the independent verifier, and personnel from Independent and National oil companies.

The following highlights were recorded during the trial:

1. All activities conducted during the field trial from 7-11th of October and the mobilisation and demobilisation activities were incident free.
2. The Automated Well Control unit and interfaces were successfully and efficiently installed and commissioned at the rig.
3. A series of system tests and additional stress and normal tests, 15 in total, were executed to demonstrate the systems functionality and capability in a range of downhole and surface situations.

4. The system was demonstrated successfully to Lloyds Register and awarded a Lloyds Register Technology Qualification certificate for both cyber and traditional rigs.
5. The system was successfully demonstrated to four VIP groups and a total of 33 people. This included senior staff from UK and Overseas Operators; Drilling Contractors; IADC; OGTC; Service Companies; Financial Investors and the Press.
6. The system was successfully demonstrated to an OGTC group including the Wells Solutions Centre Manager who gave separate interviews as to the value OGTC saw to funding such technology projects.
7. A peer review of the Interface Controls Engineering was executed by a major drilling contractor as industry benefit in kind to support the field trial project.

A comprehensive report of this field trial can be viewed as a separate document.

### 4.2.3. Rig Trial 2 – Test Rig – SRO, Houston USA

In March 2021, a rig trial and integration test of the Weatherford MPD and Safe Influx Automated Well Control system was performed at Weatherford's Spencer Road, Houston, USA (SRO) test rig.

Due to COVID 19 travel restrictions, the Safe Influx Automated Well Control equipment was required to be installed remotely by the Weatherford MPD and R&D team in Houston.

Twenty-seven (27) pre-agreed tests were performed which covered:

- Setting Up of Systems.
- Independent System Configuration and Integrated Commissioning.
- Integrated Contingency, Communications and Comparison Testing.

For all tests, the expected and actual outcomes were documented. All Integration tests 1-27 were performed on Monday 15th March 2021 and all were completed successfully without significant issues. All pre-agreed Test Criteria were met.

A comprehensive report of this field trial can be viewed as a separate document.
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### 4.2.4. Simulator and Rig Trial 3 –Simulator and STC Test Rig, Houston, USA

As part of the agreement between Safe Influx and NOV, a programme of both simulator and rig interface testing was developed as detailed below. The object of these tests was to prove that effective and reliable data communications could be achieved between Safe Influx Automated Well Control system and the NOV Drilling and BOP Operating Control Systems.

#### Remote Simulator Test

Performed in a virtual environment using NOV's cloud-based rig simulator (based in Norway), NOV's remote BOP control system (based in USA) and Safe Influx' Automated Well Control system (based in Scotland).

#### Rig Test

Performed on NOV's STC test rig in Navasota, Texas USA.

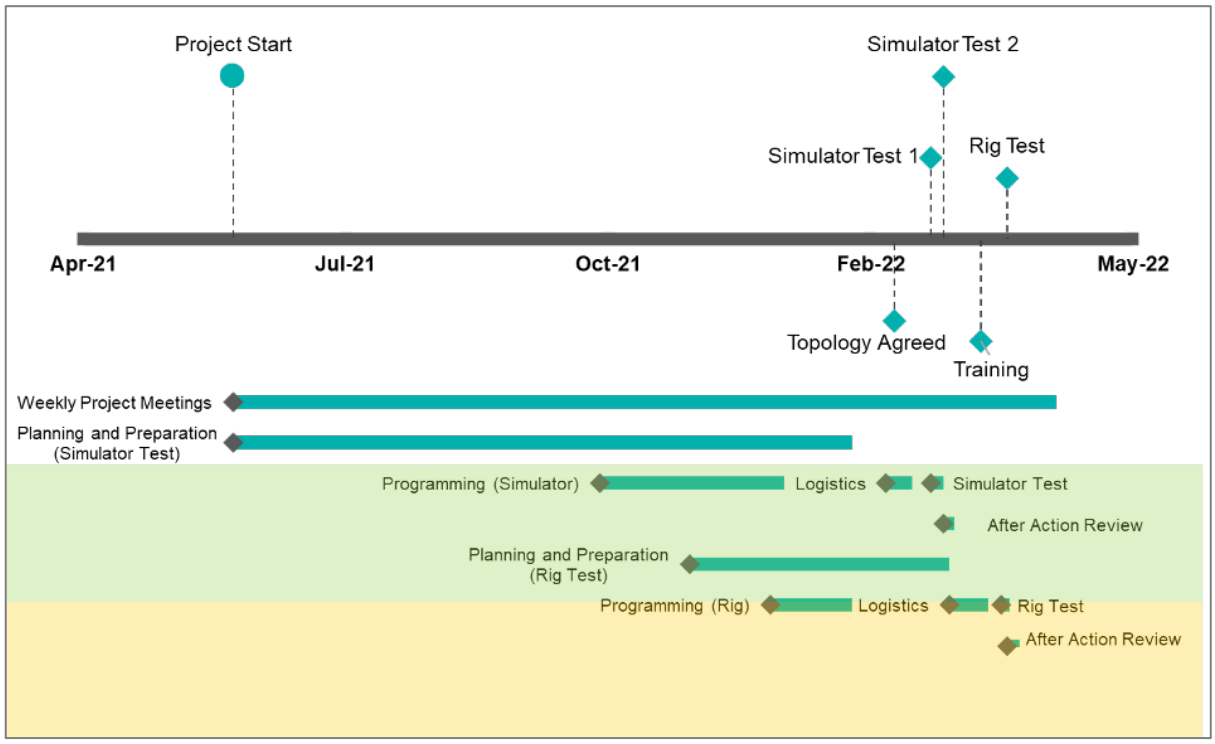


*Figure 3 Simulator and Rig Test Timeline*

The timeline of the Project is shown in *Figure 3* above

#### 4.2.4.1 Remote Simulator Test – Arbroath, UK

A simulator test was performed by the collaboration between the UK, Norway, and USA teams and was a precursor to the rig test such that interfaces, I/O addresses etc. could be proven. It was executed at the Finesse Control Systems facility in Arbroath, UK, using the virtual simulator setup as described above.

Two successful remote simulator tests were conducted to establish and test the interface arrangements to ensure that:

- The Safe Influx Automated Well Control system can be integrated with the NOV Drilling and BOP Operating Control systems.
- The integrated system successfully functions and completes the automated shut-in sequence on detection of an influx.

The test was conducted during two separate instances:

- **03 Mar 2022** – a full test team and conducted 6 tests to prove connectivity and control of the NOV systems. These were conducted successfully, but a PLC software error prevented verification of the control sequence.
- **08 Mar 2022** – the software issue was identified, and a further 9 tests were conducted with a small test team to prove the control sequence was valid across several scenarios. These tests were all successful.

For all tests, the expected and actual outcomes were documented. All Integration tests were performed, and all were completed successfully without significant issues. All pre-agreed Test Criteria were met.

A comprehensive report of this field trial can be viewed as a separate document.

#### 4.2.4.2 Rig Trial- NOV Test Rig- Navasota, TX, USA

In **April 2022**, a rig trial and integration test between Safe Influx Automated Well Control system and the NOV Amphion Rig Drilling and BOP Operating Control Systems was executed at NOV's STC Test Rig in Navasota, TX, USA. This rig-based test was the second phase of the required Safe Influx/NOV Integration after the successful evaluation of the Automated well Control in the benign simulator environment. The test was performed to establish and test the interface arrangements to ensure that:

- The Safe Influx Automated Well Control system can be integrated with the NOV Operating Control systems.
- The integrated system successfully functions and completes the automated shut-in sequence on detection of an influx.

The test was conducted as detailed below:

- **01 Apr 2022** – the test team conducted 5 tests to prove connectivity and control of the NOV systems.

The following highlights were recorded during the trial:

- Successful integration of Automated Well Control system with an Amphion Rig and BOP operating control system.
- Rig test have achieved the objectives set out.
- The Automated Well Control equipment was installed physically by the Safe Influx and NOV team in Houston.
- Proper planning, experience, and competent personnel were the key factors that contributed to the success of this project.
- This integration combines the functionally of both systems to provide a comprehensive automated well control package to the upstream industry.
- All activities conducted during the field trial and the mobilisation and demobilisation activities were incident free.
- The test was recorded on the NOV RigSense system.

For all tests, the expected and actual outcomes were documented. All Integration tests were performed, and all were completed successfully without significant issues. All pre-agreed Test Criteria were met.

A comprehensive report of this field trial can be viewed as a separate document.

## 4.3. System Verification

### 4.3.1. Lloyds Register Technology Qualification

The Automated Well Control system has been qualified by Lloyds Register and comes with a Lloyds Qualification Certificate for both cyber and traditional rig application.

The Technology Qualification (TQ) Process developed by Lloyds Register is a methodology to assess and help risks introduced by novel technology.

- *TQ is a robust and systematic risk management process that demonstrates to interested parties that the uncertainties introduced by a novel technology, or new application of an existing technology, have been considered and that any associated technology risks have been mitigated.*
- *TQ is a risk-based process that uses the readiness level framework, a total system perspective and lifecycle approach to qualify innovative technologies, unconventional designs, and new ways of applying existing technology.*
- *TQ is a methodology that provides assurance to Owners, Operators, suppliers, and investors at the distinct stages of novel technology development.*

The qualification process included a detailed Failure Mode Effect Analysis (FMEA), Factory Acceptance Test (FAT) and Site Acceptance Test (SAT). The SAT was performed as part of the October 2019 test that was performed on a test land drilling rig in Aberdeen, Scotland (see Section 4.2).

The certificates relevant to this process are listed in *Table 7* and can be viewed as a separate document.

| | | |
|---|---|---|
| Cyber Rig | TQ19/WD/PRJ1109991033 | 16-Apr-2019 |
| Cyber and Traditional Rig | TQ19/WD/DIS_UK2613 | 21-Oct-2019 |

*Table 7 Technology Qualification Certificates*

### 4.3.2. API Specification 16D

Acknowledging that automation of well control processes could encroach on statements in commonly used Standards and Procedures, Safe Influx have performed a comprehensive GAP analysis of the overarching document - *API Specification 16D, Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment (Third Edition, November 2018).*

Although Automated Well Control is not necessarily covered by API Specification 16D, a measure of conformance to API16D can be applied given that any API specifications are intended to ***'facilitate the broad availability of proven sound engineering and operating practices'***.

A total of 789 sections of API16D were reviewed and a summary is provided in *Table 8*. The full analysis can be provided on request.

| Responsible Party | |
|---|---|
| Not Applicable to Automated Well Control System | 652 |
| Purchaser | 3 |
| Manufacturer | 111 |
| Safe Influx | 23 |
| | **789** |

*Table 8 API 16D Analysis*

Several actions, mostly pertaining to documentation, were identified by the GAP analysis and once these actions have been closed out, the Safe Influx Automated Well Control System can be considered as meeting the spirit of this specification and 'conforming' to API16D.

### 4.3.3. API Bulletin 16H

The API 16H bulletin provides information on existing and emerging technologies that could be integrated to bring a well to a safe state in the event other operational barriers fail. The bulletin discusses strategies to create an automated blowout preventer actuation system, the challenges and obstacles associated with these types of system, current existing technology, and the methods of achieving widespread implementation of such a system.

Safe Influx have performed a comprehensive GAP analysis of the document API *Bulletin 16H, Automated Safety Instrumented Systems for Onshore Blowout Actuation (First Edition, February 2022)* to achieve a measure of compliance to the recommendations in the Bulletin

A total of 118 sections of API16H were reviewed and a summary is provided in *Table 9*. The full analysis can be provided on request

| Responsible Party | |
|---|---|
| Not Applicable to Automated Well Control System | 39 |
| Complies | 43 |
| Conforms | 9 |
| Considered | 18 |
| Future Modules | 9 |
| **Total** | **118** |

*Table 9 API 16H Analysis*

The conclusion of this analysis is that the current Safe Influx Well Control System MVP and programmed additional modules are fully compliant with the requirements of API16H

### 4.3.4. Cyber Security

Safe Influx recognises the concern of operators and drilling contractors that essential well control equipment could be vulnerable to external hacking. At present, Safe Influx Automated Well Control technology does not have, nor does it rely upon, any connection to the internet or use of wireless technology thus significantly reducing the exposure to cyber-hacking.

Future development of the technology will include modules that require it to connect to the internet. Such modules would allow remote troubleshooting, software updates and system monitoring to be established. Safe Influx will collaborate closely with the customer to ensure that the technology strictly adheres to relevant Cyber Security policies and international standards (IEC62443-4-1)

## 4.4. System Documentation

### 4.4.1. Patent

To protect Intellectual property (IP), the Safe Influx Automated Well Control system has been granted a patent in the United Kingdom to cover the 'drill ahead' base product (drilling and tripping) and 34 additional modules to cover the entire well construction lifecycle.

Patents are pending in United States of America (expected award: Q4 2022) and Europe, Canada, and Australia (expected award: 2024). See *Table 10* for a summary patent status. The UK Patent certificate can be viewed as a separate document.
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| Country | Application No. | Filing Date | Patent No. | Status |
|---|---|---|---|---|
| United Kingdom | | 02-Apr-19 | GB2581586 | Granted |
| United States of America | 16/788,983 | 12-Feb-20 | | Pending |
| Canada | 3135675 | 01-Apr-20 | | Pending |
| Australia | 2020254965 | 01-Apr-20 | | Pending |
| Europe | 20720733.3 | 01-Apr-20 | | Pending |

*Table 10Patent Status*

### 4.4.2. Comparative Human Factors Analysis

Given that a sizeable number of Well Control Incidents have been attributed to Human Factors (up to 70% have been reported by some sources), Safe Influx commissioned a comprehensive study to compare the human factors influence on traditional manual well control methods with the automated system.

The analysis provided a clear demonstration of the reduction in the human failure risks that the Safe Influx Automated Well Control system brings to the traditional well control method, which is achieved by a combination of factors including (but not limited to):

- Reduction in the overall number of task steps.
- Elimination of 'situation evaluation' type activities from the well shut-in process.
- Reduction in the cognitive workload and time pressures for the driller.

The quantitative assessment demonstrated that the human error probabilities associated with the traditional well control method would be reduced by **more than 90%** when the Safe Influx Automated Well Control system is used.

The full report can be downloaded from *www.safeinflux.com/reports*

### 4.4.3. Technology Readiness Level (TRL)

The concept of Technology Readiness levels was originally developed by NASA as a method of measuring the maturity of technology. Generic details of this process are included in *Figure 4*. This concept has been employed by Safe Influx to ensure that the maturity of the Automated Well Control Technology is documented, and it is considered that the Safe Influx Automation system is categorised as TRL-8 (System Completed and Qualified) and is ready for field deployment.


*Figure 4 Technology Readiness Level*

### 4.4.4. Management Processes and Documentation

Acknowledging that innovative products require robust processes and documentation, the Safe Influx document control system ensures that auditability and discipline can be applied to all Safe Influx systems.

*Table 11* details Key documents/templates in this system:

| Document Number | Contents |
|---|---|
| SATECP005 | Factory Acceptance Test Procedure |
| SATECP006 | Site Acceptance Test Procedure |
| SATECM021 | Safe Influx System Operator Manual |
| FXTECT032 | Conventional Rig Site Survey Report Template |
| FXTECT031 | Cyber Rig Site Survey Report Template |
| SATECM034 | Safe Influx HMI Training Manual |
| SABUSS040 | Product Development Process |
| FATECP011 | Software Configuration Management Procedure |

*Table 11 Key Documents*

Links to these documents can be shared with stakeholders on request

### 4.4.5. Provided Documentation

System documentation requirements have been defined by Safe Influx. *Table 12* details the documents that will be supplied with each system:

| | Document |
|---|---|
| 01 | Electrical Schematic diagram of panels and interconnections |
| 02 | Cable List |
| 03 | PLC I/O List if any required |
| 04 | Operating and Maintenance Instructions |
| 05 | Acceptance Test Document |
| 06 | ATEX Certification Book |
| 07 | CE Certificate of conformity |

*Table 12 Supplied Documentation*

## 5. Future Development Roadmap

Safe Influx has developed an internal roadmap that depicts the existing technology MVP and provides and overall map to further develop and automate relevant drilling processes across the well life cycle from well development to well decommissioning (*Figure 5*). Some of the modules have already gone through a Proof-of-Concept simulator testing exercise. Safe Influx is committed to align this map to the customer needs and adjust the road accordingly.

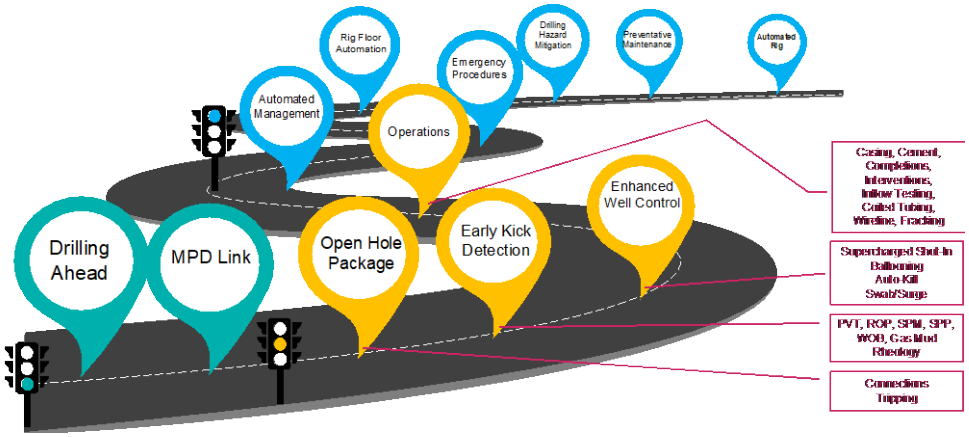


*Figure 5 Future Development Roadmap*

### 5.1 Collaboration

Please also note that the development of these modules can be accelerated through collaboration with external companies that already provide solutions for these engineering challenges.

The functionality of these products can be used as an input module into the Safe Influx Automated Well Control system. A good example of this is the Safe Influx and Weatherford partnership interfacing the Weatherford Victus MPD system with the Safe Influx Automated Well Control system, providing automated primary and secondary well control.

End of Document



Certificates and documents mentioned in this material are contained in a separate volume. If you would like access to those documents, do not hesitate to contact Safe Influx.

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