

1809797

by Lourens Brits

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ARU/SRU Gas Detection Upgrade Project

1809797

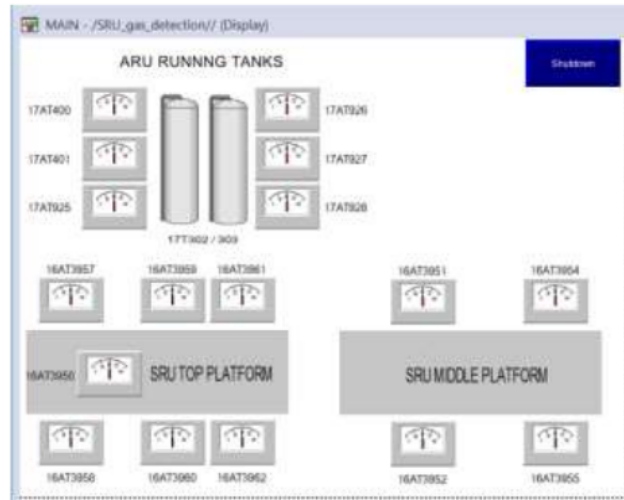
Lourens Brits

19/05/2023

Introduction

The project aims to upgrade the ARU/SRU gas detection system by amalgamating the three obsolete gas detection networks into one modern system.

- Achieved by installing the Draeger Regard 7000 controller.
- Replacing obsolete H2S gas detectors for Polytron 7000 detectors.
- Incorporating serial link communications from the Regard 7000 controller to DCS for live gas level monitoring.
- Creating appropriate DCS graphics to ensure efficient and accurate response to H2S gas leaks.
- Simulation created to show system functionality



Functional Design Specification - Amendments

Amended FDS - Simulation

2	Maintenance Activities	
2.2	Maintenance Overrides and Inhibits	Alarm inhibits must be available to enable maintenance activities. Inhibits must be captured using established site procedures
2.3 c	Loss of Power Recovery	The 24v power supply must have an N+1 redundancy configuration, where N is the number of supplies for the calculated load.
3	Environmental Requirements	
3.2	Electromagnetic Compatibility	Separation of signal and power cables and galvanic isolation
4	Performance Requirements	
4.2 a	System Response Time	The gas detection system must alert an operator through the DCS system of any gas release within 30 seconds,
4.4	Major Accident Survivability	The system must be able to produce an alarm signal in the event of a significant accident, i.e., signal cables open circuit
5	System Interfaces	
5.1 d	Operator Interface	In addition to the DCS alarms, hardwired fault loops must indicate: System Fault (0mA) & Detector Fault (3.6mA)
5.2	Alarm Levels	Gas detection alarm levels must be set to 5ppm (low) & 10ppm (high)
6	Power Supplies	
6.1 b	Electrical	Manufacturer-supplied 24v power supplies must be able to seamlessly switch to standby supply in the event of a failure.
7	Trip and Reset Philosophy	
7.1	Alarm Acknowledge	The gas-detected alarm output shall be latching. Acknowledge (AKN) switch must silence audible alarms with visual alarms staying active.
7.2	Alarm Reset	The system must only allow a full reset once all detectors are below 5ppm
7.3	Alarm Outputs (Audio / Visual)	Alarm outputs shall energise to trip (ETT) for audio/visual alarms

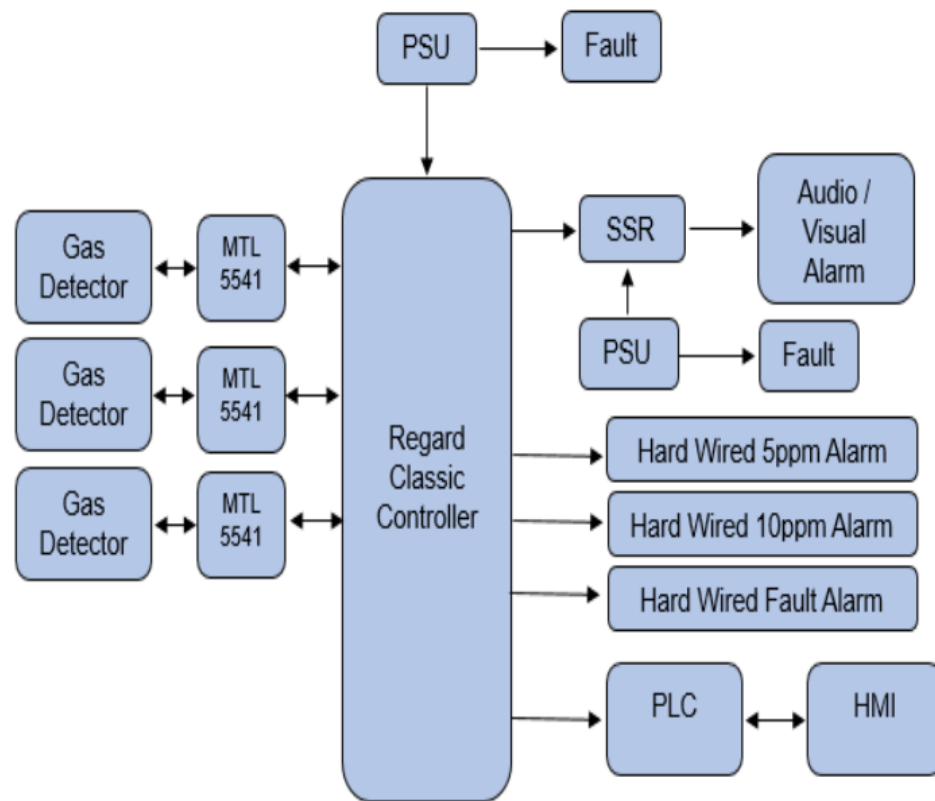
Original FDS

- Post-FDS approval modifications must be captured by following the company's management of change system. The supplier must be involved in the MOC to ensure a thorough impact assessment is carried out.
- Spare parts list has to be provided by the manufacturer to enable 2-year operation
- The MTTR must be 8 hours and must be supported by the availability of critical spares held on site
- Alarm inhibits must be available to enable maintenance activities. Inhibits must be captured using established site procedures
- The controller and audible/visual alarms must be supplied by separate uninterrupted power supplies (UPS). Seamless UPS switchover must take place in the event of mains power loss, at which time an alarm must be activated to the DCS
- SHELL DEP 33.64.10.10-GEN stipulates that the UPS must operate for 8 hours in the event of a mains power issue.
- The 24v power supply must have an N+1 redundancy configuration, where N is the number of supplies for the calculated load
- The system must be able to create application software back-ups and recovery implementation from portable devices
- Equipment installed in a hazardous area must achieve the following ATEX classifications shown in table 4 as a minimum. Refer to drawing 50-ZA-021 refinery master plot plan – hazardous areas
- The system must comply with the EMC Directive 2004/108/EC. Separation of signal and power cables, galvanic isolation and correct earthing techniques must be adhered to
- All external elements of the project must be suitable for operation in the conditions laid out in Table 5. Equipment selection must account, where possible, for the coastal location of the refinery
- DeltaV must be utilised as the master sequence of event and alarm recorder.
- The HMI must be used for secondary SoE recording.
- The gas detection system must alert an operator through the DCS system of any gas release within 30 seconds, including detector response time
- The gas detection system action time must be less than 500ms
- The processor must be able to function under full load conditions where all detectors have reached maximum mA output
- The system must be able to produce an alarm signal in the event of a significant accident, i.e., signal cables open circuit
- The system must provide the operators with two interfaces for the gas detection system. The primary interface must be the DCS DeltaV control panel, with the secondary being the local HMI housed in the RIE
- Any gas release incident must activate an alarm on DCS with a graphic showing the exact location of the detector in alarm. Information on which detector alarmed first must be available in detail on the graphic
- The controller must relay the fault conditions shown in table 6 through the Modbus serial link to the DCS via DeltaV alarms reporting protocol to NAMUR standards as well as the HMI
- In addition to the DCS alarms, hardwired fault loops must indicate • System Fault (0mA) • Detector Fault (3.6mA)
- Gas detection alarm levels must be set to the thresholds
- The SRU / ARU gas detection system must operate with 110v AC UPS backed-up supplies. The controller and audible/visual alarms must be fed from separate UPS backed-up supplies
- Manufacturer-supplied 24v power supplies must be able to seamlessly switch to standby supply in the event of a failure.
- 110V supply must meet the parameters set

Design Details to Meet FDS Requirements

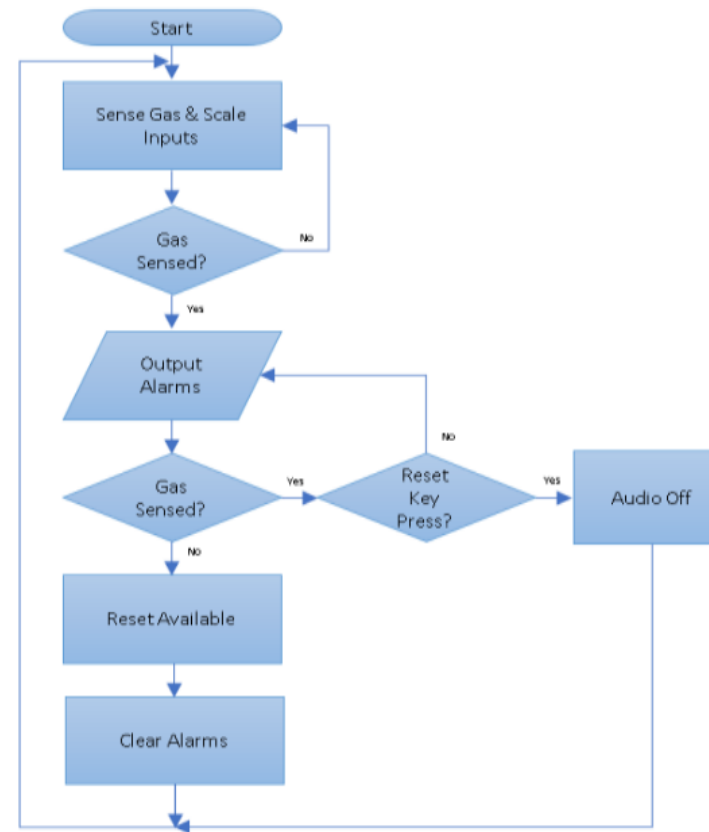
Hardware Design

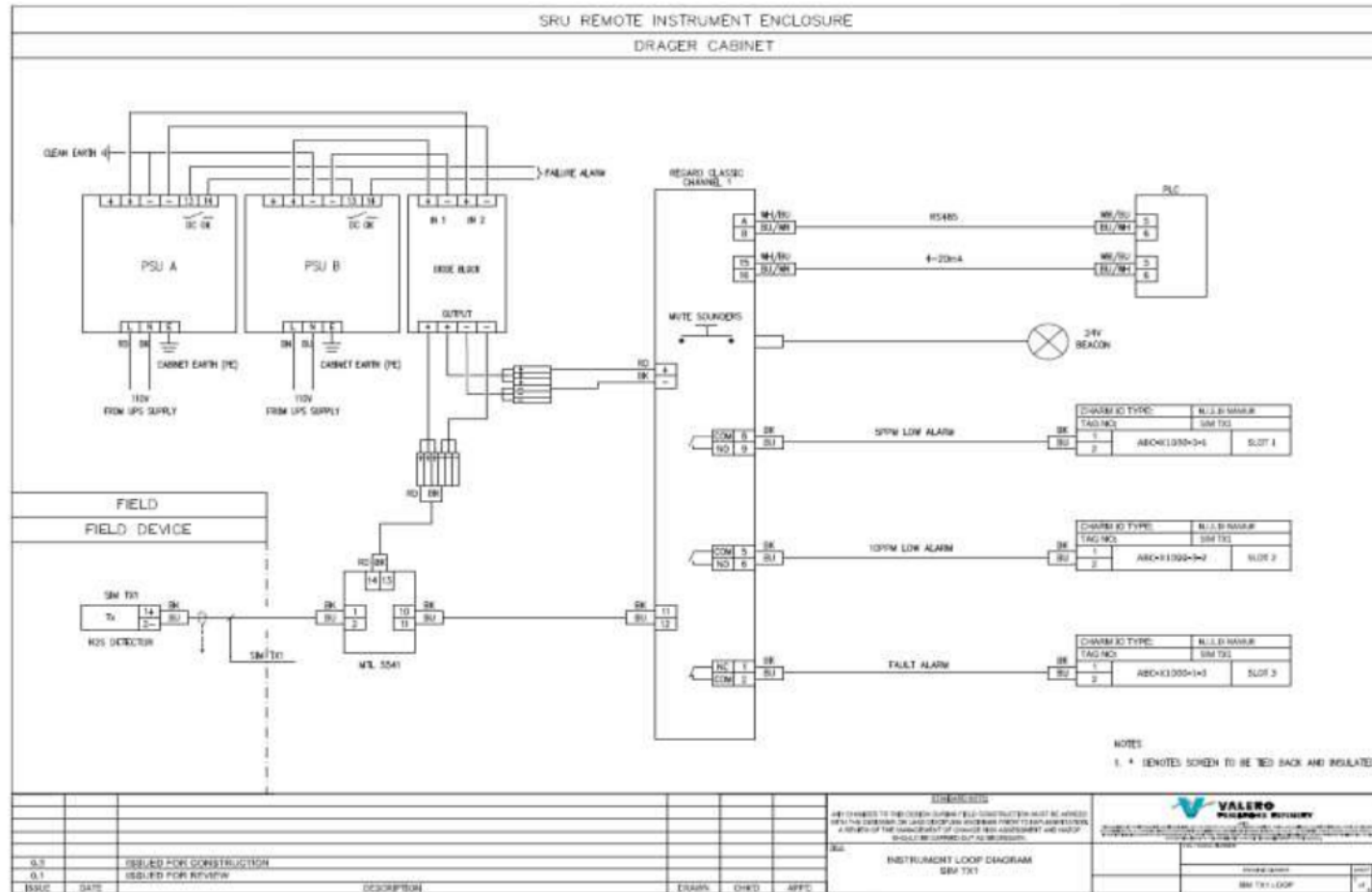
- Block diagram created to give a system overview



PLC Ladder Design

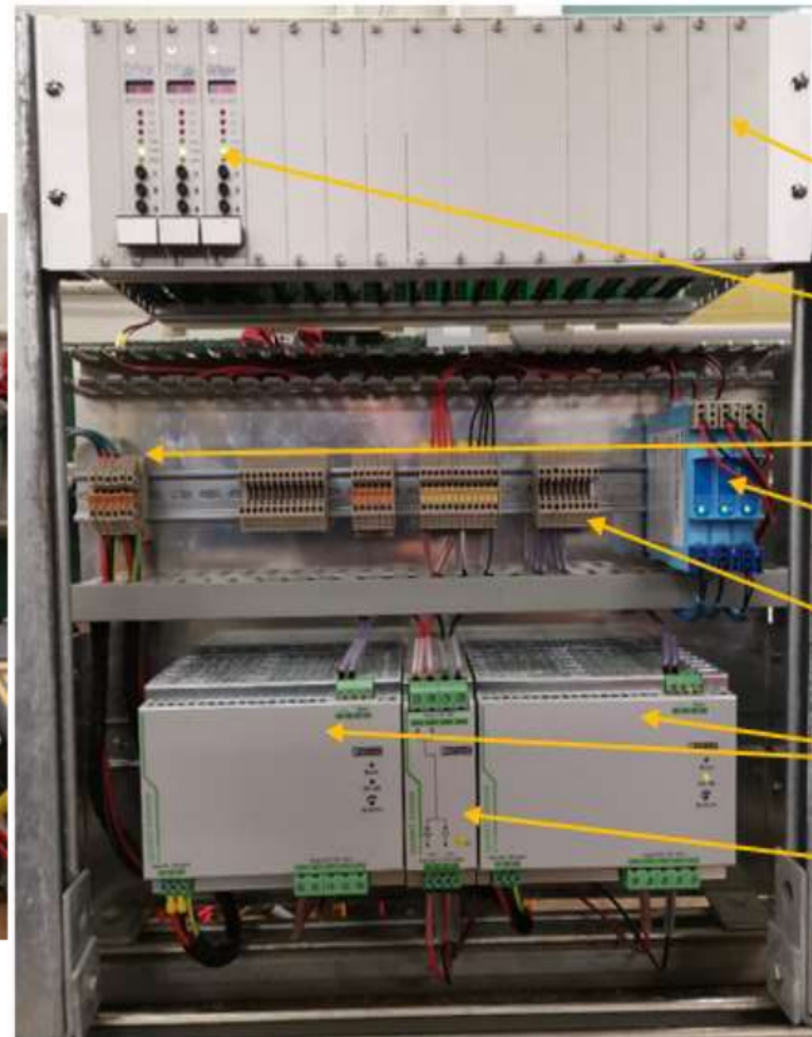
- Flow diagram to aid in creating PLC logic





Simulation Construction - Hardware

- Designed and built with sustainability in mind
- Components to be re-used in main project where applicable
- Regard Classic controller to be kept as running spare



Regard Classic Controller Chassis

4-20mA Analogue Cards

110v AC Supply

MTL 4451 Galvanic Isolators

PSU Fault Signal Terminals

Dual PSU's

Redundancy Diode

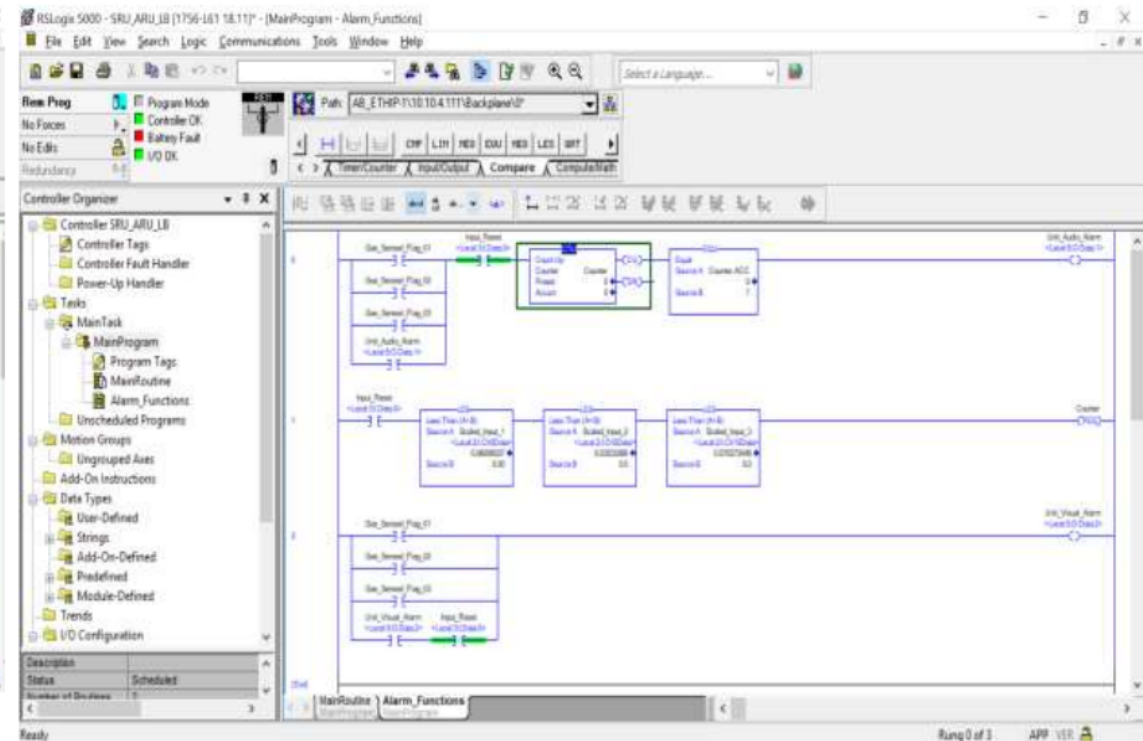
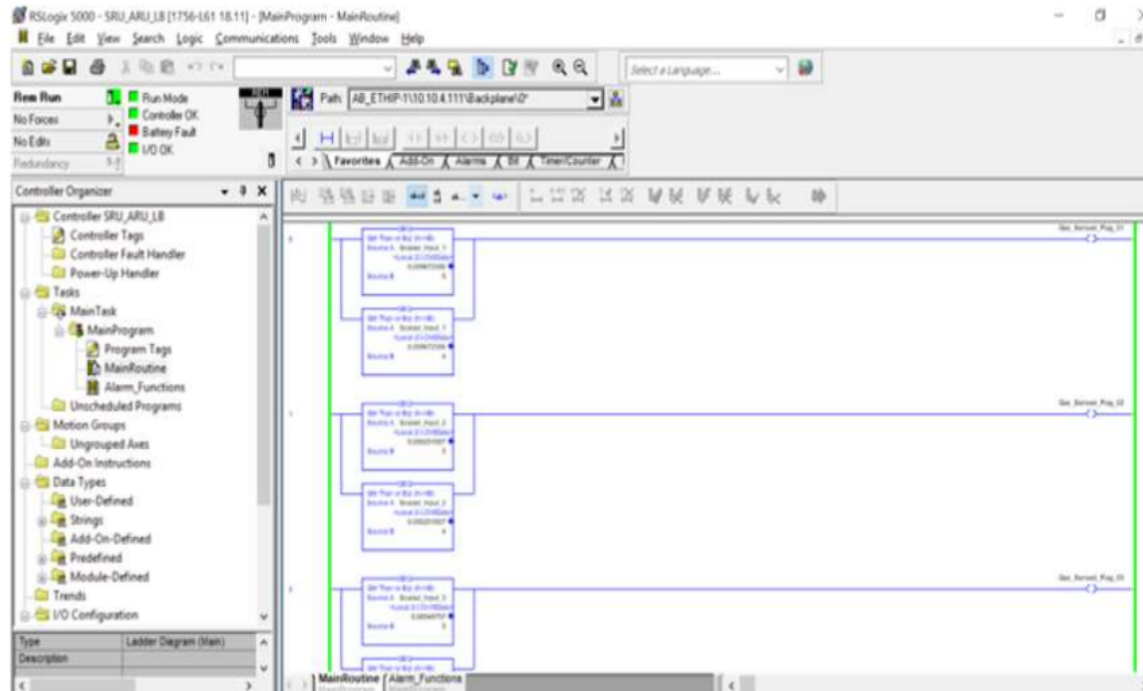
Simulation Construction – PLC Logic

Main Logic Routine

- Simplistic, yet functional design to aid in commissioning and fault finding
- Three pairs of GEQ function blocks with dead band of 1 ppm to energise alarm outputs
- Scaled 4-20mA input from AI card

Alarm Logic Routine

- Three non-latched input contacts tagged to main routine output contacts
- Latched reset contact to de-energise rung and silence audio alarm
- CTU and EQU blocks enable the reset input to function correctly
- LES blocks enable correct CTU reset function
- Visual alarm is latched on last rung – will only reset when gas is <5ppm



When using a RES instruction for a:	The instruction clears:
TIMER	ACC value to 0 control status bits to false
COUNTER	ACC value to 0 control status bits to false
CONTROL	POS value to 0 control status bits to false

on Construction – PLC Logic

Ladder Logic Function Blocks			
Function Block	Description	Flow Chart	Purpose
GEQ Grtr Than or Eq (A>=B) Source A ? Source B ??	To test whether source A is greater than source B using the ≥ operator		Tests whether the three 0-20mA analogue inputs scaled to 0 - 25 are greater than 5 to energise the audio and visual unit alarm outputs
CTU Count Up Counter ? Preset ? Accum ? CU DN	The instruction counts up each time the condition switches to true	n/a	Counts up to 1 in the event either "Gas_Sensed_flag" is true.
<RES>	The instruction resets the CTU counter	When using a RES instruction for a: The instruction clears: TIMER COUNTER CONTROL ACC value to 0 control status bits to false ACC value to 0 control status bits to false POS value to 0 control status bits to false	Resets the CTU counter and is preceded by three LES functions
EQU Equal Source A ? Source B ??	The instruction tests whether source A is equal to source B using the = operator		The EQU function tests whether the CTU output is equal to 1 and energises the "Unit_Audio_alarm" if source A is equal to 1
JSR Jump To Subroutine Routine Name ? Input Par ? Return Par ?	The instruction invokes a subroutine		The JSR function is used to jump to the alarm functions routine, thereby enabling the alarm logic
LES Less Than (A<B) Source A ? Source B ??	The instruction tests whether source A is less than source B using the < operator		LES functions are to ensure the CTU is only reset once the measured value falls below 5

Simulation Testing and Results

• FDS Test Table

FDS Item	Description	Expected Outcome	Actual Outcome	Pass / Fail	Evidence / Reference
4.2.2	Maintenance Overrides / Inhibits	Individual control cards can be inhibited for maintenance	Correct	Pass	Appendix Figure 18
4.2.3 c	Loss of Power Recovery	24v Power supplies have N+1 redundancy configuration	Correct	Pass	Appendix Figure 19
4.4.2	System Response Time	DCS alert generated within 30seconds of a gas release	Unable to Test	n/a	n/a
4.5.1 b	Operator Interface	DCS graphic indicates exact location and concentration of gas release	Unable to Test	n/a	n/a
4.5.1 c	Operator Interface	DCS graphic indicates which detector alarmed first	Unable to Test	n/a	n/a
4.5.1 d	Operator Interface	System Fault, Gas detector fault and both power supplies failures initiate an alarm on DCS	Unable to Test	n/a	n/a
4.5.1 e	Operator Interface	System fault (0mA) and detector fault (3.6mA) loops are hardwired to DCS	Unable to Test	n/a	n/a
4.5.2 a	Alarm Levels - H2S	Alarm levels set to 5ppm - low and 10ppm - high for H2S	Correct	Pass	Appendix Figure 21
4.6.1 c	Electrical Requirements	Voltage and frequency requirements are met within tolerance - 110v (5%) @ 60 Hz (2%)	117.2v	Fail	Appendix Figure 22
4.6.1 d	Electrical Requirements	Power supplies seamlessly switch to standby supply in the event of a failure	Correct	Pass	Appendix Figure 23
4.7.1 a	Trip and Reset Philosophy	The gas detected alarm output is latching	Correct	Pass	Appendix Figure 25
4.7. b	Trip and Reset Philosophy	Audible alarms are silenced by the AKN switch with visual alarms still energised	Correct	Pass	Appendix Figure 26
4.7. c	Trip and Reset Philosophy	Full reset is only allowed once all detectors are below 5 ppm	Correct	Pass	Appendix Figure 27
4.7. d	Trip and Reset Philosophy	Alarm outputs energise to trip (ETT) for audio/visual alarms	Correct	Pass	Appendix Figure 28

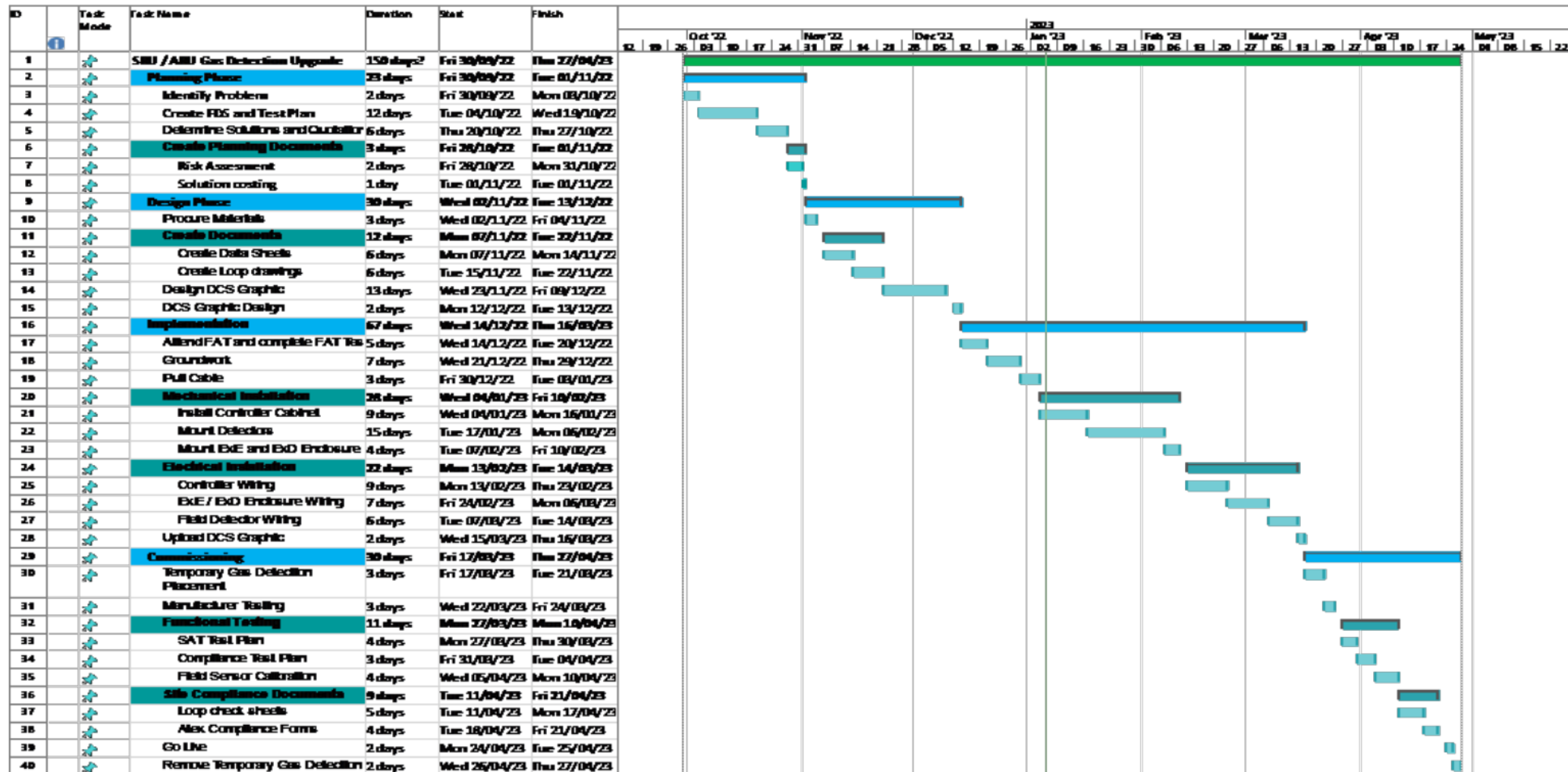
• PLC Logic Test Table

Simulation PLC Logic Test Table			
Test Description	Expected Outcome	Pass / Fail	Evidence / Reference
Analogue Scaling blocks correctly scale the 4-20mA signal to 0-25ppm	4-20mA signal is scaled to 0-25ppm	Pass	Appendix Figure 29
Gas sensed outputs energise when scaled value is >5ppm	Gas sensed outputs energise above 5ppm	Pass	Appendix Figure 30
Gas sensed Inputs energise when 5ppm gas is sensed	Gas sensed inputs energise when gas sensed value is above 5ppm	Pass	Appendix Figure 31
Unit audio alarm activates at 5ppm	Unit audio alarm activates at 5ppm	Pass	Appendix Figure 32
Unit visual alarm activates at 5ppm	Unit visual alarm activates at 5ppm	Pass	Appendix Figure 32
Reset input contact deactivates the unit audio alarm	Unit audio alarm deactivates upon reset input contact energising	Pass	Appendix Figure 33
The unit visual alarm remains active once unit audio alarm is deactivated	The unit visual alarm remains active once unit audio alarm is deactivated	Pass	Appendix Figure 34
The unit visual alarm remains active whilst gas sensed is above 5ppm and the reset input is energised	The unit visual alarm remains active whilst gas sensed is above 5ppm and the reset input is energised	Pass	Appendix Figure 34
Alarm condition reset once gas sensed value is below 5ppm	Alarm condition reset once gas sensed value is below 5ppm	Pass	Appendix Figure 35

Management Techniques, Planning & Comparison

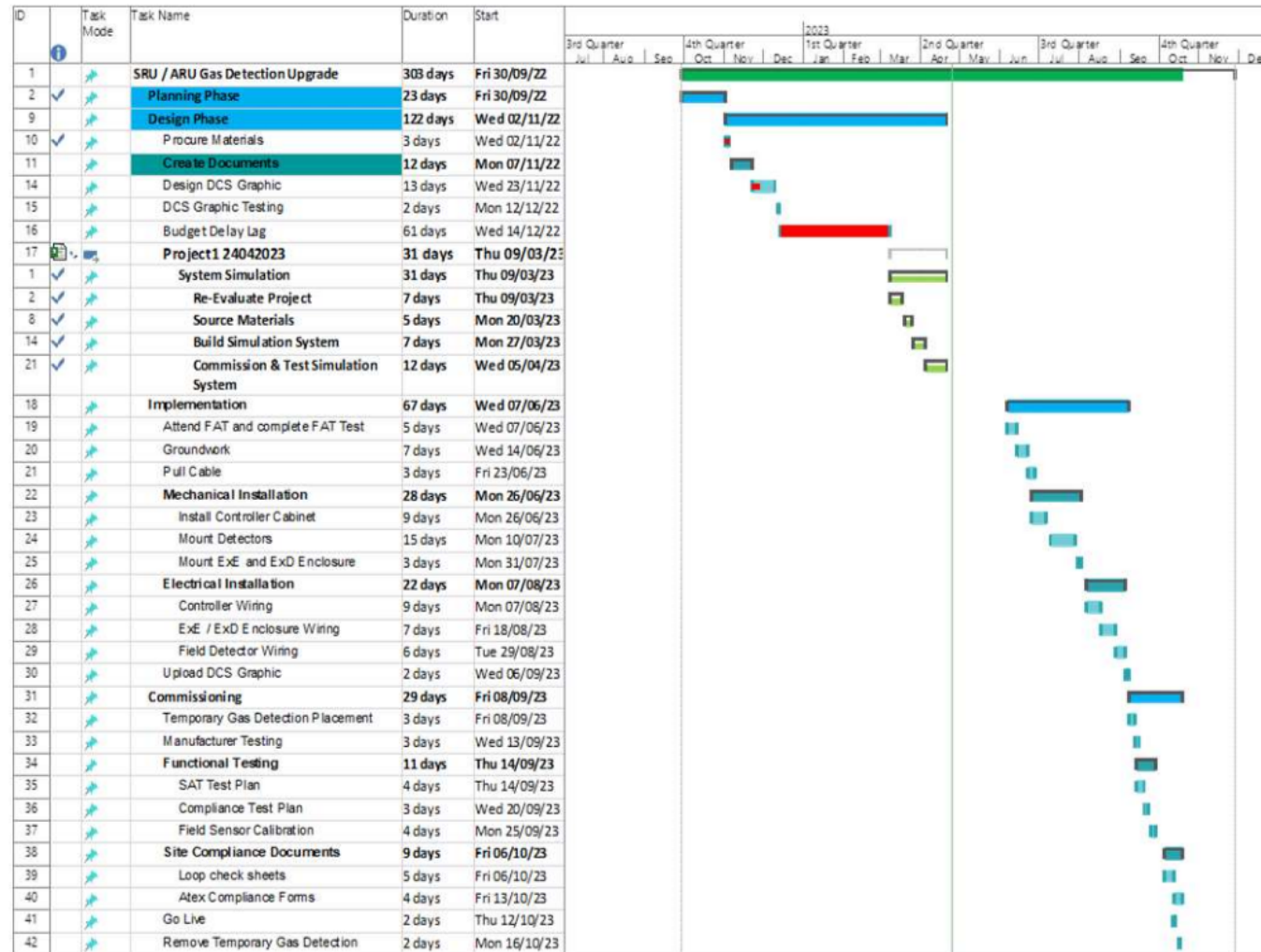
Original Gantt Chart

- Completion date 27/04/2023



Management Techniques, Planning & Comparison

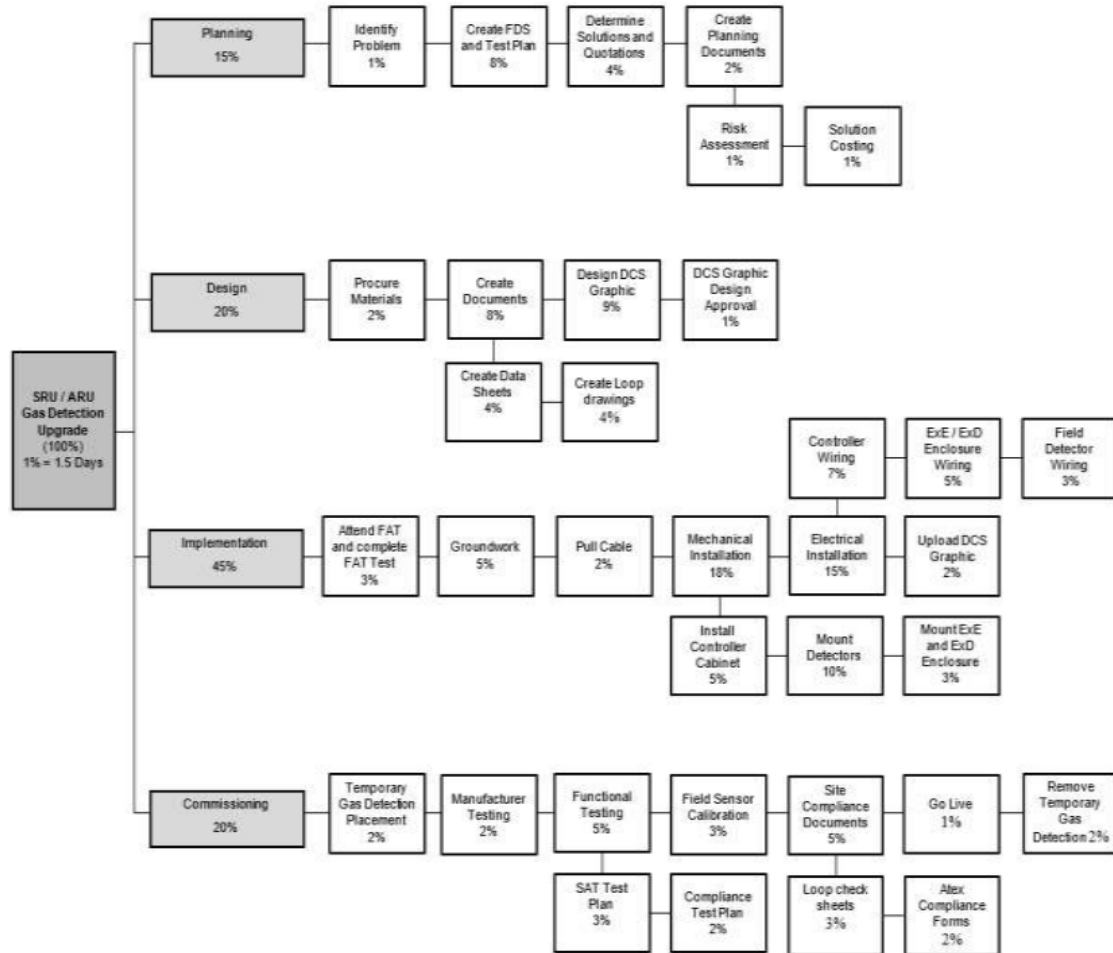
• Gantt Chart - Amended



- Revised Completion date 16/10/2023
- 61 day budget approval delay
- Simulation of project incorporated in main project timeline
- 30 days delay in implementation phase commencing – manufacturer lead time

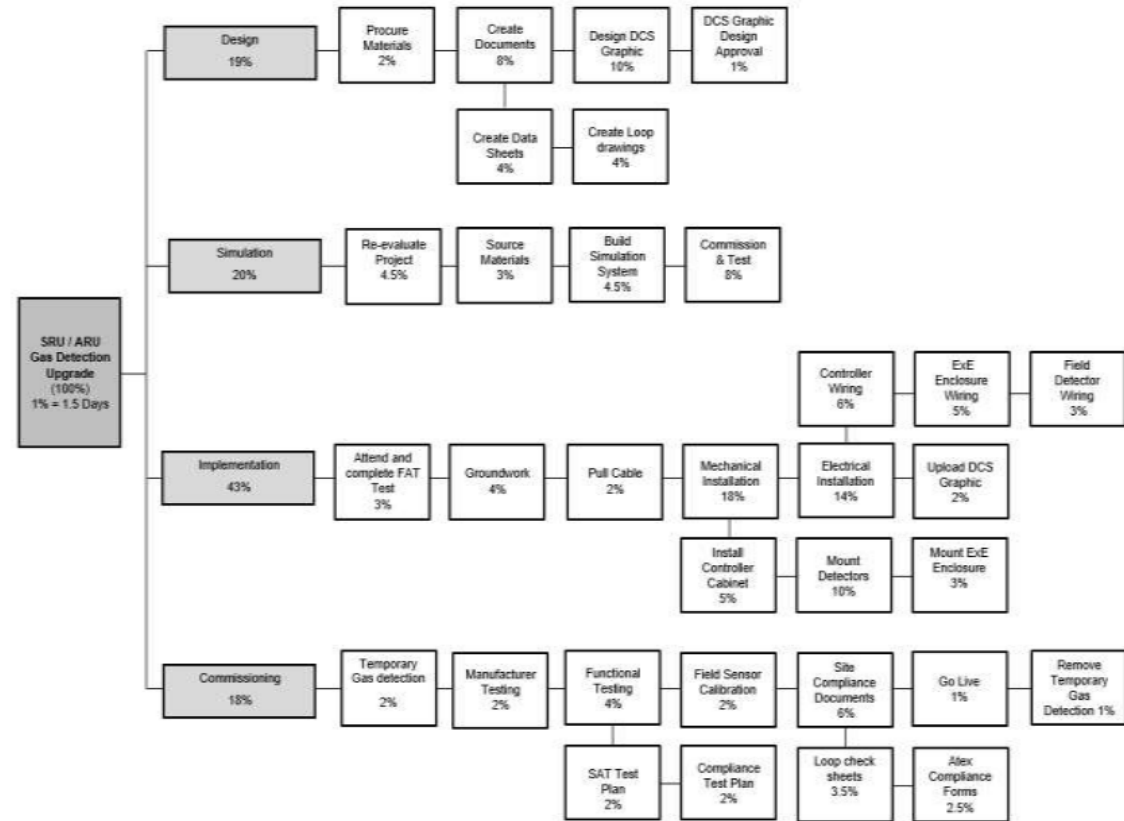
Management Techniques, planning & Comparison

Original WBS



Revised WBS

- Removal of planning phase
- Addition of Simulation phase



Management Techniques, Planning & Comparison

Simulation Component Costing			
Part	Qty	List Price	Actual Cost
Regard Classic Chassis	1	£8,000	Free Issue
Regard 4-20mA Card	3	£450	Free Issue
Polytron 7000 4-20mA Tx	3	£957.21	£2,871.63
Polytron 7000 Docking Station	3	£43.50	£130.50
H2S Sensor	3	£281.60	£844.80
PSU	2	£705.19	£1,410.38
Diode	1	£148.38	£148.38
Unistrut 1m	3	£12.40	£37.20
Bolts	20	£0.56	£11.20
Channel Nut	20	£0.74	£14.80
Washer	20	£0.54	£10.80
1.5mm single core 1m	20	£0.59	£11.80
Allen Bradley PLC	1	£2,663.91	Free Issue
Total Project Attributable cost			£5,491.49

Budget : £145 000.00

Draeger : £99 291.22

Labour : £7382.50

Hire : £4162.25

Drawings : £12 200.00

Total Predicted Expenditure : £123 035.97

Contingency : £21 964.03

	Procured Quote			Original quote	
	Quantity	Component Cost	Total	Component Cost	Total
9209378 Regard 7000 Control Panel	1.000	£19,914.75	£19,914.75	£21,258.63	£21,258.63
9209378 Compact Housing for Dashboard	1.000	£4,950.18	£4,950.18	£4,085.10	£4,085.10
9209378 Regard 7000 Parts	1.000	£17,740.28	£17,740.28	£18,849.05	£18,849.05
8317710 PEC7000 4-20mA HART D	17.000	£957.21	£16,272.57	£889.01	£15,113.17
8317990 Polytron 3000/7000 Docking Station	17.000	£43.50	£739.50	£40.41	£686.97
8317860 Sensor Diagnostic Dongle Polytron	17.000	£198.20	£3,369.40	£184.08	£3,129.36
6810435 DrägerSensor H2S	17.000	£281.60	£4,787.20	£379.40	£6,449.80
9209222 EXE Junction Box	1.000	£780.87	£780.87	£829.68	£829.68
9209222 EXD Junction Box	1.000	£2,732.94	£2,732.94	£3,416.18	£3,416.18
1965206 Installation - See Attached Scope	1.000	£6,375.00	£6,375.00	£6,375.00	£6,375.00
1965205 Commissioning	1.000	£1,830.00	£1,830.00	£850.00	£850.00
1965205 FAT	1.000	£750.00	£750.00	£750.00	£750.00
1965205 SAT	1.000	£1,000.00	£1,000.00	£1,000.00	£1,000.00
1940430 Crating and Shipping	1.000	£1,500.00	£1,500.00	£1,500.00	£1,500.00
Total Net Cost			£82,742.69	Total Net Cost	£84,292.94

Critical Evaluation of Project

- Delays were due to corporate budget re-approval and manufacturer lead times – out of project execution control
- Hardware procurement complete
- Groundwork and cable pull is in refinery schedule in line with revised Gantt Chart
- Simulation FDS testing resulted in one failure – 110v AC supply voltage outside tolerance – this will not be an issue in the main project
- Original project FDS on course to be met
- The system simulation proved to be a useful tool – Simulations should be implemented in future projects where applicable

Overall Conclusions & Recommendations

- The project is expected to be completed within the revised timescale
- The project is expected to be a success and will be delivered below budget, whilst achieving all functional design specifications
- Future improvements to the system should include boundary monitoring using Line of Sight detection systems
- Future project justifications need more exposure to upper management

FINAL GRADE

GENERAL COMMENTS

Instructor

74/100

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GRADING FORM: NEW CSG-RUBRIC

LOURENS BRITS

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1. ENGAGEMENT WITH LITERATURE



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2. KNOWLEDGE AND UNDERSTANDING



Project design
FDS was reviewed and reasons given for changes need and the switch to simulation. Good design

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evidence presented for flowchart, program and hardware circuit. (8/10)
Project implementation
Excellent build quality of hardware and good software build. (8/10)
Response to questions.
Very good answers given (8/10)

3. COGNITIVE AND INTELLECTUAL

 Testing and analysis of results
Good evidence of testing (7/10)
Critical evaluation of the project outcomes relating to FDS and constraints
Good evaluation given (7/10)
Conclusions and recommendations
Good explanation with a plan for moving forward (7/10)

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4. PRACTICAL APPLICATION

 Deployment method, use of material, tools, equipment and techniques in the construction of the project.
Very good methods and techniques employed (8/10)
Quality of the final product or system
Excellent quality (8/10)
Management of the design process including use of plans, costing spreadsheet
Very good management methods (7/10)

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5. TRANSFERABLE SKILLS



Quality of the presentation slides
Good quality but some slides have a lot of words (3/5)
Quality of the delivery style
Interesting style (3/5)

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