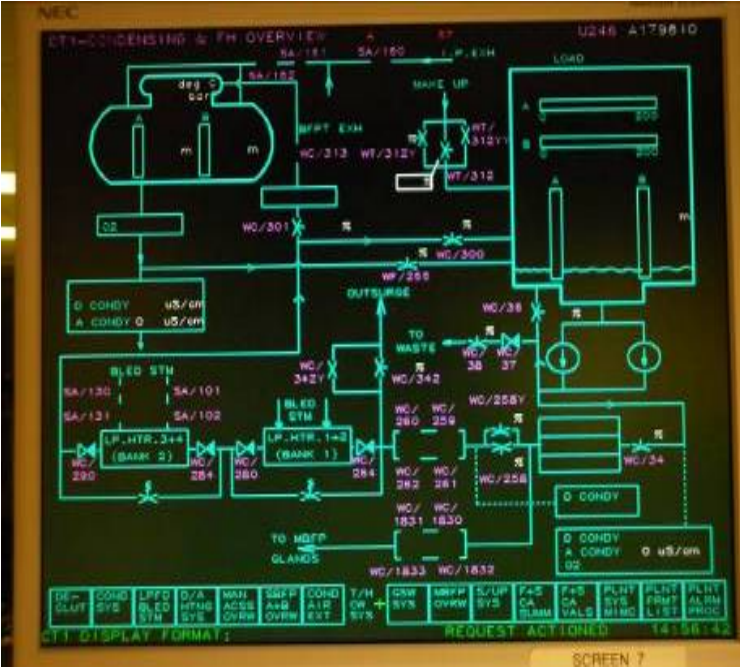


# ENERGIFORSK SEMINAR October 2016

## 'Management & Maintenance of a Legacy (but Critical) Data Processing & Control System' A. Milne (System Engineer)



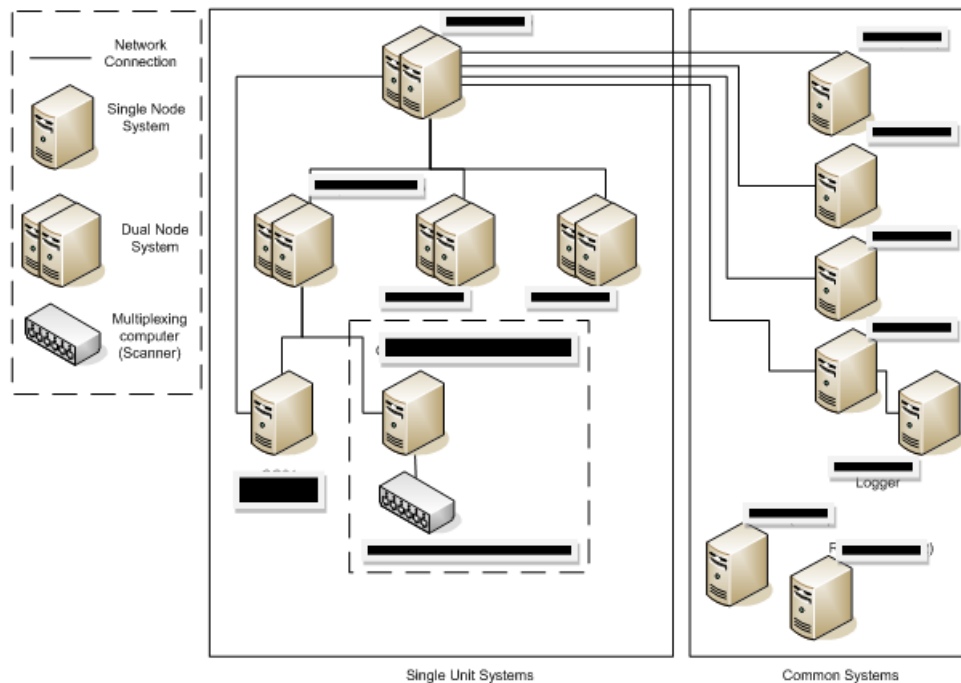
# Description of system

Torness Power Station DPCS (Data Processing & Control System) provides two main areas of functionality.

The Data Processing System (DPS) presents alarms and plant information to control room engineers.

The Auto Control (AC) system operates a number of auto control loops e.g. T2 control.

Both DPS & AC play significant roles in operational safety (i.e. are safety claimed/critical) with some failure conditions potentially resulting in reactor trip (i.e. failure to comply with safety regulation).



# History of system

The DPCS system (Ferranti) was designed in the 1970s/80s & is still in operation (with many original never replaced modules that now beyond MTBF). The system was initially used by the UK MOD for missile targeting/tracking but has been used in various military and industrial applications globally. Typically the hardware and operating system remained common whilst software applications have been tailored for use.

Although the underlying COTS system was used in various international locations and organisations (as far afield as India), there is now only one other known industrial user with the UK MOD having replaced their systems tens of years ago.

## Replace versus Retain

With regards to Torness power station an ALARP review was carried out between 2009-2011 with the end decision to retain the existing legacy system until end of station life (2030+4). Factors in the decision making included the cost, time & risk of any potential replacement balanced against the ability to maintain performance of the existing legacy system to the end of station life.

This approach has been communicated to the UK regulator and a process of substantiation has been put in place.

The substantiation revolves around known failure rates, sufficient spares, close monitoring of failures, identification of 'outwith normal' trends and sufficient forewarning of any unforeseen age related problems to provide time to either procure more spares and/or re-engineer a solution.

Regular reviews have continually reported the DPCS as operating within original design expectations (availability & integrity) with various OPEX suggesting reliability is at a peak.



# Challenges & Supporting Factors

## Legacy System Challenges

Obsolete DPCS (i.e. cannot purchase replacement HW modules).

DPCS replacement estimated to be £70M+, 7+ yrs development.

Legacy software programming language and tools obsolete.

Increasing commercial drive to improve system reliability.

Increasing regulator requirements (especially in computer security).

First & Second Line maintenance 'knowledge gap' – system 'grey beards' retired/approaching retirement.

## Supporting Factors

System perceived as reliable, fail rates within design expectations.

Although new modules cannot be obtained, most faults are repairable.

Although the OEM no longer exists, the core OEM team is still available.



# Support & Maintenance Strategy

*“..... the ability to maintain performance ... to the end of station life...”*

Can our approach work ? How do we check ?

In order to validate availability & reliability, several key programs were identified:

- **Fault and Failure (F&F) Analysis**
- **Spares Analysis**
- **Obsolescence Analysis**
- **SQEP reinforcement and monitoring**
- **Supply Chain Analysis**

To continue to provide the same levels of DPCS capability it was recognised the capability to change the system should be supported. This includes both

- **Software changes**
- **Hardware changes**



# Availability & Reliability (1) - Spares, F&F and Obsolescence Analysis

## Spares Analysis (SAR)

- How many do we have ?
- Which modules ?
- Are there enough (forecasting)?
- Do the spares work ? Storage?

## Fault & Failure Analysis

- Failure rates per module/location – trends?
- Which components are failing ?
- Supports SAR forecasting
- MTBF/Industry OPEX

## Obsolescence Analysis

- What components are used in each module (prioritisation)
- Still available/modern 'qualified' equivalent ?
- Supports Repair Loop (spares planning)



# Availability & Reliability (2) - SQEP Reinforcement, Supply Chain Analysis

## The People

- Which people ? When ?
- How many do we have ? What is the age profile ?
- What skills do they have ? gap?
- How best can knowledge be imparted ?

## The Organisations

- Strategic view – ‘outsourcing’ v ‘insourcing’
- Blue chip reputation – what is it ?
- Overall business dependency on ‘our business’
- ‘Insurance’ versus ‘flexibility’
- Contracts



# Underpinning Tools & Techniques (1)

## Asset Management Tool - Asset Guardian (data visibility & accuracy)

COTS 'plain' Asset Management System – strong tailoring capability  
System customised following detailed Use Case requirements phase  
Replaced several previous ad-hoc & unconnected systems  
Full configuration control linked with 'activity' tracking & repair loop.  
'One fits all' solution used for software & auditing (e.g. computer checks)  
Provides 'easy' GUI to analyse data – several KPI reports created

## Culture (attitude) – Fault diagnostics, resolution & tracking

Intolerance of failure v 'it's always been like that' (focus on faults)  
Closely monitor failures – ensure 'closed loop' wart repair loop understanding  
Use of AMS tool to properly record & document changes

## SQEP planning

What are the key local support skills ? Appetite for staff headcount changes  
Retirement plans – how committed ?  
SQEP 'Redundancy'  
Strategic view

## Documentation & review

All reports updated and reviewed by extended group involving local station 'grey beards', CTO & Vendor. Rigorous review process.  
Analysis & summary carried out on annually.

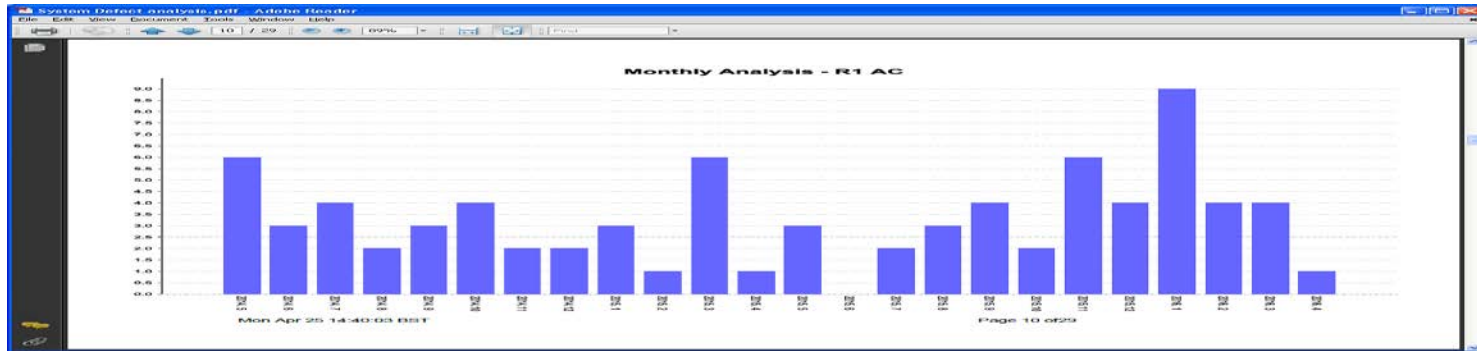
## Questioning attitude at all stages



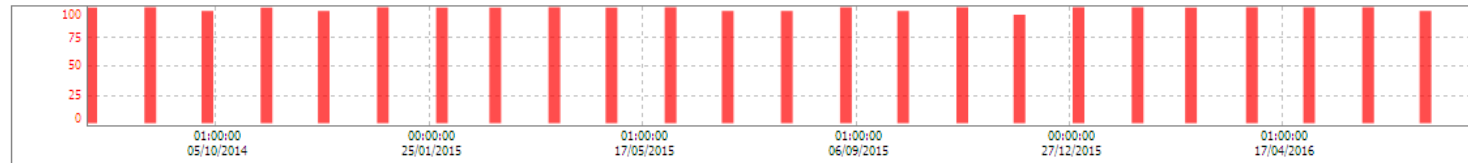


# Underpinning Tools & Techniques (2)

## System Availability



### Statistics For R2 - A



R2\_A\_AVAILABILITY

(CSV) (CSV all)

Year	Availability												Total
	January	February	March	April	May	June	July	August	September	October	November	December	
2016	100.00	99.97	100.00	100.00	100.00	100.00	100.00	0.00	0.00	0.00	0.00	0.00	100.00
2015	99.98	99.98	100.00	99.99	100.00	100.00	96.77	100.00	99.99	100.00	96.67	100.00	99.45
2014	100.00	99.93	100.00	99.91	100.00	100.00	99.97	100.00	100.00	99.98	100.00	100.00	99.98
2013	99.98	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	100.00	100.00	100.00	100.00

(reset)

Show Slots



# Underpinning Tools & Techniques (3)

## Asset Management System

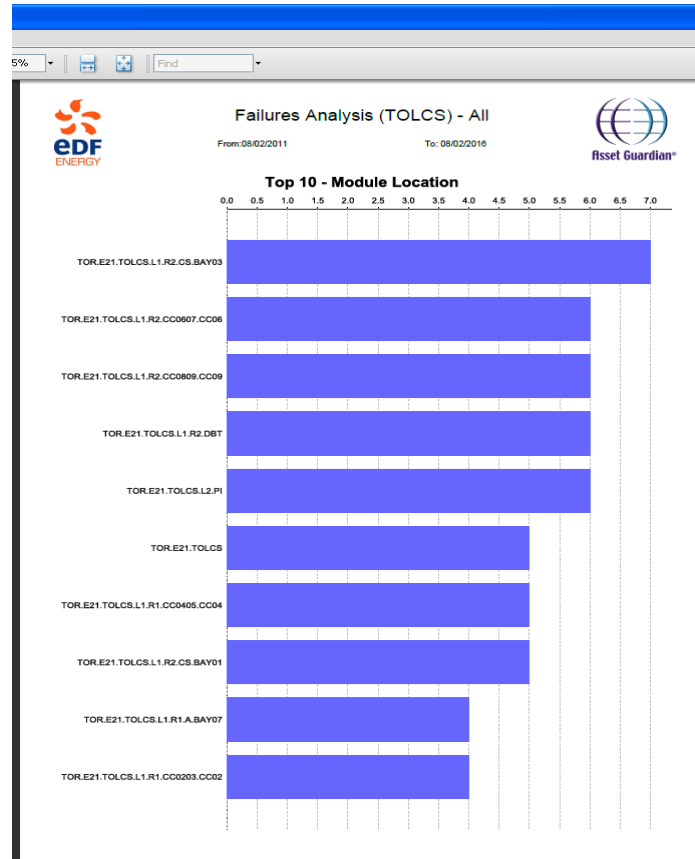
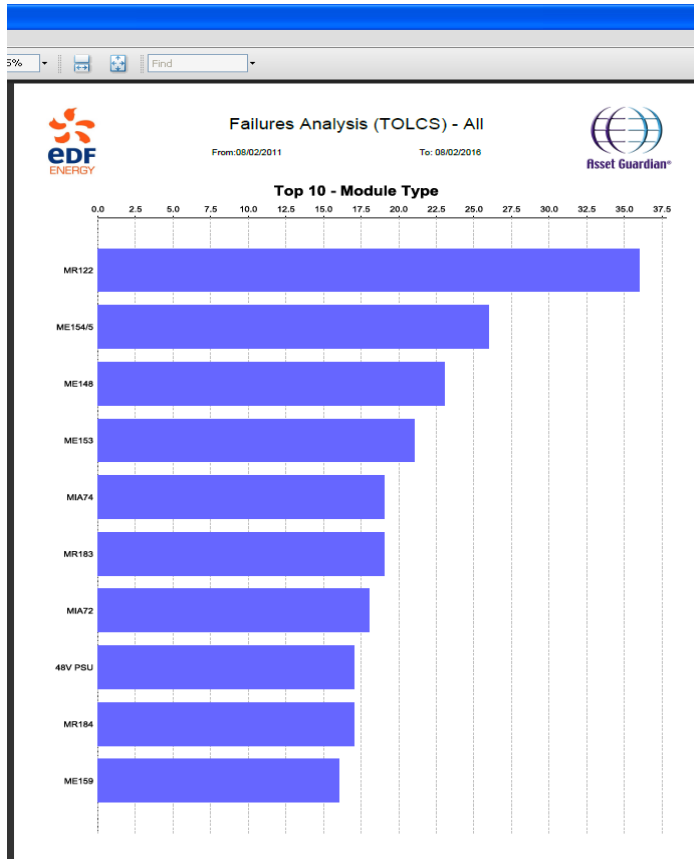
The screenshot displays the 'Asset Guardian' software interface. The main window shows a table of repair reports with columns for Asset, Repair ID, Module Type, Serial No., Fault Description, Status, and Notes. The table lists numerous repairs for assets like TOR.E21.TOLCS.L1.R2.D.BA and TOR.E21.TOLCS.L1.R1.CC00. A detailed view of a specific repair (RP140099) is shown in a pop-up window, detailing the module type (MR122), fan unit, and fault description: 'paddle loose, moving easily in/out of position whilst fan operational causing fleeting fan fail alarm.' The status is 'RETURNED'.

Asset	Repair ID	Module Type	Serial No.	Fault Description	Status	Notes
TOR.E21.TOLCS.L1.R2.D.BA	RP140095	MR122	903	Motor u/s- Stiff rotate.	Ret	RETURNED
TOR.E21.STORES.SAT - TOL	RP140064	MR122	2530	Motor ok but fan fail and alarm continually raise/clear	Ret	RETURNED
TOR.E21.TOLCS.L1.R1.D.BA	RP140570	MR122	1535	Fan unit seized.	Ret	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP140308	MR122	1619	Motor seized - burning smell.	Ret	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP140099	MR122	1635	paddle loose, moving easily in/out of position whilst fan operational causing fleeting fan fail alarm.	Ret	RETURNED
TOR.E21.TOLCS.L1.R1 - Res	RP140030	MR122	1652	Fans not running with smell of burning. Removed by R Mak	Ret	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP140029	MR122	1645	Fans intermittently failing to spin. Removed by R Mak	Ret	RETURNED
TOR.E21.TOLCS.L1.R2.CS.B	RP68440	MR122	1735	Fan unit seized.	Cal	RETURNED
TOR.E21.TOLCS.L2.P5.BAY0	RP68439	MR122	1674	Burning system and fans not rotating properly.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.A.BA	RP68436	MR122	600	Making loud rattling noise.	Cal	RETURNED
TOR.E21.TOLCS.L2.P5.BAY0	RP68384	MR122	1569	Faulty microswitch.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC1C	RP68383	MR122	1654	Fan not starting up properly, takes a long time to re	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP68382	MR122	91FRH2483	Fan paddle suspected faulty.	Cal	RETURNED
TOR.E21.STORES.MAIN.OLC	RP68270	MR122	1849	Microswitch not initialising fan fail alarm.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC00	RP68249	MR122	1676	Fan fail alarm standing - fan motor seized - replaced.	Cal	RETURNED
TOR.E21 - Torness DPS, AC1	RP68247	MR122	528	Fan failed, Overhaul required.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC1C	RP68239	MR122	320	Microswitch not working. Fans are rotating ok but fa	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP67479	MR122	603	Fan not working correctly. D Rollo Removed this.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC00	RP68664	MR122	1635	Motor noisy.	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP65602	MR122	2263	Fan motor seized.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC1C	RP65486	MR122	2392	Fault - Motor very noisy.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC00	RP65483	MR122	607	Fan seized.	Cal	RETURNED
TOR.E21.LSTF.LSTF3.BAY03	RP24632	MR122	2266	Dead.	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CC01	RP24581	MR122	1694	Fan stiff to rotate.	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP24473	MR122	1647	Fan stiff to turn.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC00	RP24430	MR122	554	Failed on/off over last couple of weeks. Still working	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CS.B	RP24329	MR122	1649	Removed from RICS BAY 5. Motor stuck. Fan fail mec	Cal	RETURNED
TOR.E21.TOLCS.L2.RD1 - 5y	RP24325	MR122	1575	Flow switch sticking.	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP24263	MR122	1614	Fan failed on plant- DEAD.	Cal	RETURNED
TOR.E21.STORES.MAIN.OLC	RP24156	MR122	1663	fan seized. R1 CC09.	Cal	RETURNED
TOR.E21.STORES.MAIN - TC	RP24105	MR122	1634	General confidence tests due to module being taken i	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP24078	MR122	1861	R1 Mux 0- Ser No in 1648- Fan fails alarm operating	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CC00	RP24065	MR122	1571	Seized.	Cal	RETURNED
TOR.E21.TOLCS.L1.R1.CS.B	RP24064	MR122	1504	Fan Unit defective. Alarm fault standing.	Cal	RETURNED Replaced by technician ar
TOR.E21.TOLCS.L2.P5.BAY0	RP24048	MR122	573	No power showing signs of the motor being burnt out	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.A.BA	RP23980	MR122	1561	Fan ok - but paddle causing alarm fault.	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC1C	RP23857	MR122	195	R2 Mux10. Intermittent fan fails alarm. MR122 inll	Cal	RETURNED
TOR.E21.TOLCS.L1.R2.CC1C	RP23671	MR122	1648	Faulty microswitch on Airflow switch.	Cal	RETURNED
TOR.E21.TOLCS.L2.BE.BAY0	BP23669	MR122	1636	Fan failed to rotate. Fan motor seized. Fan not attached to	Cal	RETURNED



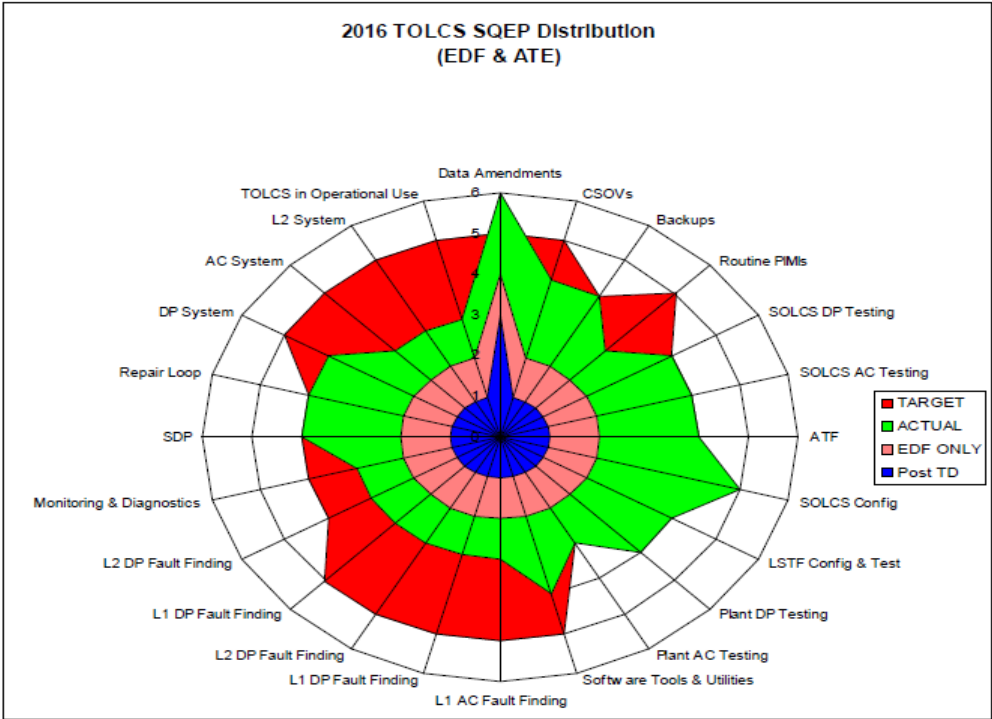
# Underpinning Tools & Techniques (4)

## Failure Analysis



# Underpinning Tools & Techniques (5)

## SQEP Planning



Axis : The numerical value on the graph represents the number of people for that role.



# Support for Change/Improvements (1)

The DPCS system is heavily relied upon as the main operational management system. There is a constant demand for changes and improvements to support new/changed plant and/or new/changed operational procedures.

The main stakeholder groups have traditionally included:

- Operators (improvements, automation)
- Project Teams (new signals)
- Internal (improvements)

Lately, the most significant demands have been from two main stakeholder groups:

- Station Management – reliability.
- Regulator – computer security
- Regulator – change related QA

These changes typically include BOTH hardware and/or software changes.

**Although DPCS reliability & functionality have peaked, there are increasing requirements and expectations.**



# Support for Changes/Improvements (2)

## Capability (Hardware)

- **Prioritised approach**
- **Use of AMS KPIs for 'best return on investment/effort'**
- **Element of reality i.e. PSUs are 'easy', dedicated logic chips 'hard'**
- **Equipment qualification can be very costly & time consuming.**
- **Commission Testing (practical ?).**
- **Maintenance change rather than replacement ?**

## Capability (Software)

- **Several highly complex legacy issues – multi year investigations**
- **Heavy dependence on handful of 'grey beard' personnel**
- **Limited resources**
- **Succession planning coupled with development opportunity**
- **Toolchain maintenance**
- **'Insurance' versus 'flexibility'**

## Cost versus Benefit



# OPEX

MG20 – Annual routine now established – already paid dividends!

R2 CC09 (electrolytic caps) – All L2, R2, SOCLS & LSTF addressed – R1!

R1 CC01 – PF options switch incorrect – extent of condition addressed.

Store relay replacement – based on well known OPEX and spot checks during the year. All R2 AC store relays bulk replaced during stat outage. R1 !

PSU Replacement – TOR OPEX (&EC substantiation/testing) shared with fleet. – Ongoing program of rollout.

MR257 Replacement – TOR OPEX (&EC substantiation/testing) – Ongoing program of rollout.

Thermal Camera Walkdown – prompted by SZB PSU issue. Several issues addressed including faulty MR172 auto changeover unit, poor PSU crimping, degraded PSU power cable (PSU replaced). Routine to be established.

System Console Replacement – TOR OPEX (& EC substantiation/ testing) shared with fleet.



# FUTURES

## Availability & Reliability

Continue with AMS KPIs and failure trend analysis

Complete ongoing priority fault investigations

Review OPEX & amend maintenance as necessary

Maintenance - 'Grey beards knowledge capture' – training & documentation

## Support for Changes/Improvements

Progress/complete ongoing hardware replacement programs

Computer Security Improvements

Continue to support stakeholder changes for DPCS integration.

## Strategic

Software change support – strategic view

Outsourcing v Insourcing (burden of cost will fall to station in 2023)

SQEP reinforcement – organisational restructuring (locally)

Minimum support needed ?





THANK YOU