ElectraNet Transmission Network Revised Revenue Proposal

Appendix O ElectraNet, System Condition and Risk Framework, January 2013

System Condition and Risk Framework

A framework for understanding asset risk in the transmission network

January 2013

Version 2.0

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1. Purpose

This report describes ElectraNet's System Condition and Risk (SCAR) framework and coding process and presents an analysis of the outcomes of applying this process to ElectraNet's substations and transmission lines.

Current defect profiles are presented as well as the sensitivity of these profiles to changing risk thresholds (defect response times). Analysis of these profiles provides a high level demonstration that the forecast corrective maintenance effort is robust to changing risk thresholds.

2. Introduction to SCAR

The condition and serviceability of all assets deteriorate as they approach the end of their technical life decreasing reliability and leading to increased maintenance effort and ultimately replacement to maintain serviceability.

The task of the asset manager is to understand where assets are in their lifecycle and all reasonably expected asset failure modes and to develop an appropriate timely response based on the risk and consequence of the failure modes identified.

ElectraNet's SCAR framework has been developed to minimise corrective maintenance effort in the long term by systematically identifying for each identified failure mode the maximum acceptable time to respond based on the risk and consequences of failure.

2.1 The P-F Interval

As assets deteriorate they will eventually reach the following points in the asset lifecycle:

- **Potential Failure** – Condition of the asset changes (slow deterioration) to a point where resistance to failure is compromised (a potential failure).
- **Functional Failure** – Condition of the asset continues to change following a potential failure (the rate of change is dependent on a wide range of internal and external factors) to a point where failure occurs (functional failure).
- **End of Technical Life –** Condition of the asset and external supporting frameworks (for example availability of spare parts, technical obsolescence, operational performance) continue to deteriorate to a point where it is no longer fit for purpose (end of technical life). End of technical life may be reached before reaching functional failure.

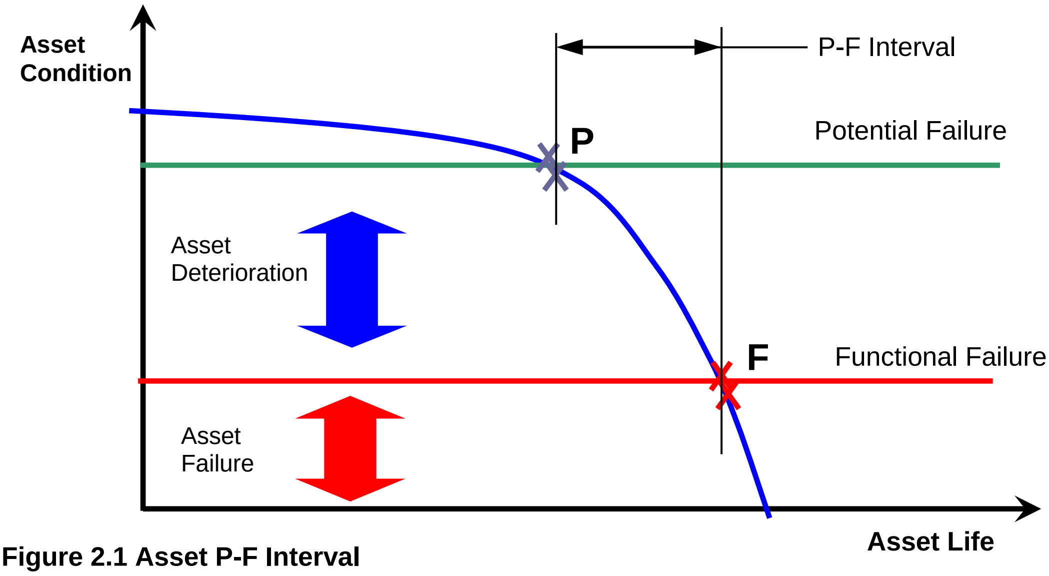


Figure 2.1 Asset P-F Interval

Understanding the P-F interval, which for a particular type of asset is the expected time interval between potential failure and functional failure, is fundamental to prudent asset management.

2.2 SCAR Framework

SCAR coding has been developed in order to:

- Systematically identify and document all reasonably expected failure modes for substation and transmission line assets
- Determine the risk and consequence of all failure modes identified based on ElectraNet's corporate risk framework
- Identify those failure modes that are unacceptable and require corrective action to prevent asset failure and minimise the impact of that failure resulting from significant safety, environmental, operational or asset risk
- Develop for each failure mode requiring a response, the longest acceptable response time based on understanding of the P-F interval of the asset
- Provide a consistent data framework for asset defect identification and analysis within the SAP asset maintenance management system

In order to support the above requirements the SCAR Coding Risk Matrix has been developed in conjunction with the Mobile Grazer Terminal (MGT) for field data assessment and associated SAP interface. The process for implementing SCAR and MGT is discussed in the following sections.

SCAR is intended to minimise corrective maintenance effort in the long-run by systematically identifying the maximum acceptable time to respond based on the risk to network performance.

SCAR is based on organising existing SAP defect notification system data in a manner that provides for:

- SAP defect codes that describe the level of risk and priority of asset defects (in line with SCAR coding)
- SAP defect notification data is aligned with defect codes, response times and cost estimates developed by SCAR
- Data capture occurs at the point of asset field inspection and provides full integration with SCAR and SAP
- All defect notifications are photographed to enable verification of asset defects and SCAR coding and audit of the SCAR coding system

Additional information is provided in the Implementation Plan that ElectraNet followed to implement SCAR – refer to Appendix C.

SCAR is based on the improved organisation of asset data and integration of field data collection with risk assessment and SAP defect notifications.

2.3 SCAR Coding

The SCAR coding matrix has been developed in four main modules, these are:

- Asset Structure – A hierarchical structure based on each main high voltage plant or transmission line component asset (the hierarchy extends down to the sub component level that is inspected or maintained)
- Failure Mode Risk Analysis – For all sub components at the lowest level of the asset hierarchy a risk and consequence analysis based on the ElectraNet corporate risk framework
- Inspection Notes – notes provided to guide inspection and selection of the most appropriate failure mode and risk analysis
- SAP Data – defect short text, asset identification, response codes, cost estimates and fault codes for the defect notification

A screen view of the SCAR coding matrix (refer to Appendix A) shows the development of a typical failure mode profile. All inspection processes using SCAR are based on verification of the asset condition. SAP notifications generated by SCAR are used to capture both asset defect and condition information using the data framework shown below.

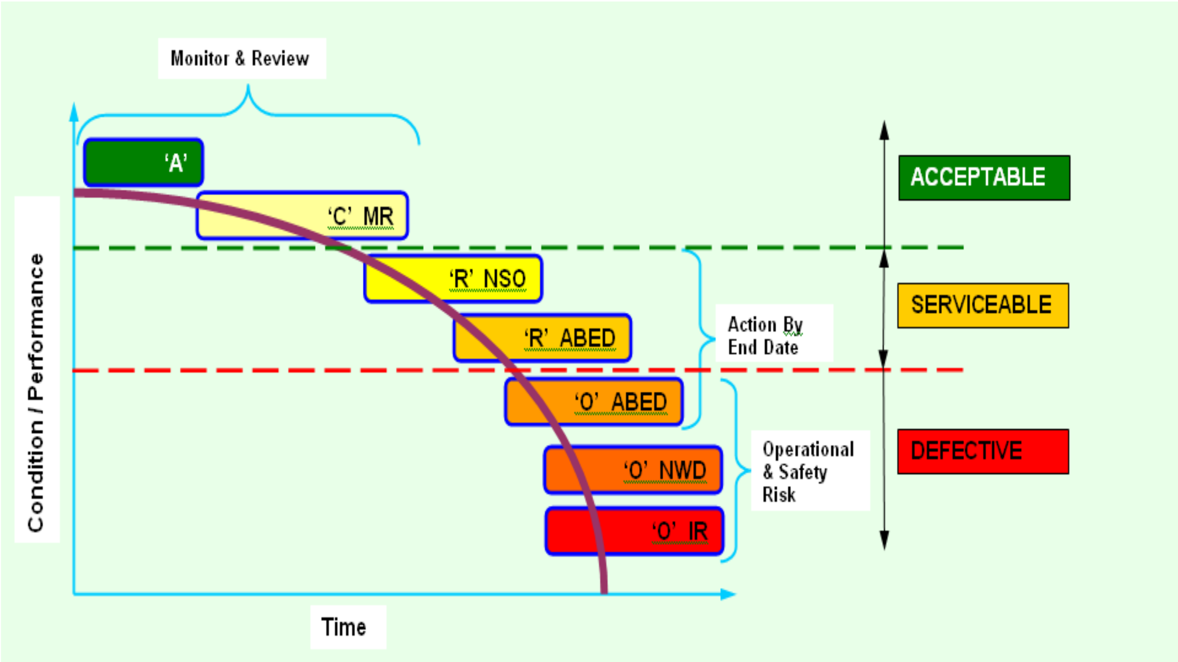


Figure 2.2: SAP Notification Codes

2.4 Development of SCAR Risk Framework

Identification of failure modes and associated P-F intervals was undertaken in consultation with experienced field personnel and expert consultants. The process is described diagrammatically below.

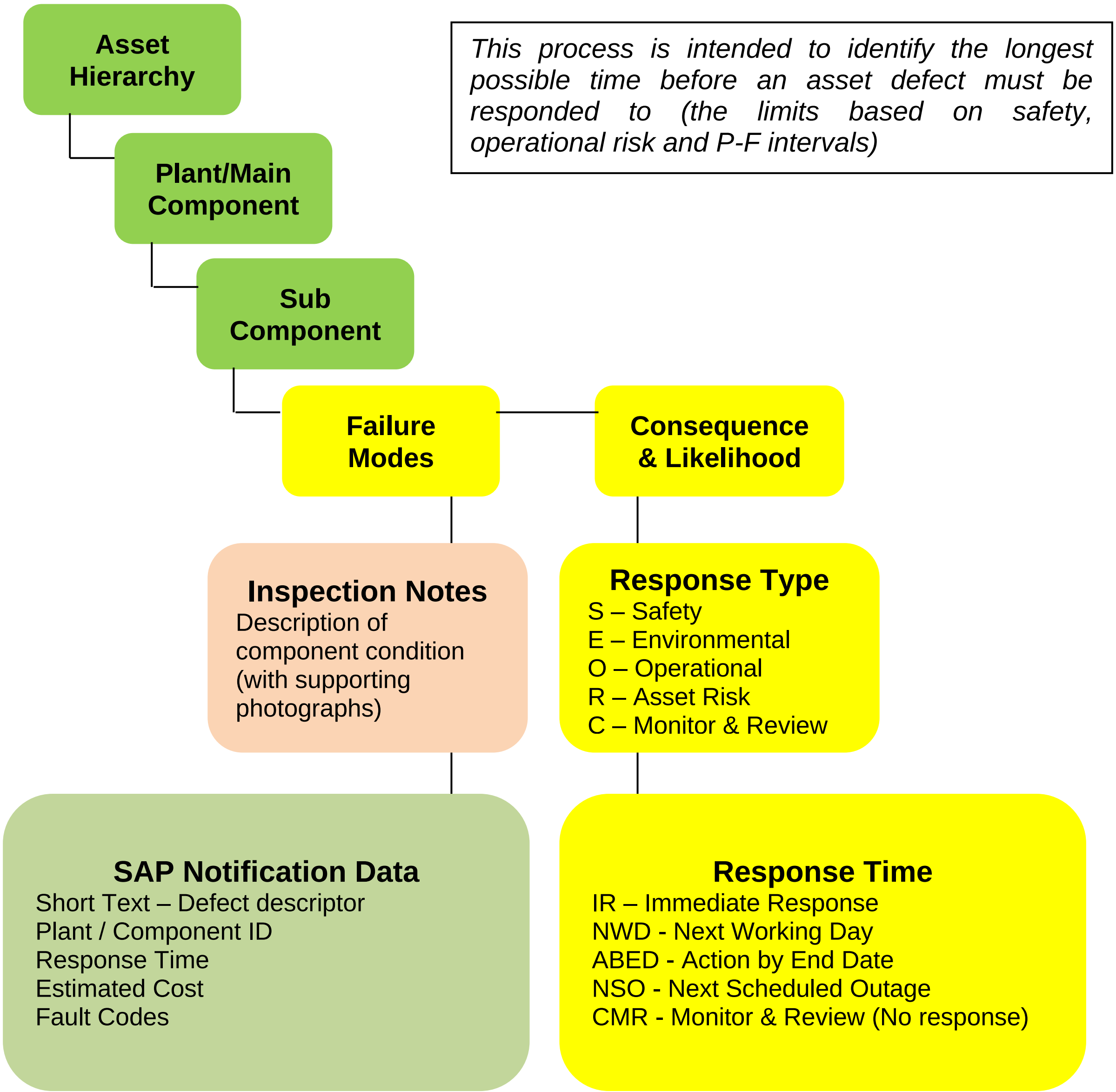


Figure 2.3: Development of SCAR Risk Assessment

Refer Appendix D: Failure Mode SCAR Risk Assessment Example for an illustration.

2.5 Implementation of SCAR Coding

Implementation of SCAR coding and the relationship to corrective, refurbishment and replacement response is shown below, the main features of this process are:

- High risk defects (<360 days) are allocated to corrective maintenance;
- All other defects are managed through planned maintenance or replacement programs;

- Response times, risk thresholds and data quality are audited and reviewed monthly.

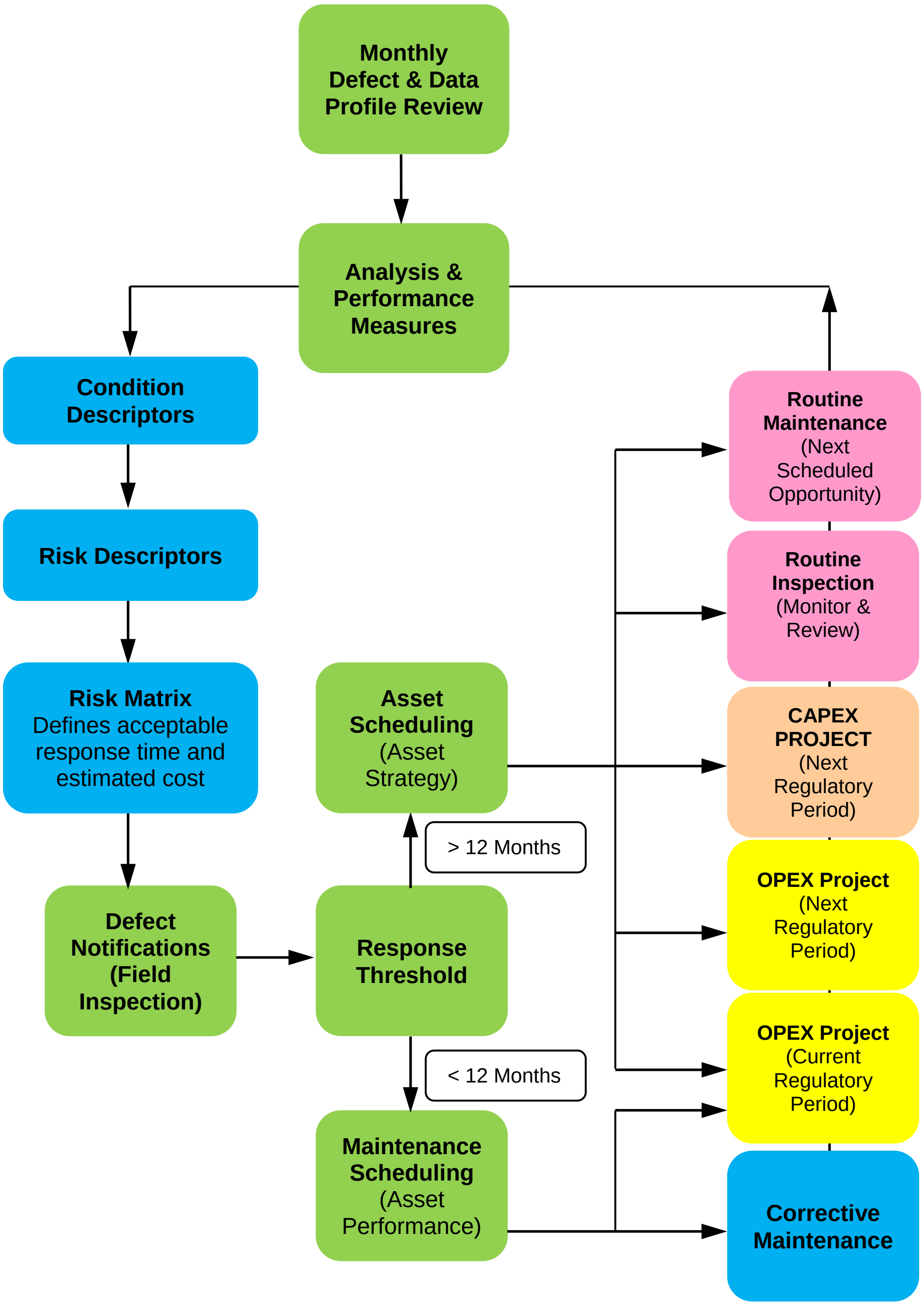


Figure 2.4: Defect Management Process

2.6 Corrective Maintenance Model

Modelling of corrective maintenance trends is based on SAP defect notification history and SCAR coded SAP defect notification inflow from field inspection and maintenance tasks. The corrective maintenance model is outlined below and has the following features:

- Defect inflow is measured in $ (a two year moving average of defect notifications requiring corrective maintenance response);

- Estimates of cost used for modelling are reviewed against actual costs each month in order to improve cost projections;
- The model allows for cost estimating error and the effect of changes in data quality and volume by reducing trailing cost estimates – this has the effect of discounting the defect inflow by approximately 20 per cent;
- This model shows the level of residual risk (assets that have actually failed or have a high risk of failing as they have not been responded to within the P-F interval);
- The model also indicates the level of funding required to respond to overdue defects (the cumulative requirement).

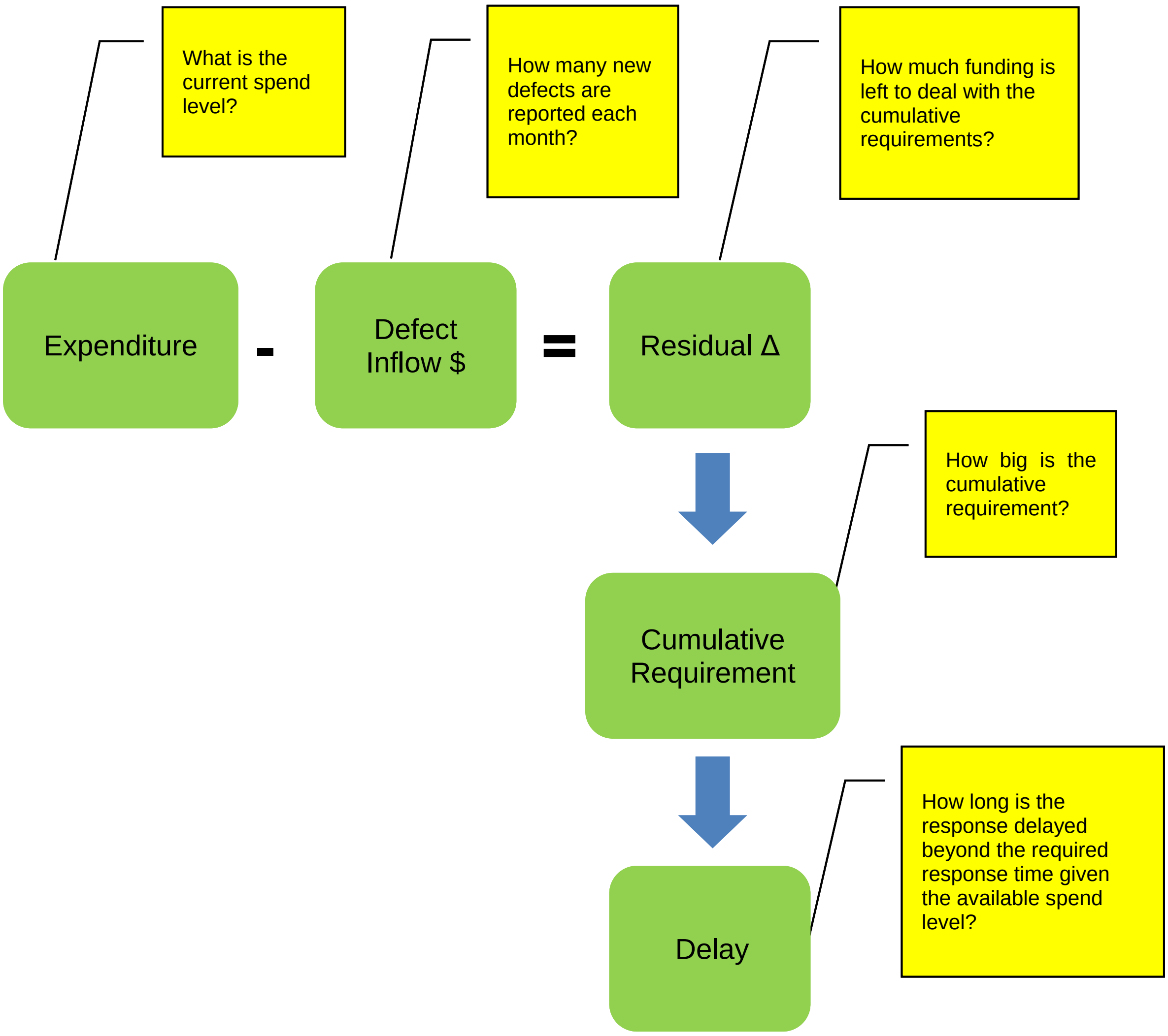


Figure 2.5: Corrective Maintenance Model

3. SCAR Coding Profile

SCAR coding profiles for substations and transmission lines resulting from the SCAR coding matrix are shown below for all possible risk response outcomes.

The substation coding profile is dominated by monitor and review failure modes (no response) with only 11% of the coding relates to fast failure mode high risk defects (<30 days).

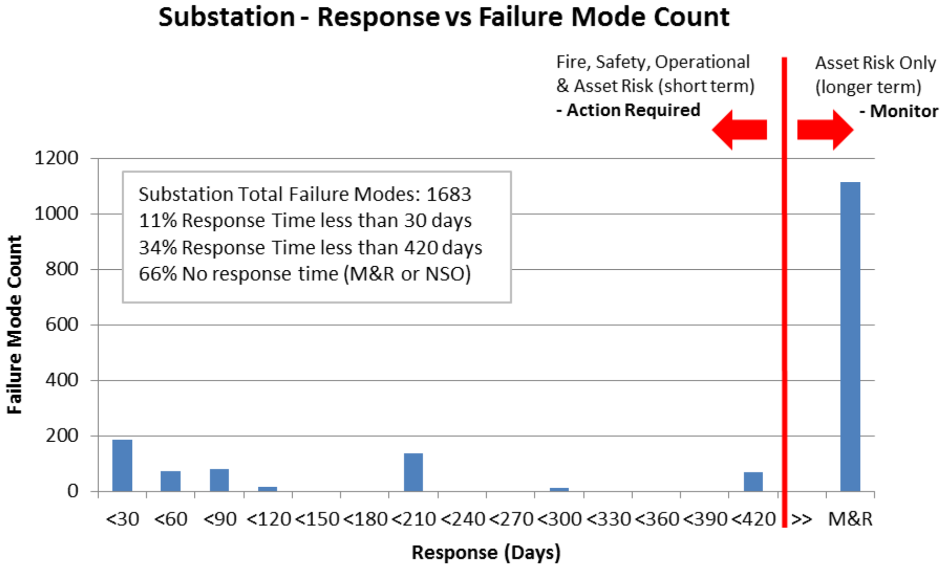


Figure 3.1: Substation SCAR Matrix Coding Profile

Transmission line coding reflects a greater number of shorter response times associated with high risk fire start, safety and operational defects (<120 days 48 per cent), asset risk defects with longer P-F intervals (120-540 days 16 per cent) and monitor/review (no response 36 per cent).

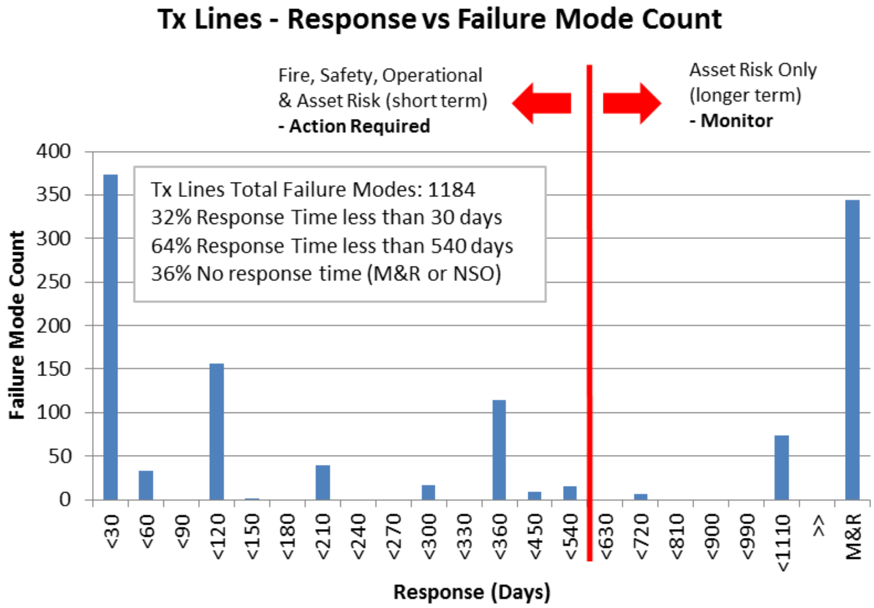


Figure 3.2: Transmission Line SCAR Matrix Coding Profile

4. Defect Profile Sensitivity

4.1 Substations

Based on a two year (to December 2011) view the substation corrective maintenance profile is shown in the following figures (excluding monitor and review defects).

Figure 4.1 shows the substation defect profile based on defect notifications requiring corrective maintenance response (two year sample). This clearly illustrates that substation corrective maintenance effort is being driven by high risk defects.

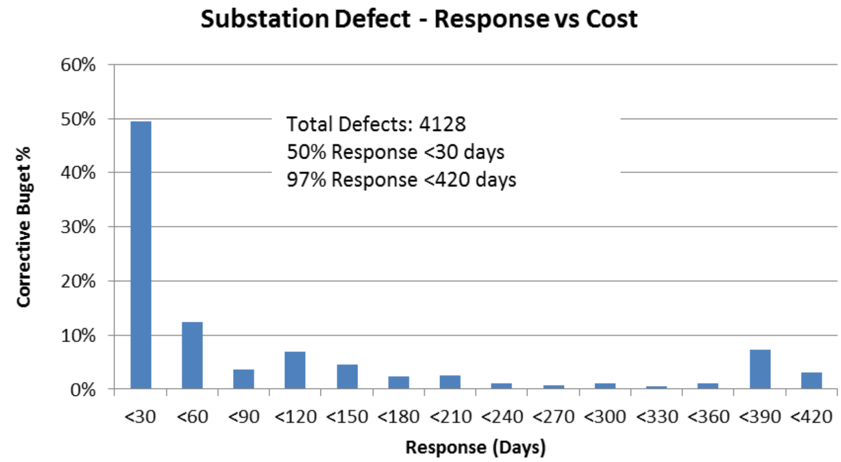


Figure 4.1: Substation Defect Response

Figure 4.2 shows the substation defect profile where response times for all defects have been increased by 10 per cent. The defect profile is generally insensitive to this assumed change in risk threshold due to the dominant high risk short response time defects. This means that a change in risk thresholds of this magnitude will not have a material impact on the forecast corrective maintenance effort.

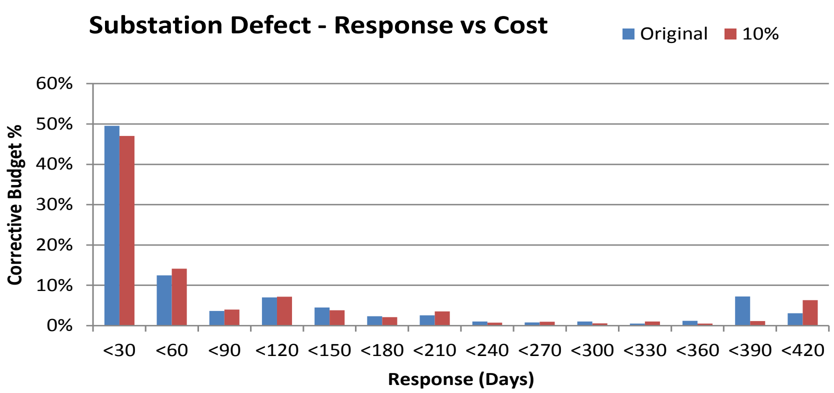


Figure 4.2: Substation Defect Response (Risk Threshold increased by 10 per cent)

4.2 Transmission Lines

Based on a two year view the transmission line corrective maintenance profile is shown in the following figures.

Figure 4.3 shows a defect profile with two aspects. Approximately half of the defects are high risk fast response defects associated with fire start, safety and operational risk with longer asset related defects representing the remaining.

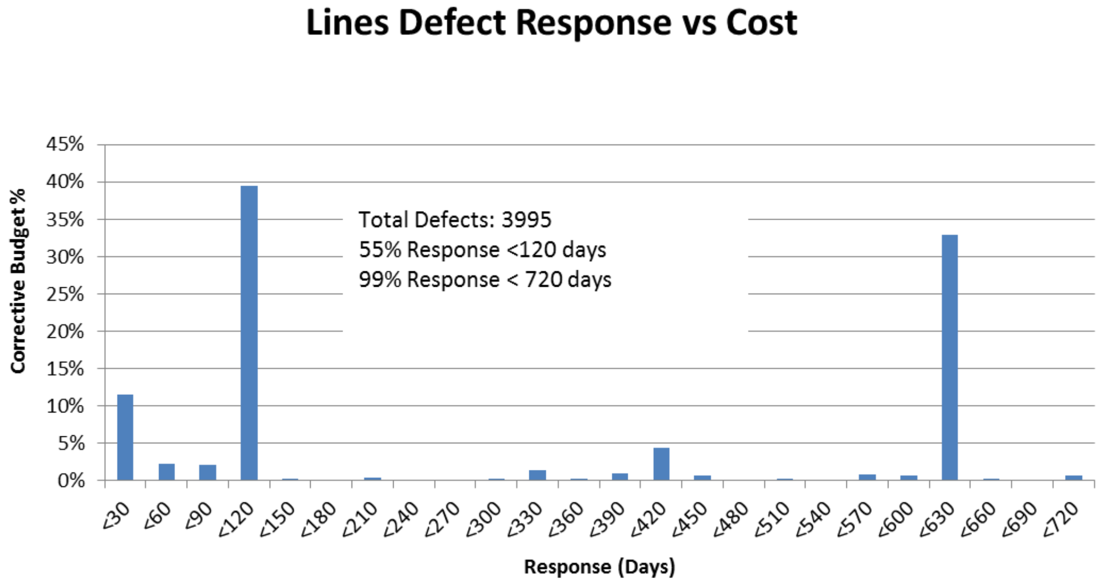


Figure 4.3: Transmission Line Defect Profile

Figure 4.4 shows the transmission line defect profile where response times for all defects have been increased by 10 per cent. Due to the dominant defect grouping, this profile is generally insensitive to changes in risk threshold. This means in turn that forecast corrective maintenance effort is also generally insensitive to changes in risk threshold of this magnitude.

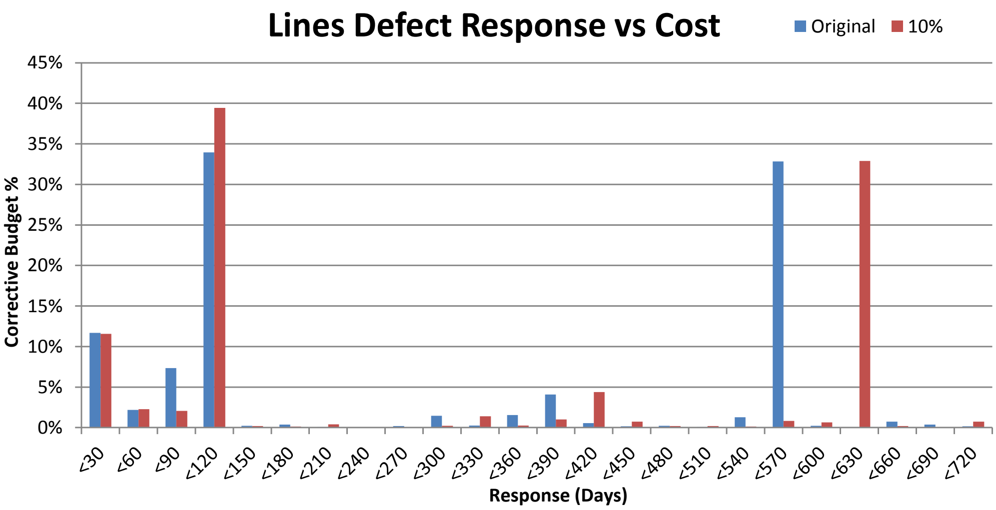


Figure 4.4: Transmission Line Defect Profile (Response Threshold increased by 10%)

5. Projected Corrective Maintenance Trends

SAP corrective defect maintenance trends are shown in the figures below with each graph showing:

- Incoming defect notification counts for each month;
- Close out (completion) of defect notifications each month; and
- The cumulative total of open (active) defect notifications each month.

The substation defect notification trend shows:

- The rate of incoming defects has reached a steady state;
- An increase in the completion of defect notifications has reversed the increasing cumulative trend.

The incoming rate of corrective defect notifications is driven by high risk asset defects resulting from the current profile of substation assets. This asset profile will change during the current and future regulatory periods and is discussed further in the following pages (defect data tables are in Appendix B).

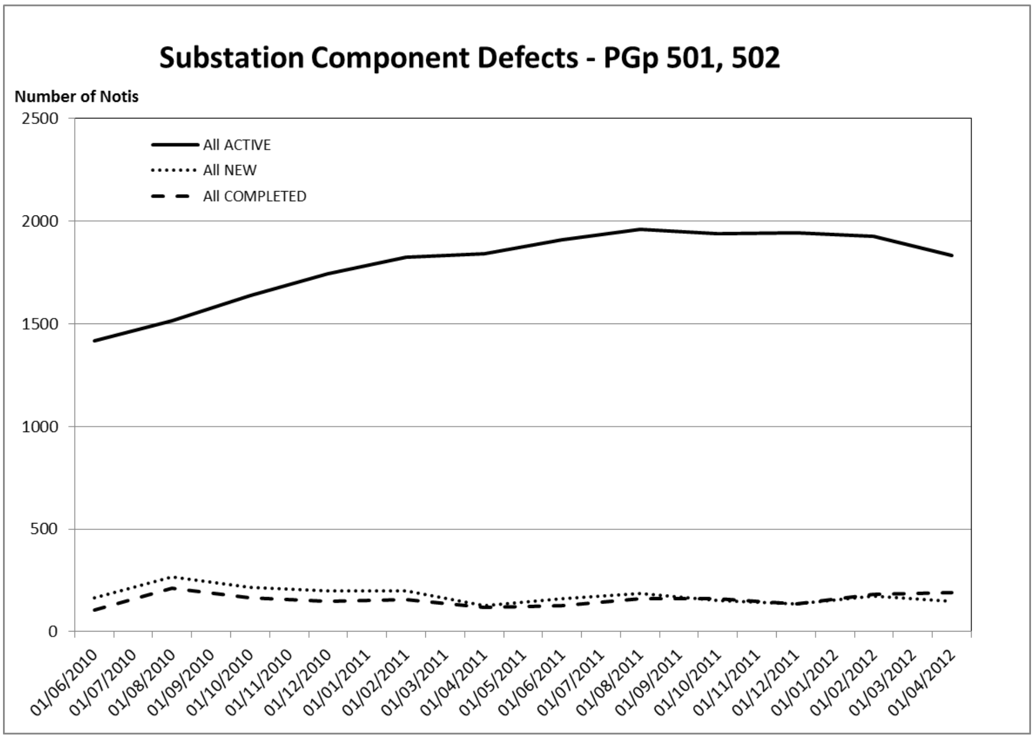


Figure 5.1: Substation Corrective Defect Notification Trend

The transmission line defect corrective notification trend shows:

- The rate of incoming corrective defects has reached a steady state (subject to annual maintenance cycle fluctuations);
- An increase in the completion of corrective defect notifications has slowed the rate of increase of the cumulative trend.

The incoming rate of corrective defect notifications is driven by asset inspection and maintenance plans. As each annual inspection cycle (based on asset sampling across all line assets) is undertaken it is expected that the current level of defect discovery will continue therefore maintaining the current trend.

At present there are no network wide transmission line replacement projects planned. Therefore, as the current trend is a reflection of the transmission line asset condition of existing assets, the trend is highly likely to continue at the current level.

During the next regulatory period (when a substantial amount of the transmission lines have been inspected) it is anticipated that future changes in the trend may be identified.

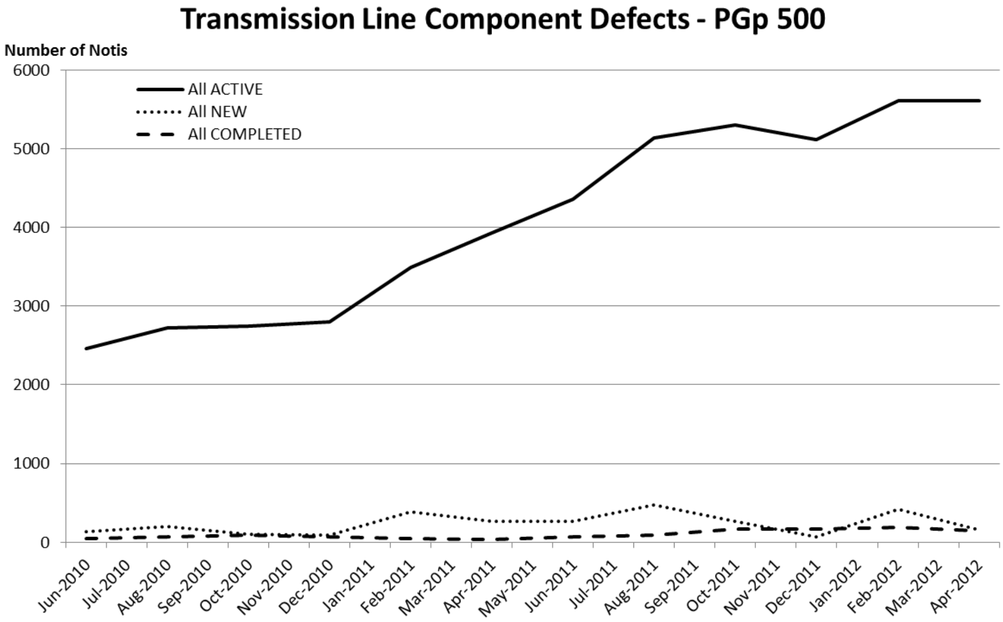


Figure 5.2: Transmission Line Corrective Defect Profile

5.1 Substation Corrective Maintenance Trends

Corrective maintenance trends reflect the condition of substation assets in the network at a particular time. The trend is changed by (in order of greatest impact):

- Replacement of the asset
- Refurbishment of the asset
- Improved routine maintenance

At present the main driver for reducing corrective maintenance effort is substation asset replacement as the current regulatory and following regulatory periods have a significant number of large asset replacement projects.

Although substation asset replacement will reduce corrective maintenance effort, in the short run initial corrective effort for new assets may be high as demonstrated in the figure below showing corrective effort for new substation assets.

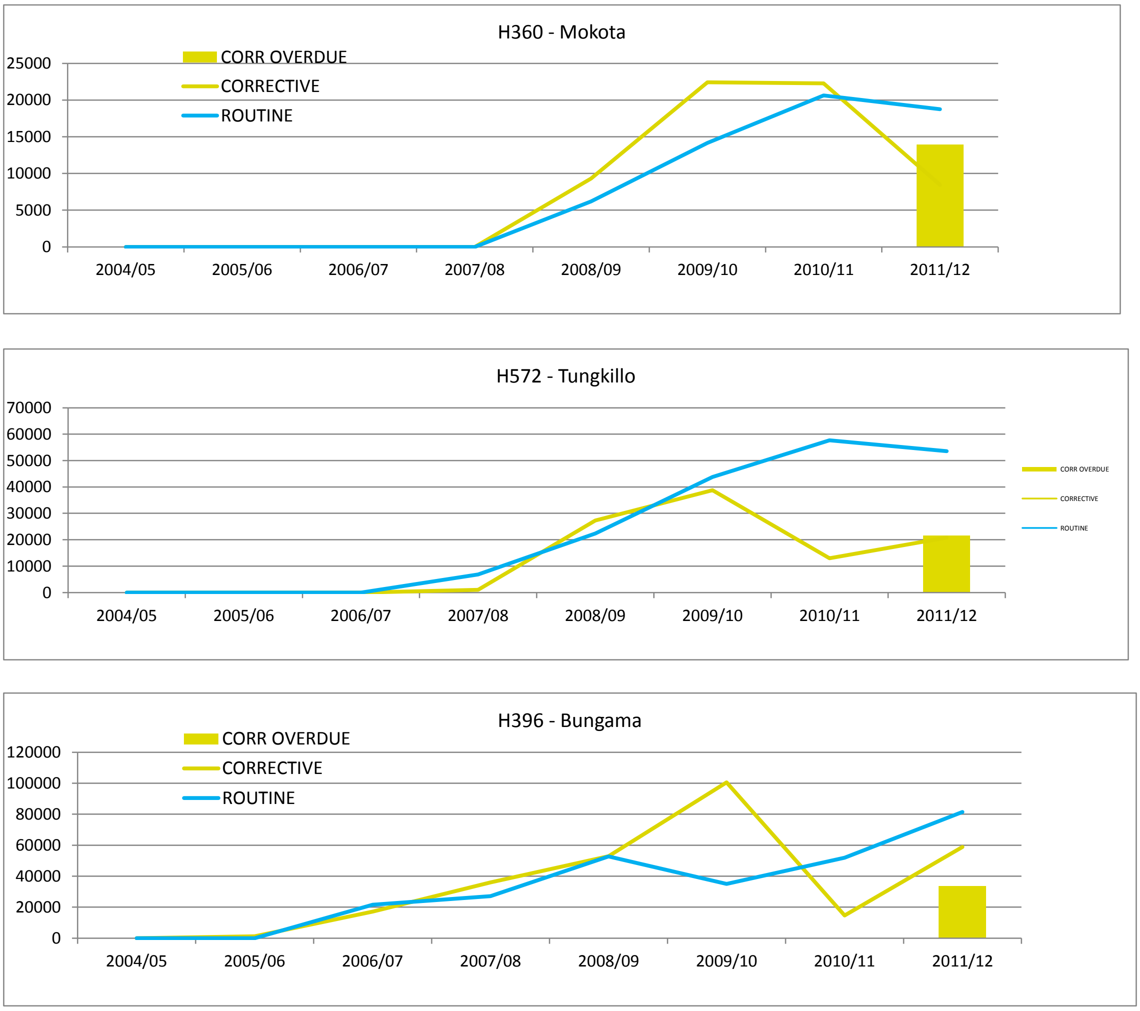


Figure 5.3: New Substation – Corrective Maintenance Profile

Figure 5.4 below shows the commissioning timeframe (solid) and likely corrective defect tail, based on the previous example (shaded), for new substation construction during the current and following regulatory period. Note also a substantial number of additional substation sites are being added to the network.

Taking into account the effect of these new assets it is expected that:

- During the next regulatory period an increase in new asset corrective effort will offset the replacement driven reduction of poorer performing assets; and
- The corrective maintenance trend will begin to fall at the end of the next regulatory period.

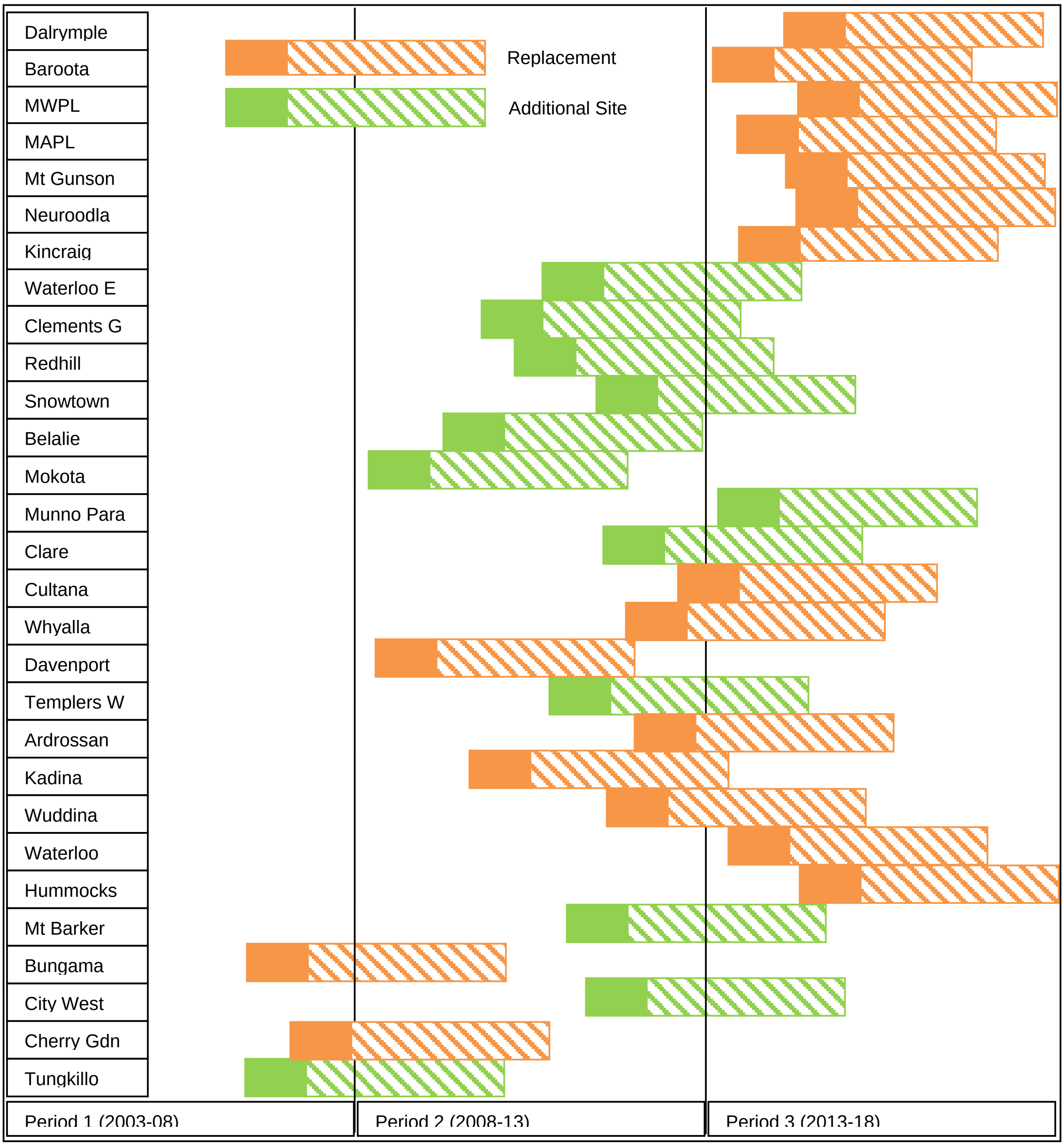


Figure 5.4: New Substation Commissioning Timing

6. Conclusion

The aim of SCAR coding is to minimise asset lifecycle cost while maintaining acceptable levels of performance and risk. The diagram below sets out the mechanisms incorporated into the asset management plan to optimise investment and funding decisions based on whole of life cost, performance and risk.

Note that increasing the risk threshold associated with a particular failure mode has the following effect:

- Cost is moved from corrective maintenance to refurbishment projects to address the asset risk, as documented by the Defect Management Process diagram shown in Figure 2.4 above; and
- The risk of unacceptable asset failure and consequent cost impact is increased (as the response time may now exceed the P-F interval).

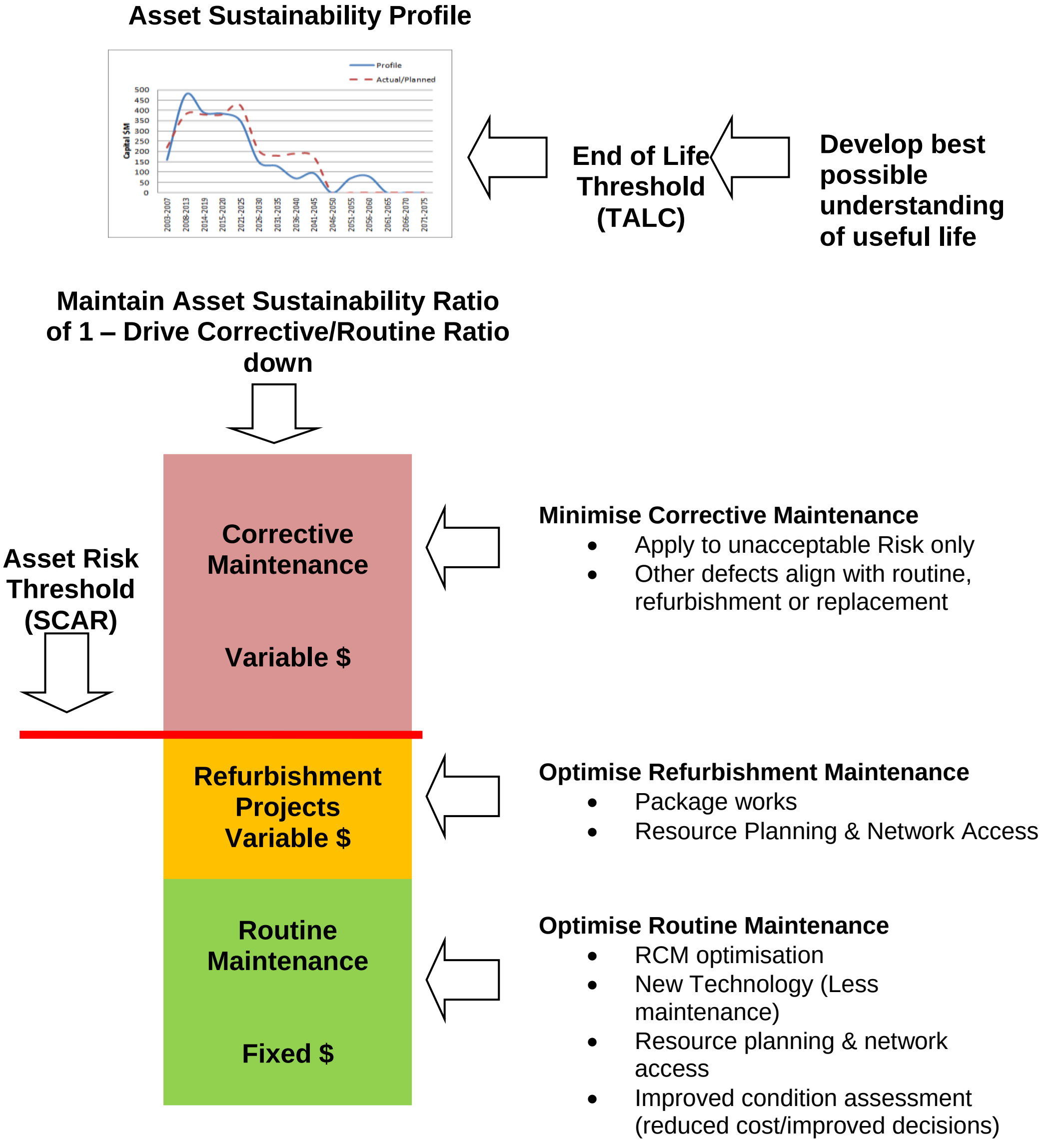


Figure 6.1: Cost Optimisation Framework

SCAR also provides a threshold (based on P-F interval) that is used to identify unacceptable asset failure, where unacceptable failure is classified as:

- Safety or significant environmental risk;
- Operational risk - where asset failure has occurred and has reduced the security of the network; and
- Asset Risk – where deteriorating asset condition will substantially change the availability and reliability of the asset (to the point where material impacts on safety, environment or network performance will occur).

In the case of the above, identification of failure modes and associated P-F intervals is the basis for good asset management practice and risk management.

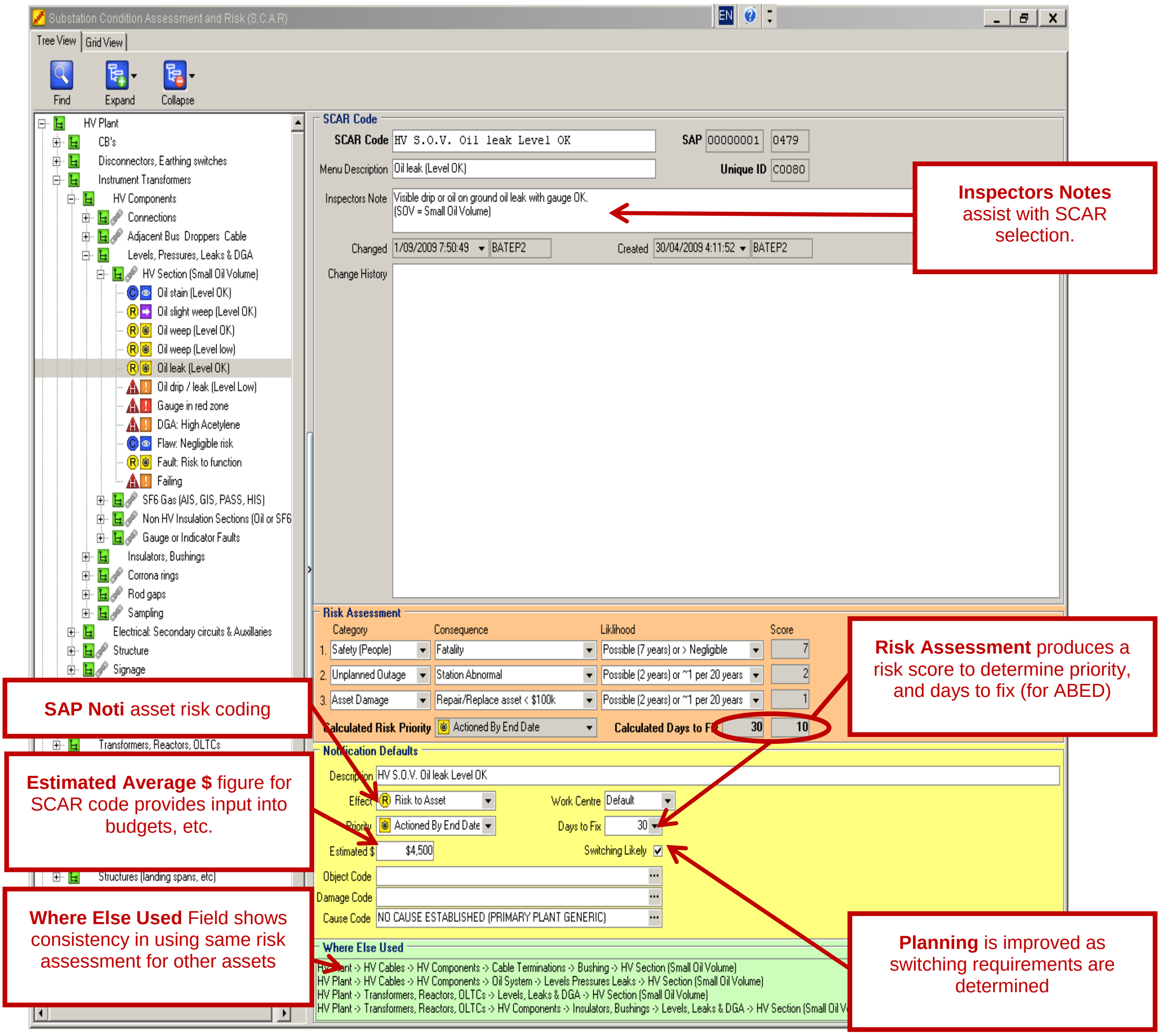
SCAR Coding:

- Represents good asset management practice by systematically identifying all reasonably expected asset failure modes and their associated P-F interval
- Identifies an appropriate maintenance response based on mitigating risk associated with material deterioration of asset safety, availability and reliability
- Provides a framework for optimizing maintenance cost by balancing unplanned corrective maintenance response with planned asset maintenance, refurbishment and replacement.

Corrective Maintenance Profiles:

- Substation assets corrective maintenance profiles show that a steady state has been reached that will largely be maintained until the end of the next regulatory period as new assets are transitioned into the network. At that time corrective maintenance costs will trend to a lower long run steady state.
- Transmission line asset corrective maintenance profiles show an increasing trend based on a continuing asset condition assessment programme. During the next regulatory period as the majority of the network has been assessed, a long run view of defect trends and efficient cost balanced against replacement and refurbishment plans can be determined.

Appendix A SCAR Coding Matrix



Appendix B Defect Profiles

Substation Defect Profiles

Recalculate this Sheet

Download Data From SAP

Category	Cod	Measure	1/06/2010	1/08/2010	1/10/2010	1/12/2010	1/02/2011	1/04/2011	1/06/2011	1/08/2011	1/10/2011	1/12/2011	1/02/2012	1/04/2012
All		All ACTIVE	1416	1513	1639	1742	1825	1842	1909	1959	1939	1942	1925	1834
All		All NEW	331	536	434	399	394	253	318	371	301	272	349	292
All		All COMPLETED	214	421	326	295	312	235	250	323	319	270	367	381
Cap Banks & Air Rea	CA	Cap Banks ACTIVE	8	5	7	6	8	8	7	6	6	6	8	6
Cap Banks & Air Rea	CA	Cap Banks NEW	3	1	12	9	3	3	0	3	2	1	4	0
Cap Banks & Air Rea	CA	Cap Banks COMPLETED	0	4	10	10	1	3	1	4	2	1	2	2
Circuit Breakers	CB	Circuit Breaker ACTIVE	132	178	185	199	215	213	215	219	225	221	213	198
Circuit Breakers	CB	Circuit Breaker NEW	40	61	21	34	30	12	15	24	26	8	14	11
Circuit Breakers	CB	Circuit Breaker COMPLETE	2	15	14	20	14	14	13	20	20	12	22	26
Comms	CM	Comms ACTIVE	7	6	8	8	7	8	8	11	16	17	16	16
Comms	CM	Comms NEW	5	4	3	2	1	3	3	3	7	3	5	1
Comms	CM	Comms COMPLETED	5	5	1	2	2	2	3	0	2	2	6	1
Conds & Bus Bars	CO	Conds & Bus ACTIVE	3	3	4	4	4	5	5	6	7	7	7	6
Conds & Bus Bars	CO	Conds & Bus NEW	1	0	1	3	0	3	1	1	1	1	0	1
Conds & Bus Bars	CO	Conds & Bus COMPLETED	0	0	0	3	0	2	1	0	0	1	0	2
Diesel Gens	DG	Diesel Gen ACTIVE	3	9	10	12	7	8	9	9	10	12	12	10
Diesel Gens	DG	Diesel Gen NEW	1	7	5	2	1	2	2	3	2	2	8	5
Diesel Gens	DG	Diesel Gen COMPLETED	1	1	4	0	6	1	1	3	1	0	8	7
Earthing	EA	Earthing ACTIVE	57	75	117	116	100	100	101	108	110	80	73	70
Earthing	EA	Earthing NEW	8	36	56	8	6	8	10	20	13	15	7	4
Earthing	EA	Earthing COMPLETED	3	15	17	9	22	8	9	13	11	45	14	7
Insulators	IN	Insulators ACTIVE	9	11	11	13	13	15	15	16	16	19	21	21
Insulators	IN	Insulators NEW	0	4	0	3	3	2	1	1	1	4	3	3
Insulators	IN	Insulators COMPLETED	0	2	0	1	3	0	1	0	1	1	1	3
Isol & Eswitches	IS	Isolators ACTIVE	96	113	117	118	122	123	130	135	123	126	128	123
Isol & Eswitches	IS	Isolators NEW	10	18	8	5	10	2	18	12	13	6	10	7
Isol & Eswitches	IS	Isolators COMPLETED	5	1	4	4	6	1	11	7	25	3	8	12
Instrument TFs	IT	ITs ACTIVE	6	2	2	2	3	4	3	5	5	4	4	4
Instrument TFs	IT	ITs NEW	2	1	0	0	2	1	0	2	0	0	1	0
Instrument TFs	IT	ITs COMPLETED	3	5	0	0	1	0	1	0	0	1	1	0
Site Infrastructure	PR	Site Infrastr ACTIVE	404	421	447	484	519	524	543	568	557	565	555	482
Site Infrastructure	PR	Site Infrastr NEW	63	111	98	113	101	55	82	113	58	79	108	46
Site Infrastructure	PR	Site Infrastr COMPLETED	33	90	76	75	67	49	63	89	67	72	119	118
Surge Arrestors	SA	SAs ACTIVE	0	0	0	1	1	1	1	0	0	0	0	0
Surge Arrestors	SA	SAs NEW	0	0	0	1	0	0	0	0	0	0	0	0
Surge Arrestors	SA	SAs COMPLETED	0	0	0	0	0	0	0	1	0	0	0	0
Sec Systems	SS	SS ACTIVE	272	285	308	329	355	351	376	371	388	410	414	384
Sec Systems	SS	SS NEW	36	57	56	75	73	48	74	55	79	54	67	34
Sec Systems	SS	SS COMPLETED	22	43	34	54	47	52	49	60	62	32	63	63
Structures	ST	Structures ACTIVE	5	10	33	44	48	47	49	51	50	50	53	54
Structures	ST	Structures NEW	0	5	23	11	5	0	2	3	4	1	5	1
Structures	ST	Structures COMPLETED	0	0	0	0	1	1	0	1	5	1	2	0
Pwr TFs	TF	TFs ACTIVE	62	74	85	95	95	95	98	99	99	101	119	108
Pwr TFs	TF	TFs NEW	14	27	20	35	21	14	13	21	17	15	34	17
Pwr TFs	TF	TFs COMPLETED	2	15	9	25	21	14	10	20	17	13	16	28
UG Cable	UG	UG Cable ACTIVE	2	3	5	9	8	9	12	14	11	13	12	6
UG Cable	UG	UG Cable NEW	0	1	2	4	0	1	5	2	1	2	2	0
UG Cable	UG	UG Cable COMPLETED	0	0	0	0	1	0	2	0	4	0	3	6

Note:

- NEW and COMPLETED defect notifications are aggregated 2 monthly totals. For monthly defect rates must divide by 2.
- For asset category ALL, the measure ALL NEW incoming rate is 177 defects / month and ALL COMPLETED outgoing rate is 155 defects / month.

Transmission Line Defect Profiles

Recalculate this Sheet

Download Data From SAP

Category	Co	Measure	Jun-2010	Aug-2010	Oct-2010	Dec-2010	Feb-2011	Apr-2011	Jun-2011	Aug-2011	Oct-2011	Dec-2011	Feb-2012	Apr-2012
All		All ACTIVE	2461	2727	2742	2795	3491	3925	4361	5138	5302	5118	5608	5609
All		All NEW	277	406	197	186	781	531	539	951	524	146	840	312
All		All COMPLETED	95	140	182	132	86	67	133	174	325	343	372	299
AntiClimb	AC	AntiClimb ACTIVE	131	140	139	143	146	176	168	188	192	140	208	175
AntiClimb	AC	AntiClimb NEW	19	10	3	10	3	38	29	21	39	29	92	18
AntiClimb	AC	AntiClimb COMPLETED	5	1	4	6	0	1	44	1	35	81	24	51
Conductor	CO	Conductor ACTIVE	15	19	21	22	26	29	32	39	47	47	42	41
Conductor	CO	Conductor NEW	2	5	3	2	4	5	4	9	9	0	4	1
Conductor	CO	Conductor COMPLETED	0	1	1	1	0	2	1	2	1	0	9	2
Earthing	EA	Earthing ACTIVE	197	235	256	265	414	491	600	691	752	761	793	824
Earthing	EA	Earthing NEW	32	43	22	17	151	88	113	115	75	11	51	65
Earthing	EA	Earthing COMPLETED	1	5	1	8	2	9	6	24	14	2	19	33
Foreign Object	FJ	Foreign Object ACTIVE	92	145	135	112	145	142	151	205	164	134	63	55
Foreign Object	FJ	Foreign Object NEW	6	56	81	14	36	4	14	83	98	6	2	0
Foreign Object	FJ	Foreign Object COMPLETED	8	3	91	37	3	7	5	29	139	36	73	8
Footings	FO	Footings ACTIVE	356	381	384	393	460	465	469	448	418	351	340	341
Footings	FO	Footings NEW	20	25	3	9	71	6	8	17	11	0	29	40
Footings	FO	Footings COMPLETED	0	0	0	0	4	1	4	38	13	85	50	38
Hardware	HA	Hardware ACTIVE	262	247	253	267	358	389	474	667	787	779	762	738
Hardware	HA	Hardware NEW	14	21	8	14	92	37	88	199	128	1	19	10
Hardware	HA	Hardware COMPLETED	25	36	2	0	1	6	3	6	8	9	36	29
Insulators	IN	Insulators ACTIVE	253	273	240	251	323	419	442	513	460	461	482	463
Insulators	IN	Insulators NEW	35	39	35	40	87	103	33	104	46	33	51	17
Insulators	IN	Insulators COMPLETED	23	19	68	29	15	7	10	33	97	34	30	31
Right of Way	RW	Right of Way ACTIVE	382	388	389	395	438	502	509	509	516	513	516	517
Right of Way	RW	Right of Way NEW	8	10	1	12	46	64	13	5	8	7	38	9
Right of Way	RW	Right of Way COMPLETED	5	4	0	6	3	0	6	5	1	10	35	8
Signage	SI	Signage ACTIVE	475	601	635	642	851	955	1140	1415	1489	1482	1879	1961
Signage	SI	Signage NEW	107	153	34	35	212	143	193	303	78	42	463	124
Signage	SI	Signage COMPLETED	19	27	0	28	3	20	27	28	4	49	66	42
Structures	ST	Structures ACTIVE	278	282	277	286	318	344	364	447	459	436	505	481
Structures	ST	Structures NEW	29	27	5	16	70	39	39	88	23	3	81	17
Structures	ST	Structures COMPLETED	4	23	10	6	39	11	21	5	6	19	24	41
UG Cable	UG	UG Cable ACTIVE	10	4	4	5	5	6	5	7	7	6	7	6
UG Cable	UG	UG Cable NEW	3	1	0	2	2	1	4	2	1	0	1	3
UG Cable	UG	UG Cable COMPLETED	2	7	0	1	2	0	5	0	1	1	0	4

Note:

- NEW and COMPLETED defect notifications are aggregated 2 monthly totals. For monthly defect rates must divide by 2.
- For asset category ALL, the measure ALL NEW incoming rate is 237 defects / month and ALL COMPLETED outgoing rate is 98 defects / month.

Appendix C SCAR Implementation Plan

C1 Introduction

This Appendix provides more detailed information on ElectraNet's implementation of the SCAR framework.

Substation Condition and Asset Risk (SCAR) Coding for substation inspection has been developed to provide:

- A structured process for assessing and coding the condition of an asset using SAP Notifications.
- A consistent maintenance response to the asset condition based on an underlying risk profile.

The SCAR Codes then allow three categories of asset risk to be developed and managed, these are:

- Operational, safety and environmental risk – these categories of risk require immediate (up to 3 months) attention and are managed through the reactive, corrective maintenance process.
- Asset risk – this category of risk requires non urgent attention (up to next scheduled maintenance – 5 years) and are managed through the planned, OPEX Maintenance Project or Capital Replacement and Augmentation Project process.

SCAR Codes have been developed for each asset type and include:

- An underlying risk assessment (that determines the response time frame); and
- An estimate of cost.

All SAP Notifications will include fields that identify:

- The Asset Risk Category (e.g. O, R, S, H, E etc);
- The response time frame (e.g. NWD, ABED);
- The Planned completion date (based on SCAR Risk Matrix);
- The Scheduled completion date (based on allocated maintenance stream and available budget);
- The estimated cost (based on SCAR Coding estimates);
- The allocated maintenance stream (i.e. corrective, OPEX Project, Capital Project);
- The specific project identifier (e.g. Bulk Oil Circuit Breaker Replacement); and
- Project Timing (e.g. March 2010).

In order to support the above requirements development of the SCAR Coding Risk Matrix has been completed in conjunction with the Mobile Grazer Terminal (MGT) for field data assessment and SAP interface. The process for implementing SCAR and MGT is discussed below.

C2 Process

The SCAR Coding will introduce a consistent risk based view of asset condition and defect response timing, the overall process is shown in Figure C.1.

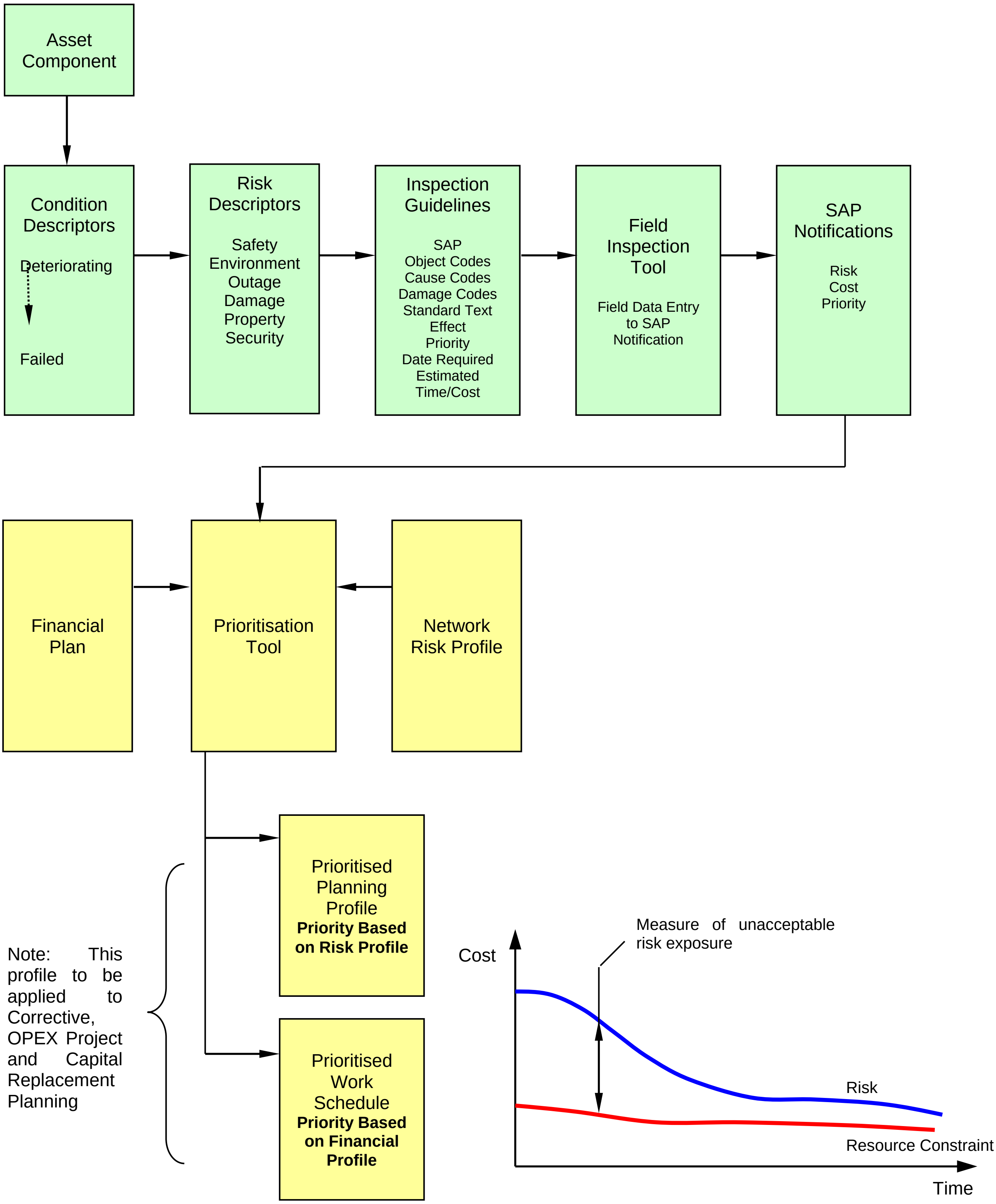


Figure C.1: Asset Risk and Response Prioritisation

C3 Stage 1 – Implementation Map

MGT will be implemented to provide field inspectors with an electronic field interface to SAP in order to provide information to the inspector at the point of inspection and allow data entry at the point of inspection, SCAR will be implemented in stages in order to simplify the data entry and management requirements.

The initial SCAR and MGT implementation is summarised in the diagram below.

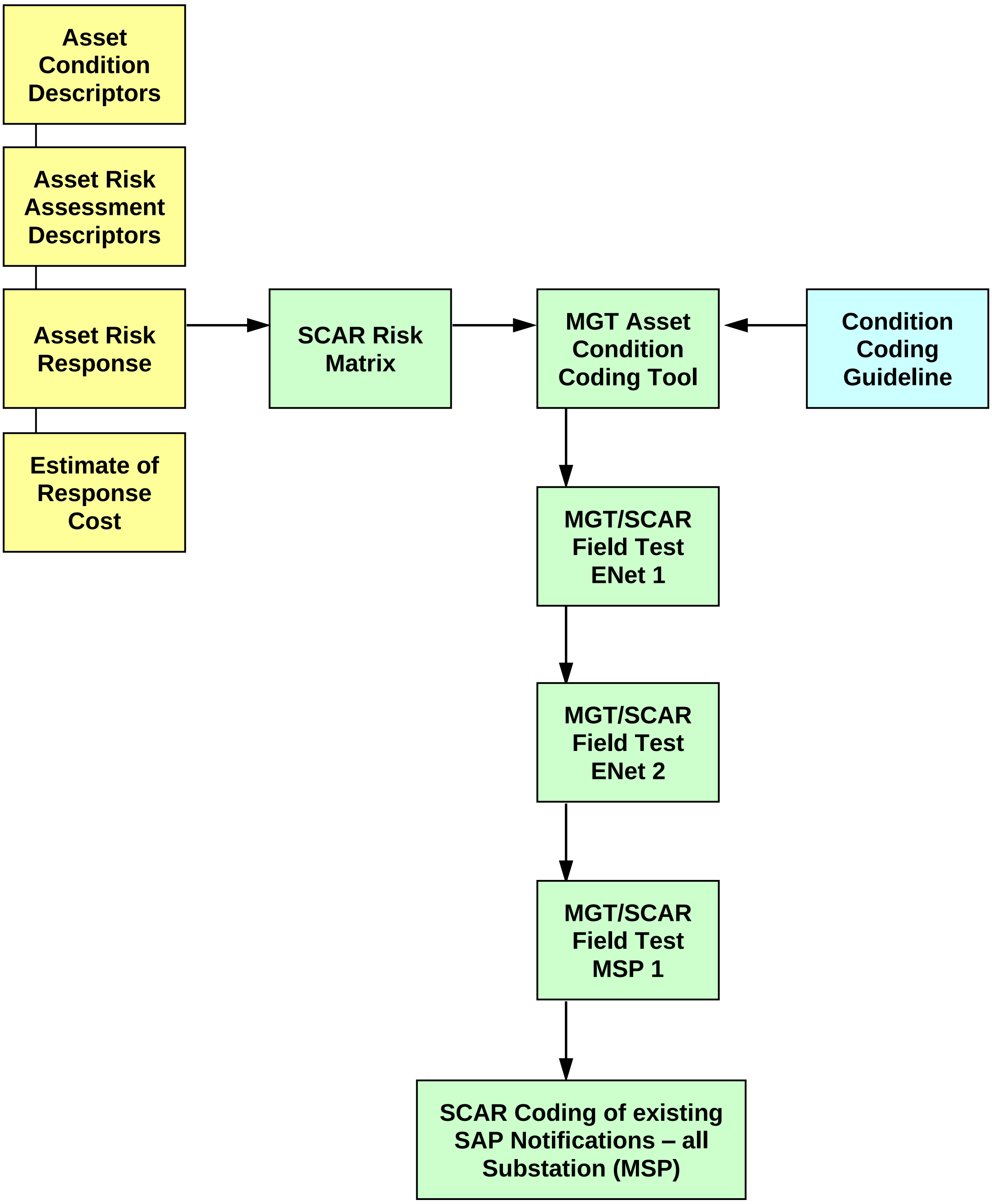


Figure C.2: SCAR and MGT Implementation Stage 1

C3.1 Stage 1 – Implementation Notes

Notes relating to stage 1 implementation are shown in Figure C.3 below.

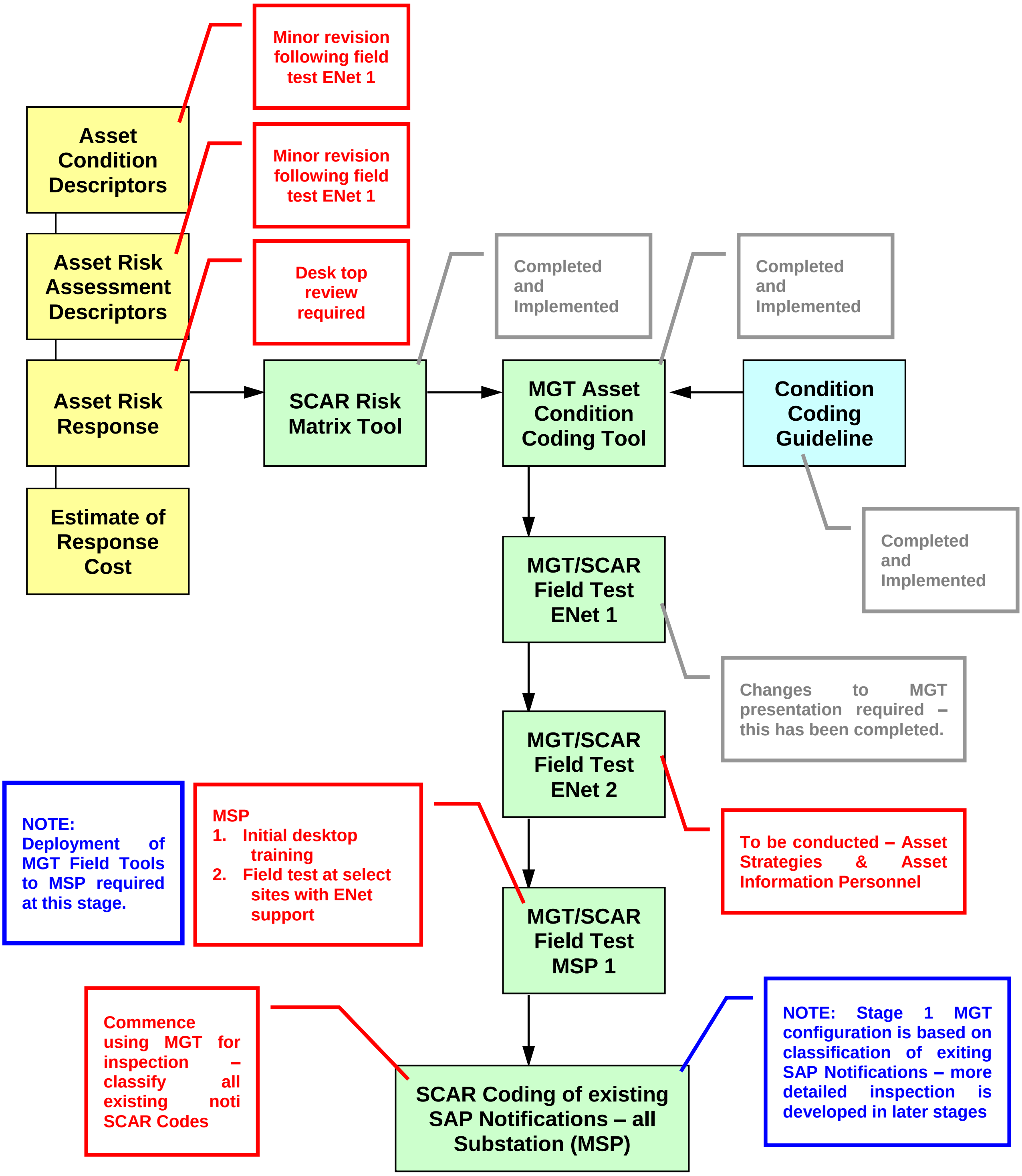


Figure C.3: SCAR and MGT Implementation Notes Stage 1 (30 July 2009)

C4 Stage 2 – Safety and Environment

Following implementation of MGT for SCAR classification of existing notifications and routine inspection (stage 1), additional inspection requirements will be introduced for specific site safety and environmental inspection. Stage 2 implementation is summarised as follows.

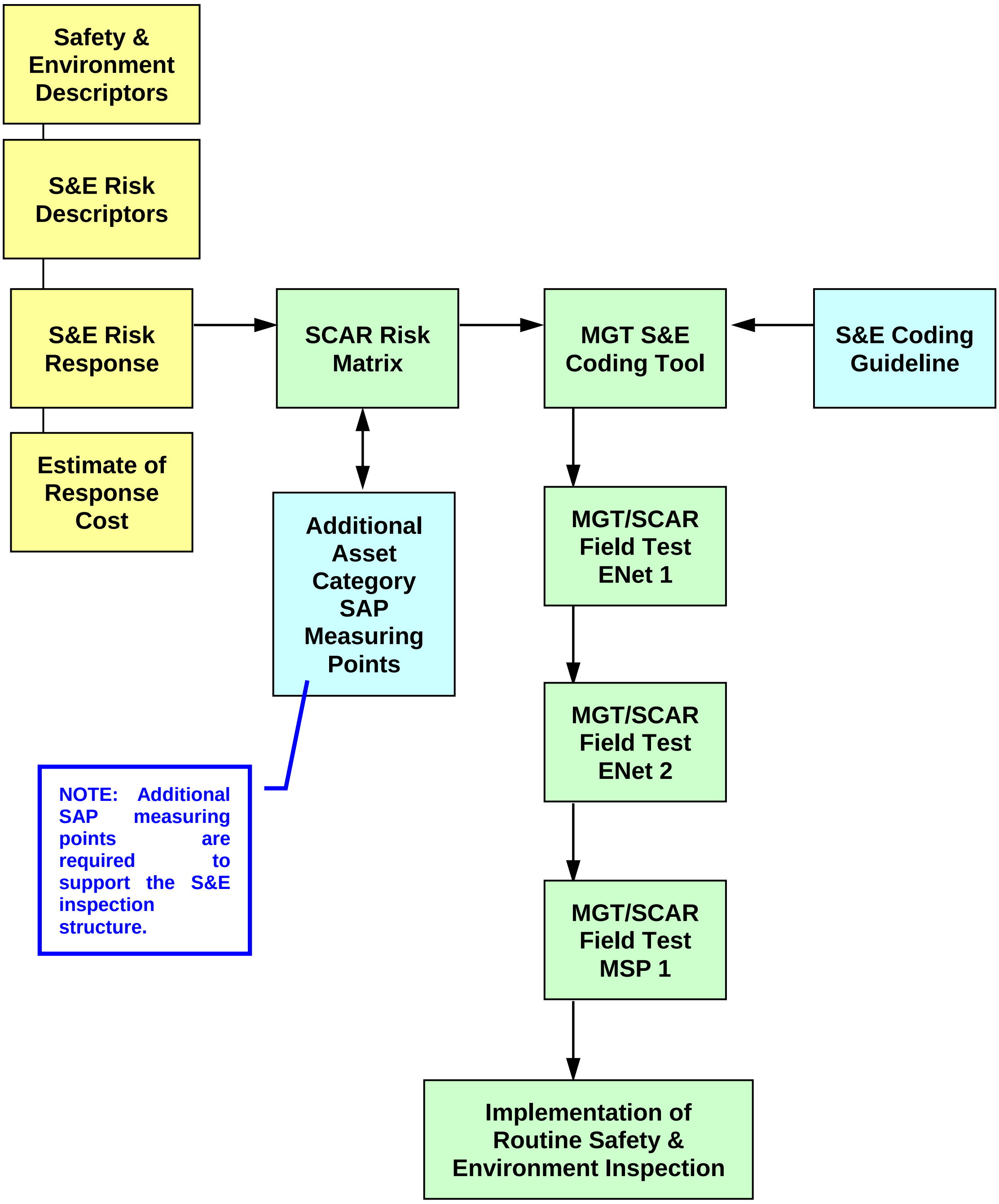


Figure C.4: SCAR and MGT Implementation Stage 2 Safety and Environment

C5 Stage 3 – Additional Asset Inspection

At present there are a number of asset groups not included in routine inspection and maintenance, major asset categories are:

- Substation Structures
- Portable Earth Leads
- Fire Extinguishers
- HV Cables

Stage 3 of the implementation programme will include development of SAP asset structures followed by MGT deployment, this process is summarised below.

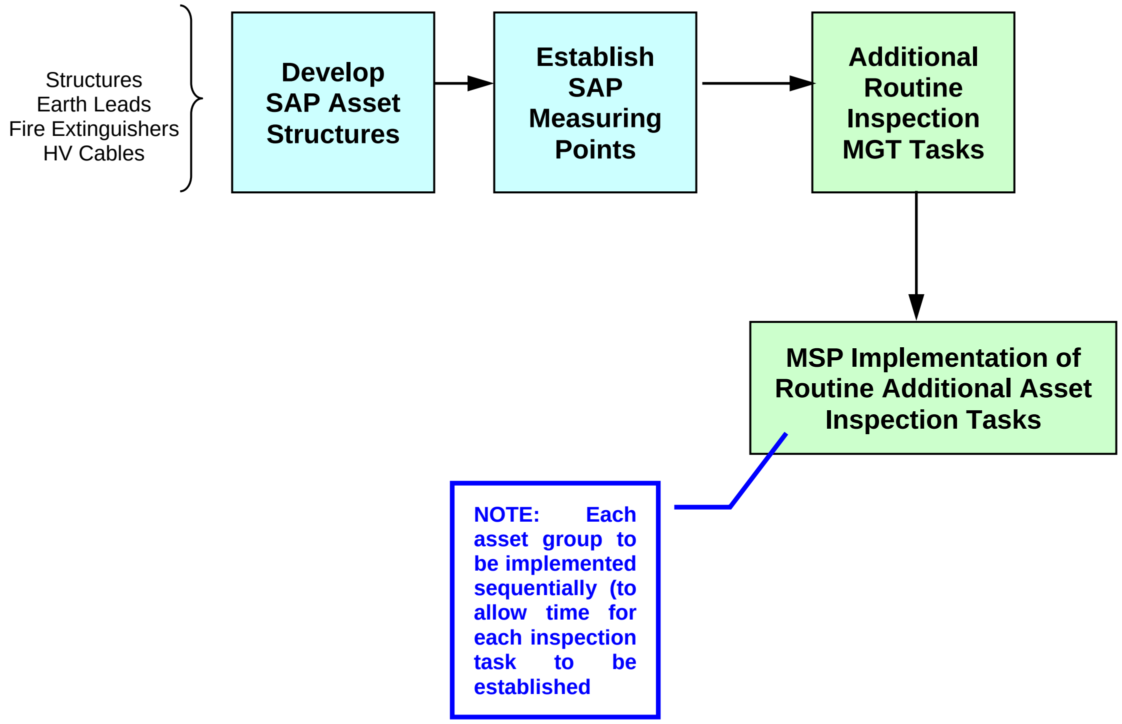


Figure C.5: Stage 3 Implementation – Additional Asset Inspection

C6 Stage 4 – Detailed Condition Assessment

MGT and SCAR Coding can also be used to specifically develop detailed asset condition assessment information. It is expected that Asset Strategies and Asset Performance personnel would undertake more detailed asset condition assessments (where more detailed information is required for project development) using MGT and the SCAR Coding structure.

The detailed condition assessment would be based on:

- Detailed site inspection of the Asset(s)
- Recording asset condition using MGT / SCAR Coding

Note that once a more detailed asset condition assessment is captured in SAP the routine substation inspection process would systematically review these notifications and update due to change in asset condition.

C6.1 Development Plan

The plan for development of each stage of MDT / SCAR is set out diagrammatically below.

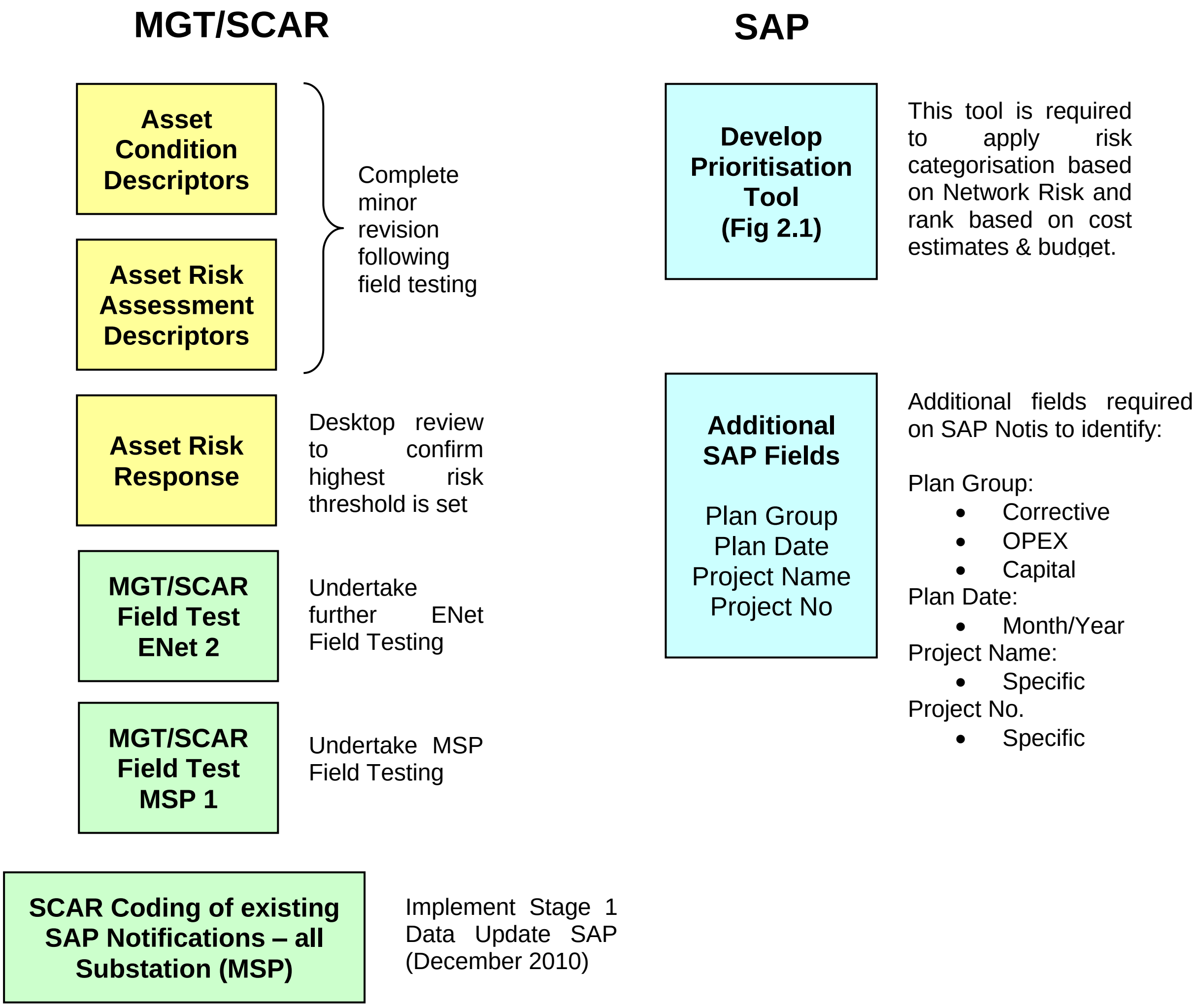


Figure C.6: Development Plan Stage 1 – Initial SCAR Coding

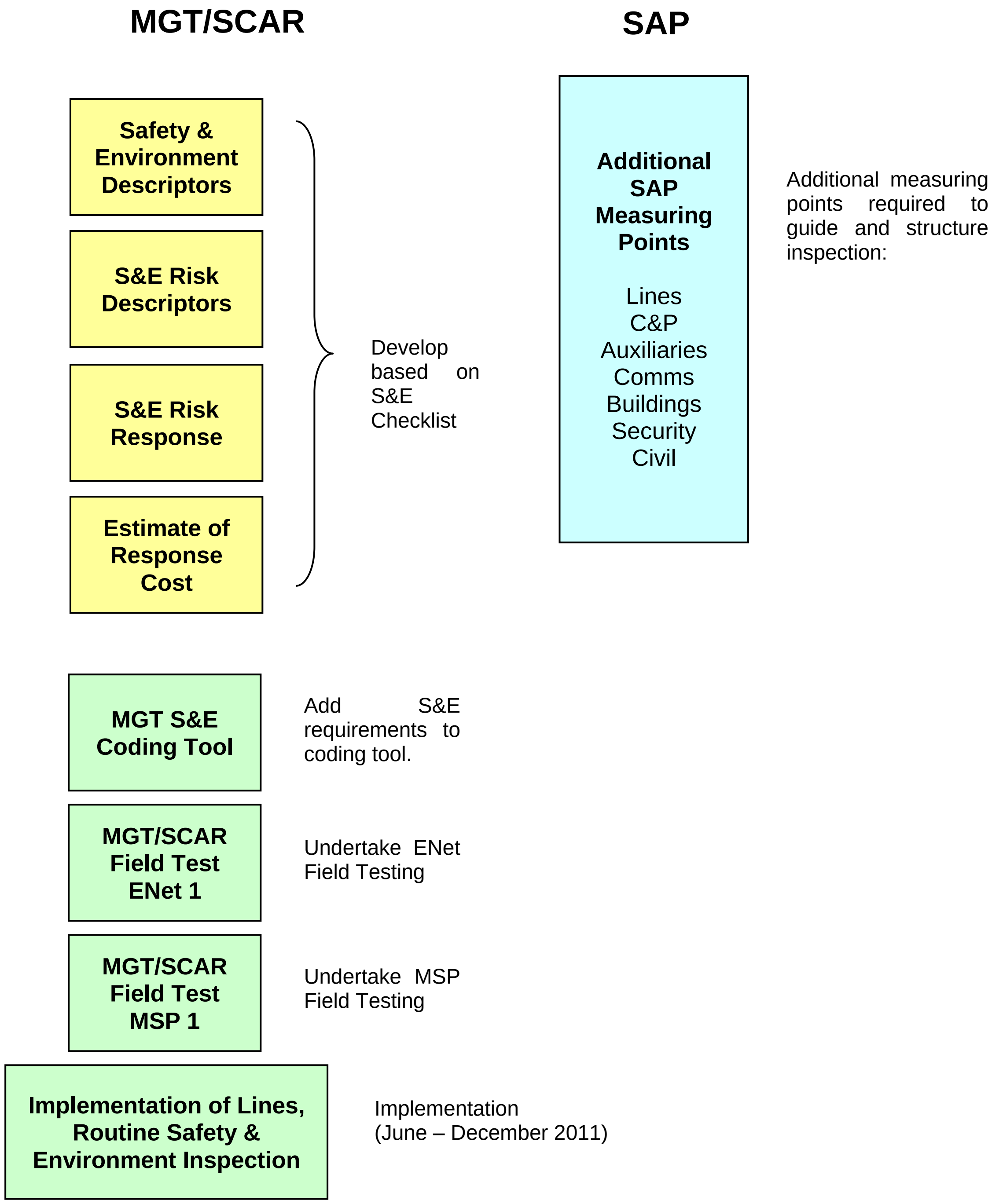


Figure C.7: Development Plan Stage 2 – Safety and Environment

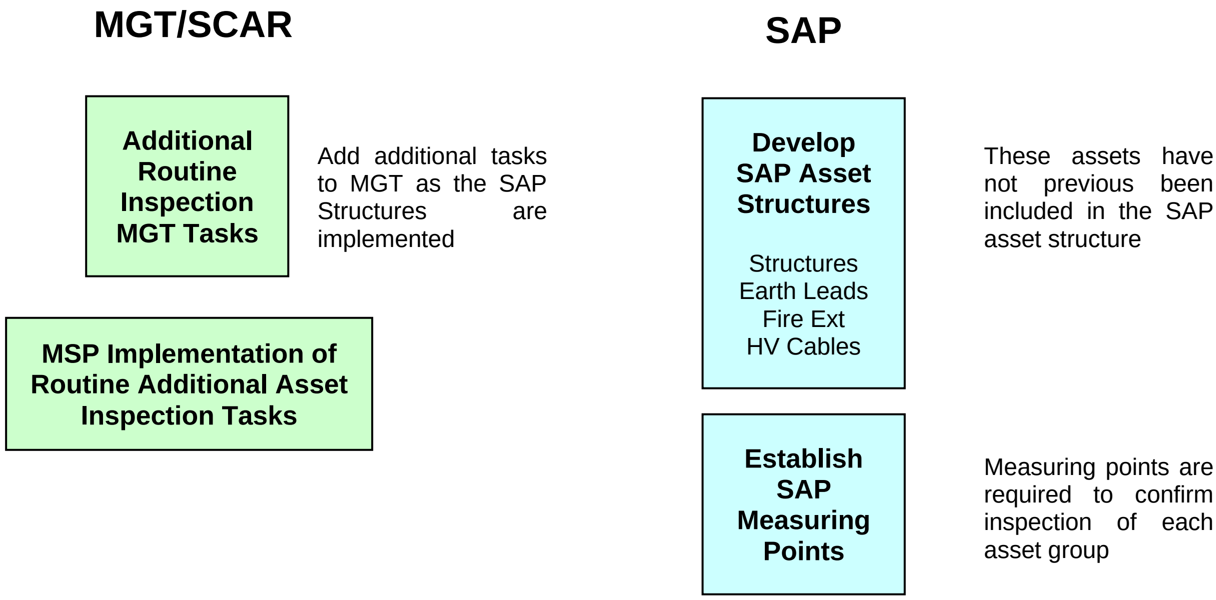


Figure C.8: Development Plan Stage 3 – Additional Asset Inspection

At this point the overall substation checklist structure should be as follows:

1. Circuit Breakers
2. Isolators
3. Instrument Transformers
4. Transformers
5. Bus
6. HV Cables
7. Structures
8. Secondary Systems
9. Substation Auxiliaries
10. Communications
11. Buildings
12. Security
    - Fences
    - Alarms
    - Signs
    - Detection
13. Civil
    - Substation surface (earthing)
    - Roadways
    - Drains
    - Dams
    - Tanks

Figure C.9: Substation Inspection Checklist – Overview

C6.2 Outcomes

Implementation of SCAR coding provides a prioritised list of SAP notifications based on the underlying asset risk matrix and response times. The prioritised SCAR list then provides the basis for identifying the appropriate strategy for the asset. An example of the application of this process is shown in figures 9.1 and 9.2.

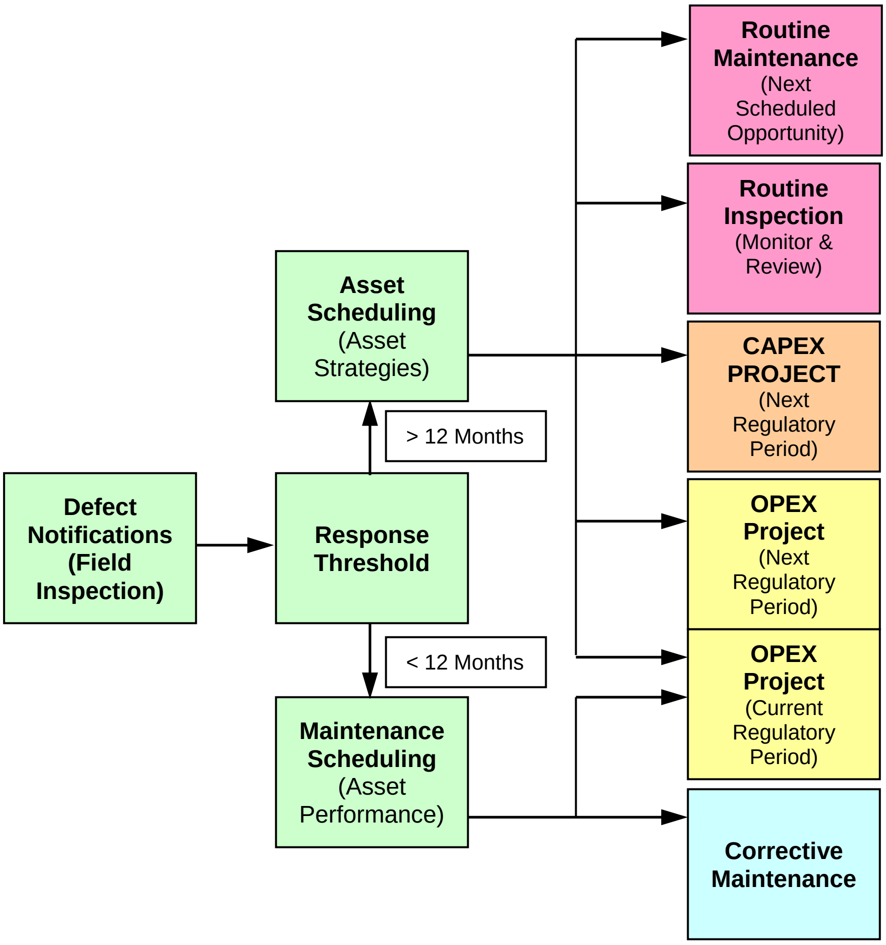


Figure C.10: SCAR Prioritisation – Application

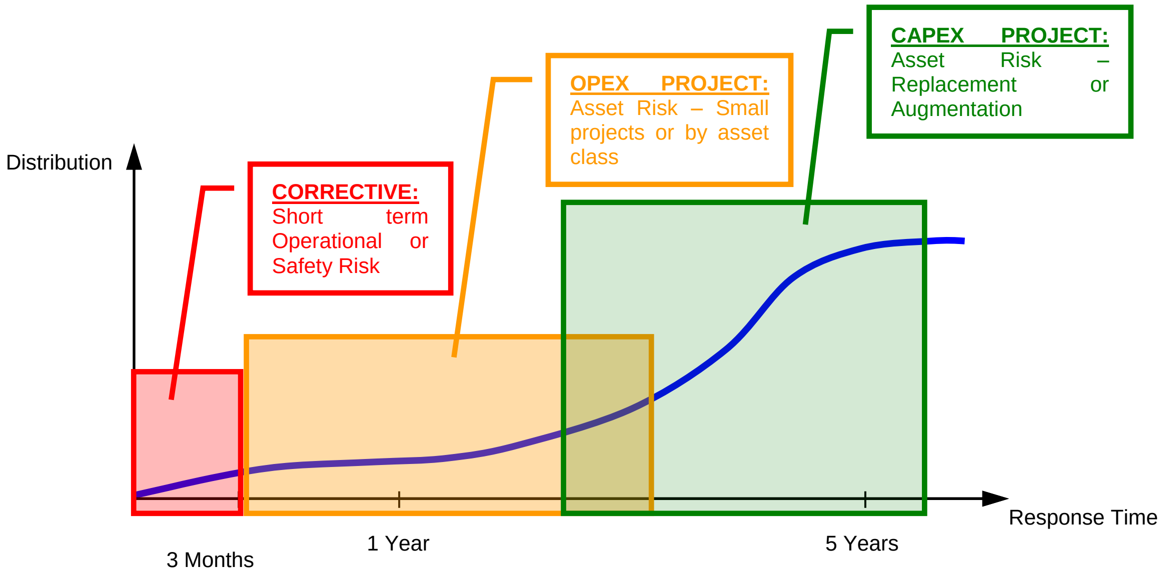


Figure C.11: SCAR Prioritisation – Structure

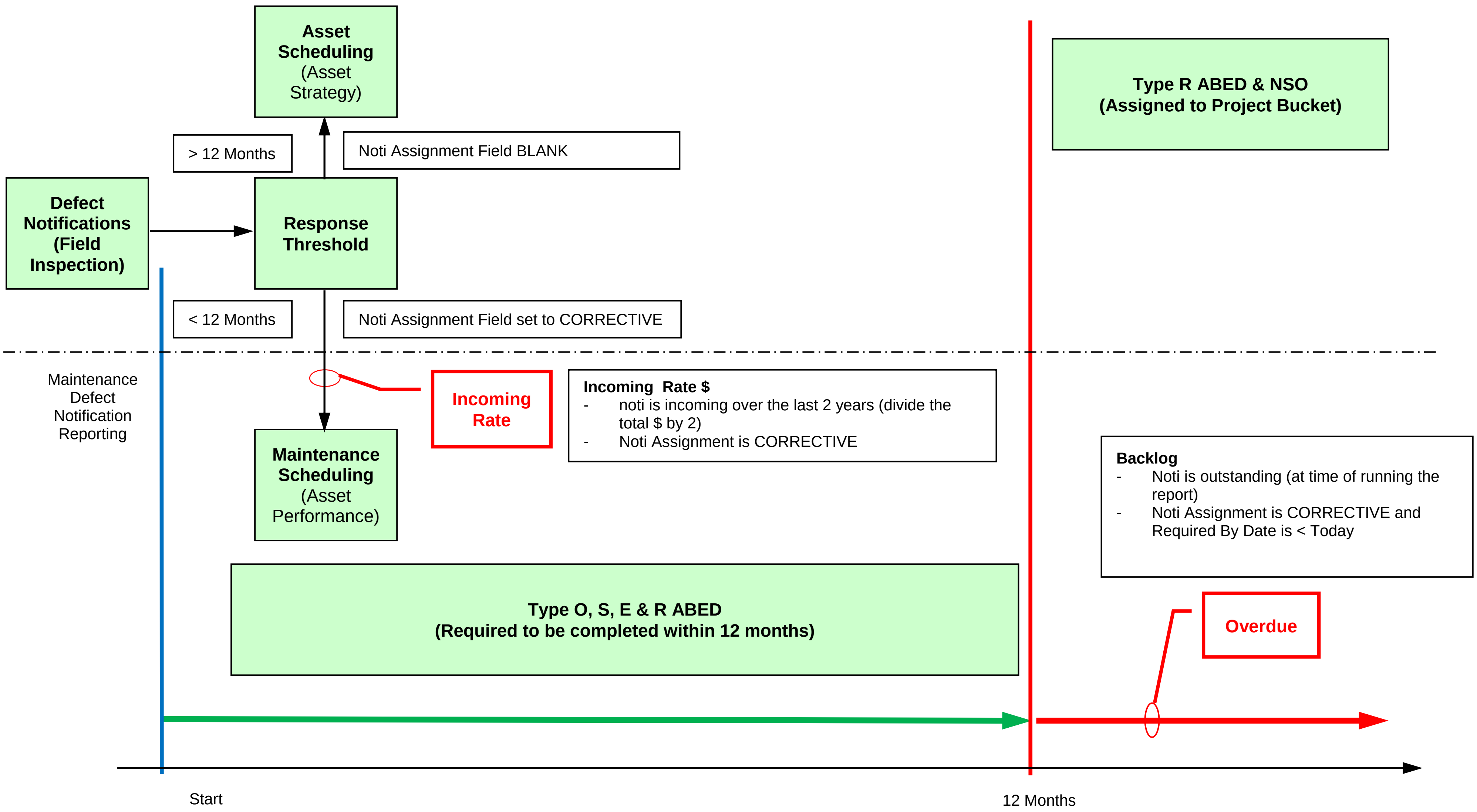
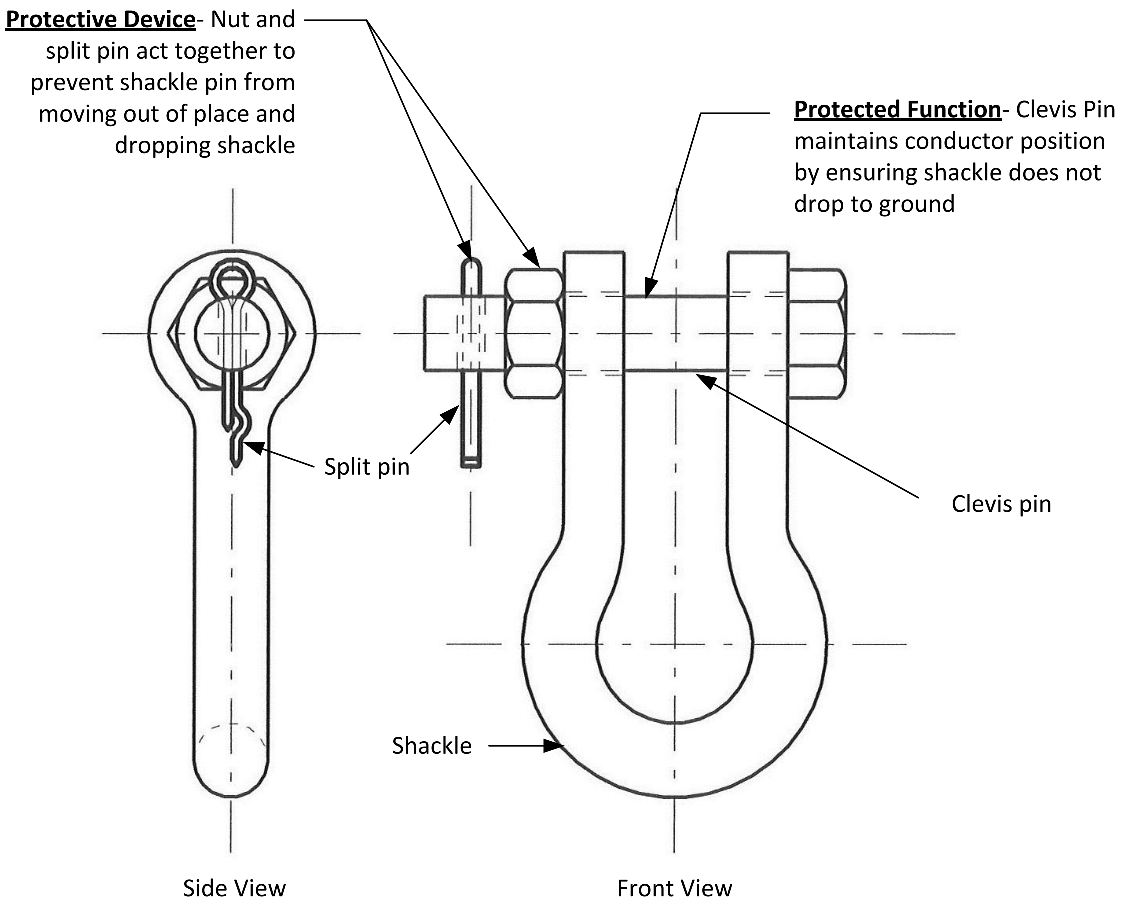


Figure C.12: Reporting

Appendix D Failure Mode SCAR Risk Assessment Example

Insulator Assembly Attachment Hardware failure



The philosophy of Reliability Centred Maintenance (RCM) describes the concepts of protective devices and protected functions . A protective device is a device, which may a physical object, a procedure, or some other controls, that limits or eliminates the likelyhood and/ or consequences of failure for a given function. That function is called the protected function. Generally protected functions are those that are critical to the asset owner's operation whose failure will cause unacceptable outcomes.

The shackles used in transmission line assemblies has been analysed using these concepts. A basic shackle includes the shackle and a clevis pin. The consequences of a shackle failure are extreme because it is possible that a bushfire could be started. The clevis pin is used to complete the link made by a shackle around adjacent hardware items in an assembly. This allows the shackle to maintain the position of the energised conductors in the intended position. This is considered to be the protected function. In a basic shackle, the clevis pin is free to move out of place, because there are no stoppers at one end. Therefore a small split pin was historically used to prevent this.

The split pin was used as a protective device for the protected function of the clevis pin. It was seen from ElectraNet operational failure history of shackle failure that this is not adequate. Because of this and other similar cases in the industry, modern construction requires that the clevis pin be threaded, a nut is screwed onto it, and a split pin inserted into the clevis pin to prevent the nut from coming loose. In this configuration, the split pin and the nut act together as the protective device. This is shown in the above drawing. The possible combinations of the split pin, nut, and clevis pin failures were analysed to determine the likelihood, consequences, and therefore the risk of dropping conductors due to a shackle failure.

The table below depicts the required response times following risk assessment for various stages of the asset failure mode.

SAP Code	SCAR Code	Unique ID	SCAR Code Description	Bushfire Risk Area	Effect	Priority	Days to Fix	Inspectior's Notes
00000002	1045	C3425	AH Split pin partially out & nut present	All BFRA	C	MR	N/A	Split pin is loose or coming out. Nut is present. Poses a risk of dropping the conductor in high load conditions if split pins works all the way out and the nut comes off.
00000002	0057	C2312	AH Missing split pin & nut present	All BFRA	R	ABED	540	Split pin in line fitting is missing. Nut is present. Poses a risk of dropping the conductor in high load conditions if the nut comes off.
00000002	1065	C3492	AH Missing split pin & nut coming loose	NBFRA	R	ABED	360	Split pin in line fitting clevis bolt is missing. Nut is present but is noticeably undoing. Poses a risk of dropping the conductor in high load conditions if the nut comes off.
00000002	1066	C3493	AH Missing split pin & nut coming loose	BFRA, HBFRA	O	ABED	90	Split pin in line fitting clevis bolt is missing. Nut is present but is noticeably undoing. Poses a risk of dropping the conductor in high load conditions if the nut comes off.
00000002	1067	C3494	AH Missing split pin & nut missing	NBFRA	O	ABED	15	Split pin in line fitting clevis bolt is missing. Nut is missing but bolt has not moved. Poses a risk of dropping the conductor in high load conditions.
00000002	1068	C3495	AH Missing split pin & nut missing	BFRA, HBFRA	Z	ABED	10	Split pin in line fitting clevis bolt is missing. Nut is missing but bolt has not moved. Poses a risk of dropping the conductor in high load conditions.
00000002	0060	C2313	AH Loose clevis pin/bolt - coming out	NBFRA	O	IR	1	This applies to all clevis pins or bolts in an insulator assembly. Split pin will be missing for a clevis pin and the split pin and nut will be missing for a clevis bolt. The head of the clevis pin / bolt is will noticeably be sticking out from the line fitting. Poses a risk of dropping the conductor in high load conditions.
00000002	1069	C3496	AH Loose clevis pin/bolt - coming out	BFRA, HBFRA	Z	IR	1	This applies to all clevis pins or bolts in an insulator assembly. Split pin will be missing for a clevis pin and the split pin and nut will be missing for a clevis bolt. The head of the clevis pin / bolt is will noticeably be sticking out from the line fitting. Poses a risk of dropping the conductor in high load conditions.

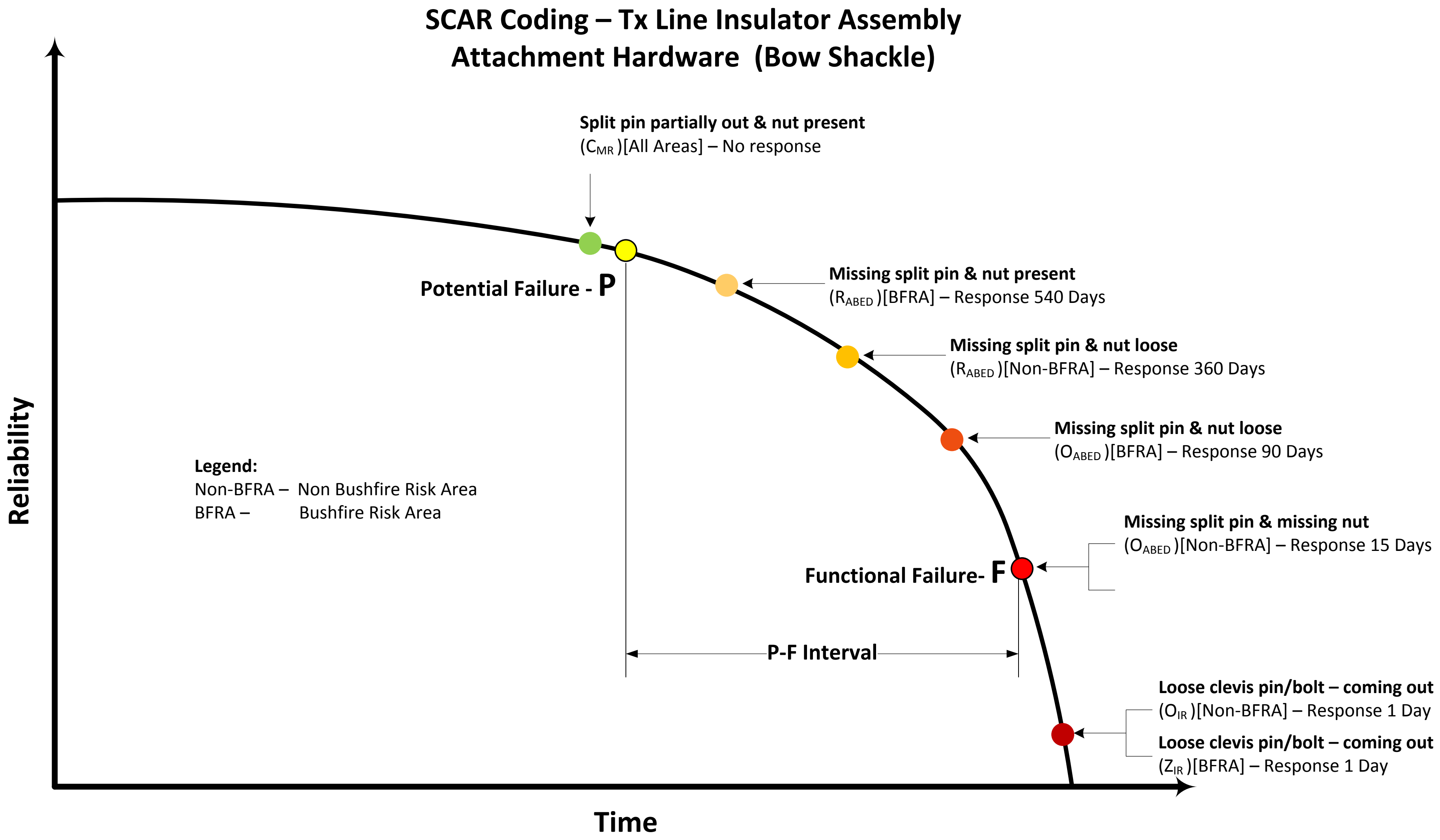


Figure D.13: Tx Line Insulator Assembly Attachment Hardware P-F Interval