Deloitte.

Openreach Fault Data

Data analysis

Contents

Introduction

This document has been commissioned by Openreach within the context of its submission to the Ofcom consultation on fixed access charge controls.

Openreach has identified a number of factors which they believe are responsible for an upward pressure on the volume of reported faults and on fault repair times.

Openreach appointed Deloitte LLP to interrogate a number of datasets relating to those factors and determine the level of correlation between specific metrics representing those factors, and fault volumes and fault repair times. In addition, we were asked to analyse certain factors that may affect Openreach's ability to meet Service Level Agreements ('SLAs'). This paper documents the key findings from this analysis.

Notwithstanding that a copy of this report will be provided to Ofcom for publishing, no-one other than Openreach is entitled to rely on our report for any purpose whatsoever and we accept no duty of care or liability to any other party (including, without limitation, any party who is shown or gains access to this report).

Context for data analysis

Scope of data analysis

We have investigated two of the primary factors that determine the effort Openreach expends on resolving faults: the volume of faults and the repair time required to resolve each fault.

- The volume of faults is derived from the number of lines and the number of faults per line, also referred to as 'fault rate' and expressed as faults per 1,000 lines per week
- The engineering time required to repair a fault is also referred to as 'task time' and expressed in hours. If a fault requires more than one engineering visit, task time for each visit is included

Deloitte reviewed datasets relating to fault data for the period September 2011 to early September 2013; a subset of the data reaches back to April 2011. Openreach and Deloitte agreed three main areas for investigation to assess their contribution to increasing pressure on both fault volumes and time per fault. These areas are:

- Line type
- Customer switching
- Weather conditions

In addition, Deloitte reviewed the potential impact of fault reporting patterns on Openreach's ability to meet its SLAs, as well as data usage levels and their potential impact on fault rates.

We deployed a number of different approaches in determining the levels of correlation between metrics, including calculating the correlation coefficients, analysing the evolution over time of key metrics, and analysing the alignment of peaks between two or more data series. Our analysis was bound by the data sets provided and the time available. Details about the analytical methods used can be found in Appendix 2.

Whilst we have tested the correlation between certain metrics and fault volumes and repair times, we have not sought to prove, nor do we infer, a causal relationship between them. In addition, we acknowledge that there may be other metrics outside of those we have been asked to test which may also have an impact on fault volumes and repair times.

Key definitions

All customer reported faults have been included in the analysis. In certain cases chargeable faults (where the line has been tested as working) have been excluded in order to look at specific trends of products against the contractual definition of a fault to which the line is tested (SIN349).

Non-chargeable faults are defined by Openreach as faults with repair costs that are recovered through Openreach's tariff. By contrast, chargeable faults are defined by Openreach as faults with repair costs that are recovered through a separate "cost to repair" process. For the avoidance of doubt, the process of determining whether a fault is chargeable or not occurs once the fault has been cleared, not at the time at which is it reported.

The delimitation of the line at the exchange end is the main distribution frame ('MDF'). All faults on the MDF and all faults between the MDF and the customer premises are within scope; all faults on the exchange (i.e. on the core network end of the MDF) are out of scope.

Key findings

Having reviewed the fault data for the period October 2011 to September 2013, our key findings are:

- Fault rates vary between types of lines. Lines used for data products, such as MPF and WLR+SMPF lines, have a higher fault rate than lines used only for voice (WLR/PSTN). In a market in which broadband penetration is increasing, this would imply an increase in fault rates

- The rate of customer driven interventions is higher on MPF than on other copper products. MPF also has a higher share of total early-life faults as well as higher and increasing early-life fault rates compared to other products

- 34 per cent of total faults, corresponding to 43 per cent of total task time, show some correlation (correlation coefficient of between 0.2 and 0.4) with weather metrics. Some categories of faults exhibit a stronger correlation with adverse weather than others, for instance those associated with the overhead network. Our analysis suggests that the volatility of faults may also be positively influenced by the volatility of weather

- The profile of fault reporting varies for different CPs. Faults are increasingly reported after 6pm and faults reported after 6pm have a higher proportion of SLA breaches

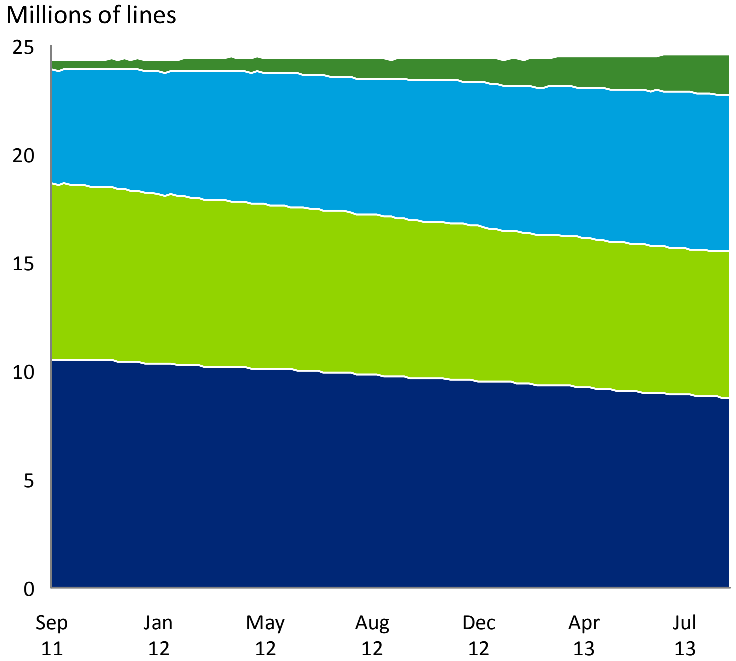
- We have found no direct connection between higher levels of data usage and volumes of standard faults but there is an increase in the usage of fault investigative products by CPs for higher usage customers

Background

Overview of reported faults

The profile of Openreach's lines has evolved over time, driven by broadband penetration, NGA roll-out, and other changing requirements of CPs (Figure 1).

Figure 1: Number of lines by line type



	Growth CAGR	Fault rate (faults/1,000 lines) Average	In-life	Early life
Other	110%	N/a	N/a	N/a
MPF	18%	2.0	1.7	13.2
		% of faults:	*79%*	*21%*
WLR/PSTN	(9)%	1.6	1.5	4.0
		% of faults:	*90%*	*10%*
WLR+SMPF	(9)%	2.3	2.1	4.5
		% of faults:	*85%*	*15%*

Openreach received c. 7 million reported faults between September 2011 and August 2013, the period for which data was available. Openreach categorises the faults either by the type of line on which they occur (e.g. MPF, WLR+SMPF) or by the type of fault or activity involved (e.g. Chargeable, Special Fault Investigation ('SFI'), etc) The faults in scope for this analysis, unless stated otherwise, are MPF, WLR+SMPF, WLR/PSTN and Other (which include NGA related faults), and these account for 60 per cent of total fault volumes (Figure 2).

The total volume of faults in these categories has increased. Data for the most recent time period, July to August 2013, indicates a 12 per cent increase in monthly fault volumes run-rate versus the same period a year earlier (Figure 3).

Figure 2: Total faults breakdown

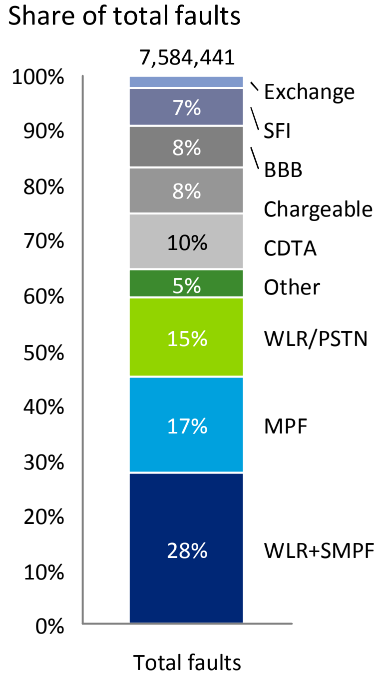
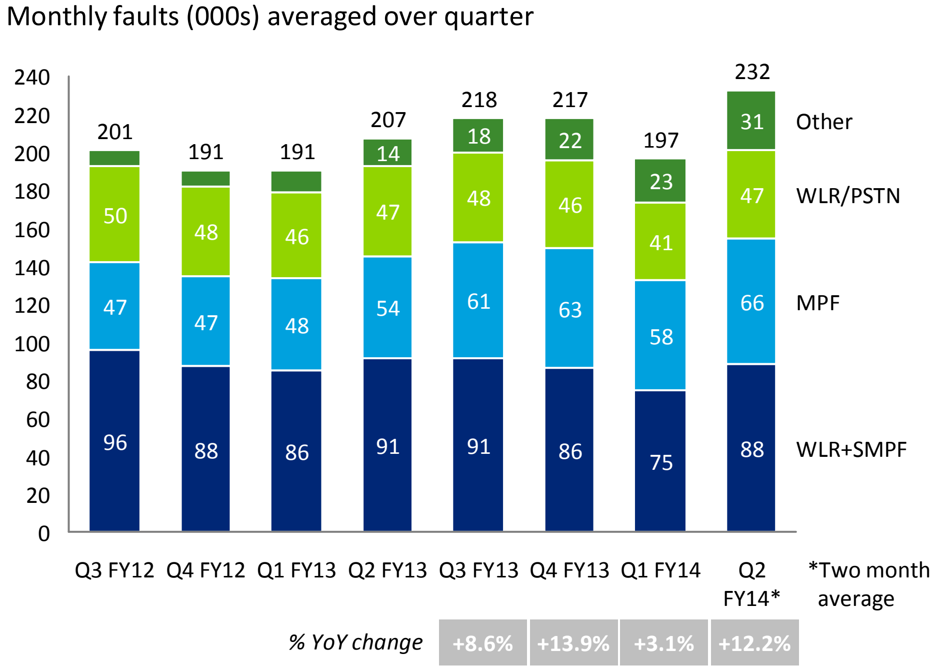
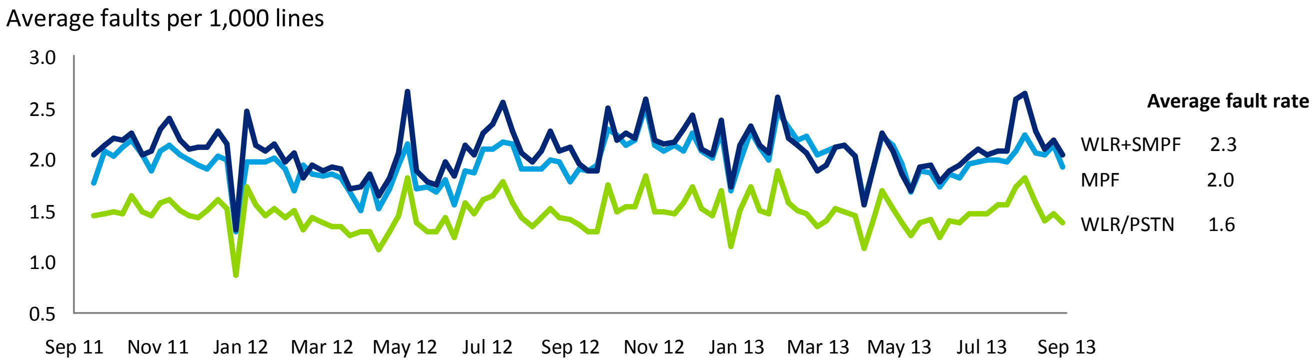


Figure 3: Total faults by line type



Total average fault rates for MPF, WLR+SMPF and WLR/PSTN have remained at broadly the same level over the same time period (Figure 4), i.e. close to 2.3 weekly faults per thousand lines for WLR+SMPF, 2.0 for MPF and a lower level of 1.6 for WLR/PSTN.

Figure 4: Average fault rates by line type (in-life and early-life)



1 Line type

Deloitte explored whether the types of lines that carry data (i.e. MPF and WLR+SMPF) have a higher average fault rate than lines that carry voice-only services (i.e. WLR/PSTN). In the context of increasing broadband penetration, this would result in increasing total average fault rate per line.

In order to explore the possible influence of line type on fault rates and task time, our analysis reviewed:

- The relationship between types of lines and average fault rates
- Average fault rate by CP by type of line

Our key finding is that fault rates vary between types of lines. Lines associated with data products such as MPF and WLR+SMPF lines have a higher fault rate than voice-only lines (WLR/PSTN). In a market in which broadband penetration is increasing, this would imply an increase in fault rates.

1.1 Average fault rate by type of line

MPF has a higher fault rate than other line types

MPF lines and WLR+SMPF lines show a higher in-life fault rate than WLR/PSTN only (Figure 5). The fault rate for MPF is 11 per cent higher than that of WLR/PSTN on average, over the period September 2011 to September 2013 (Figure 6). The fault rate for WLR+SMPF is 35 per cent higher than that of WLR/PSTN on average, over the same period.

Figure 5: In-life fault rates by line type

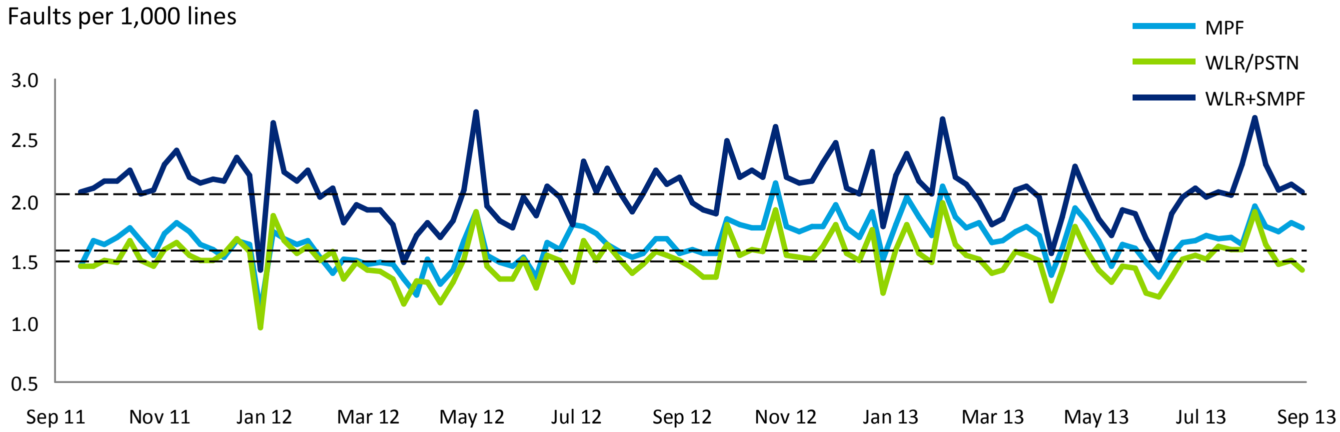
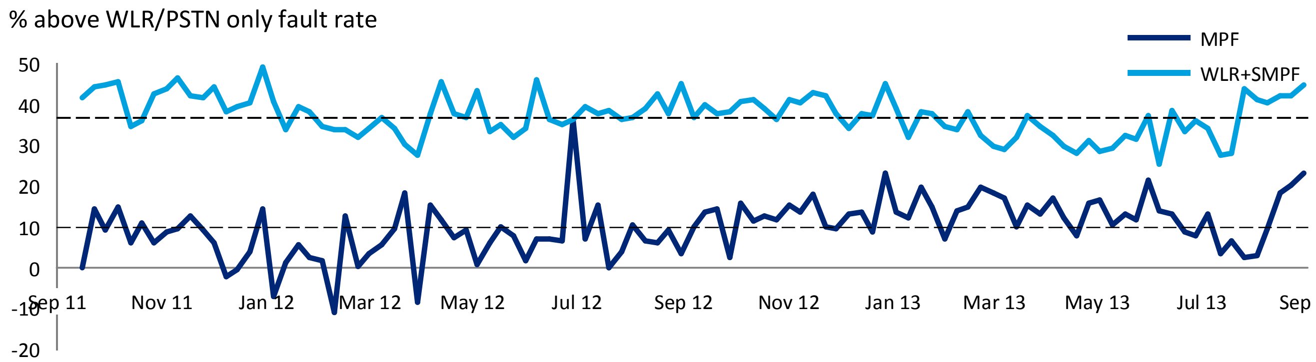


Figure 6: In-life fault rate above WLR/PSTN



1.2 Average fault rate by CP

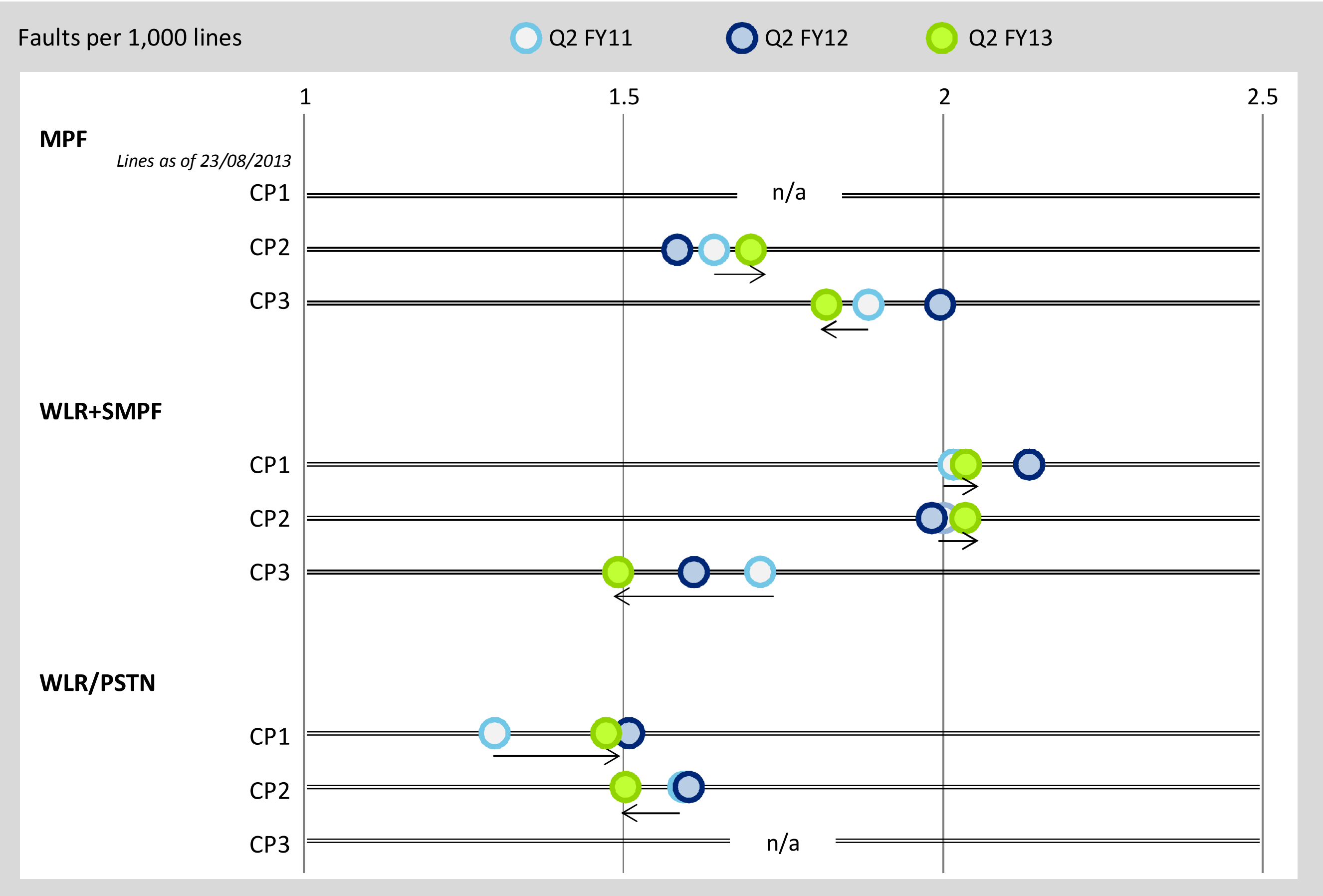
Fault rate by product varies by CP

In addition, there is a variance between the fault rates on each type of line when analysed on a per CP basis. This variance is set out in the chart below.

For WLR+SMPF both CP2 and CP3 have a very limited number of lines, so the variance in CP fault rate may be influenced by a range of other factors. The same applies to WLR/PSTN, in which CP2 has a very limited number of lines.

In the case of MPF, both CP2 and CP3 have an equivalent, and sizeable, number of lines. The fault rates for each CP have been converging over time but the difference still represents c. 0.1 weekly faults per 1,000 lines.

Figure 7: In-life fault rates by line CP and line type



2 Customer switching

Deloitte explored whether customer switching has an impact on the average fault rate, which could result from the disruptive effects of network interventions, provisioning processes and new customer expectations. Our analysis tested the relationship between levels of customer switching and fault rates.

Our analysis is based on customer-driven interventions, which we have defined as any Provision initiated by a customer and involving either the reconnection of a line, a change in CP or product, or any engineering activity. More precisely, this includes instances when an active line is transferred from one customer to another (Working Line Takeover), when an installed but inactive line is activated (Start Of A Stopped Line), when an active line is transferred from one CP, and/or one Product to another (Migrations, Transfers and Conversions), as well as other Provisions and Cease orders where at least one frame or engineering activity has taken place. Our analysis excludes faults such as pre-emptive repairs or interventions related to platform migration.

In order to explore the possible influence of customer switching on fault rates, our analysis reviewed:

- The incidence of customer switching over time, by type of line
- The relationship between customer switching and fault rates

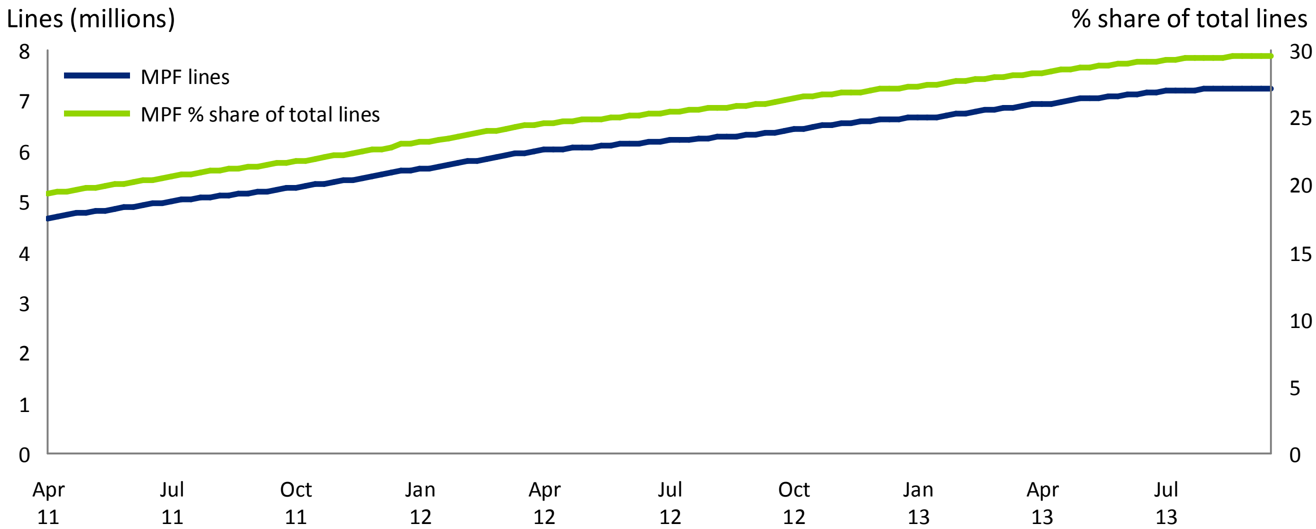
Our key finding is that the rate of customer driven interventions is higher on MPF than on other copper products. MPF also has a higher share of early-life fault rates as well as higher and increasing early-life fault rates compared to other products.

2.1 Customer switching volumes and fault rates over time by type of line

MPF is growing as a proportion of total lines

Openreach's mix of line types has been changing over time, as broadband penetration increases the proportion of data lines (i.e. MPF and WLR+SMPF lines), and as CPs change their requirements for wholesale copper products. Figure 8 illustrates that of the types of lines, MPF is growing at the fastest rate (a growth of 40 per cent between September 2011 and July 2013).In contrast, WLR/PSTN voice-only lines have declined by 9 per cent within the same period (Figure 1).

Figure 8: MPF share of lines



MPF has the highest rate of customer-driven interventions

We analysed the rate of customer-driven interventions that are related to customer switching (as defined above) for each type of line per week (Figure 9). On average, there were 58 per cent more customer-driven interventions on MPF lines than there were on WLR lines over the January 2012 to July 2013 period.

The majority of customer-driven interventions take place on MPF lines, and the majority of those interventions occur in dense urban and suburban areas (Figure 10).

Figure 9: Customer driven interventions by line type

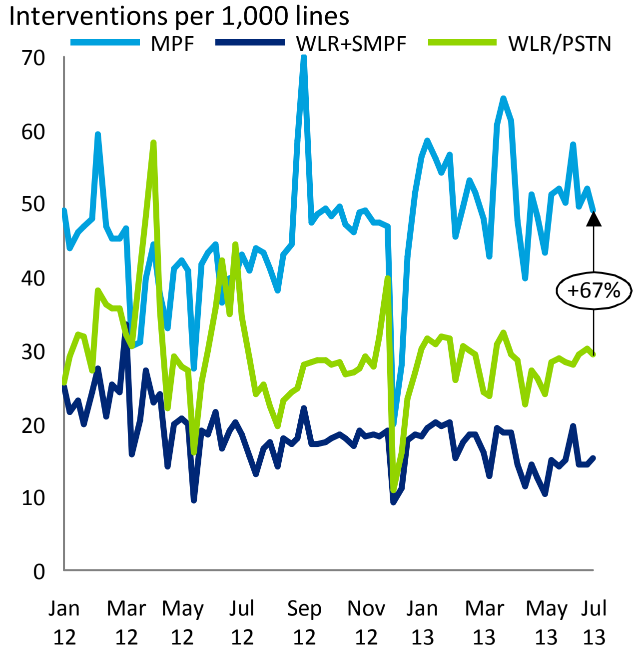
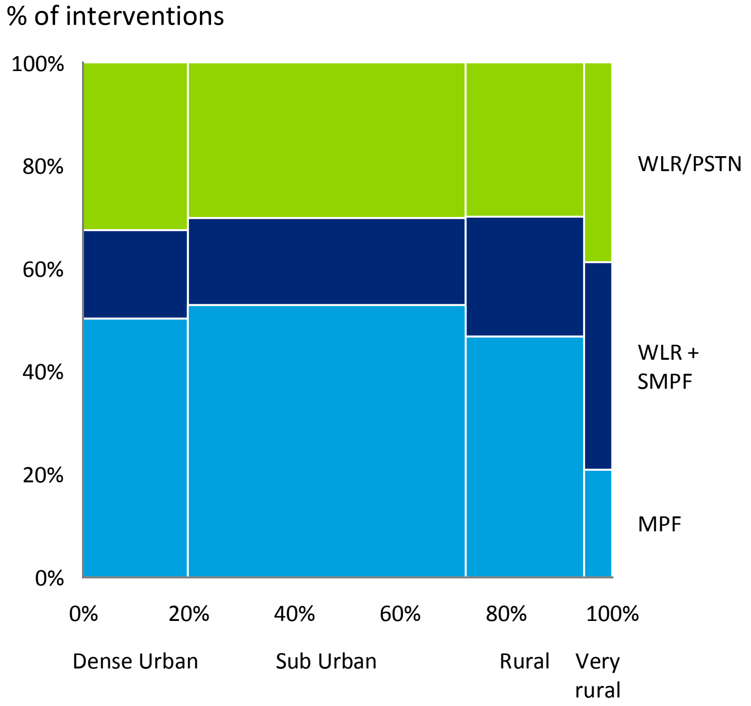


Figure 10: Customer driven interventions by geo-code

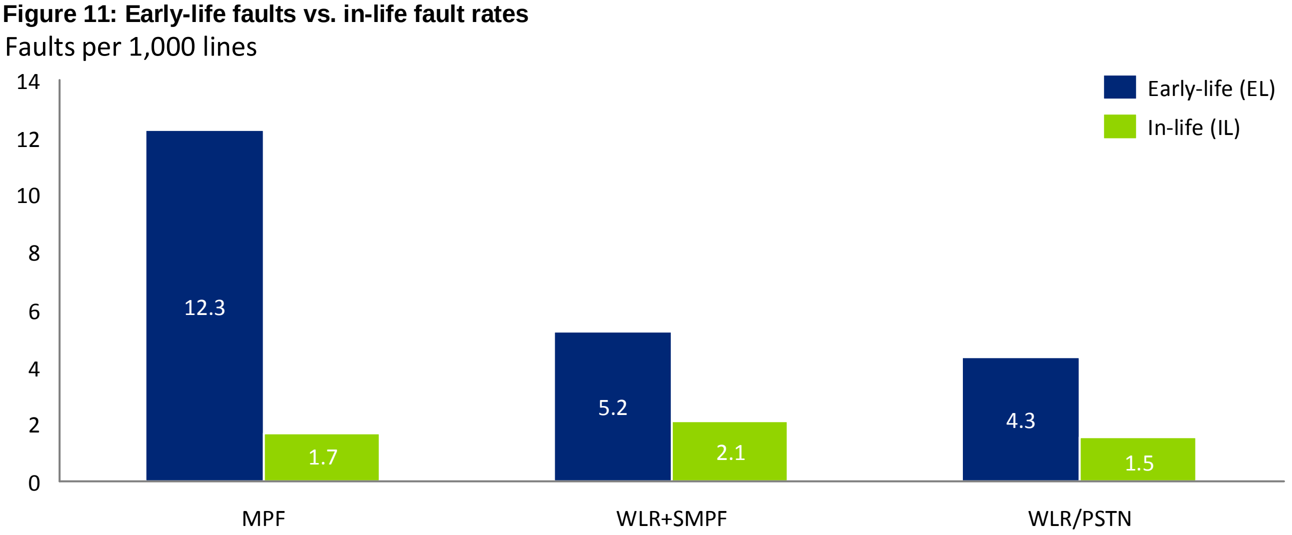


MPF has the highest early-life fault rate

Early-life faults are those reported up to 28 days after the initial engineering work associated with the customer switching; faults reported at any point after that are defined as in-life faults.

Our analysis of early-life and in-life fault rates (Figure 11) demonstrates that early-life fault rates are higher than in-life fault rates for all types of line. Analysis by type of line demonstrates that MPF has an early-life fault rate that is 186 per cent higher than that of WLR/PSTN, and 137 per cent higher than that of WLR+SMPF.

Figure 11: Early-life faults vs. in-life fault rates



The early-life fault rate for MPF is increasing

In addition to having a higher early-life fault rate than both WLR/PSTN and WLR+SMPF, MPF's early-life fault rate is also increasing over time (Figures 12, 13).

Figure 12: Early-life weekly fault rates by line type

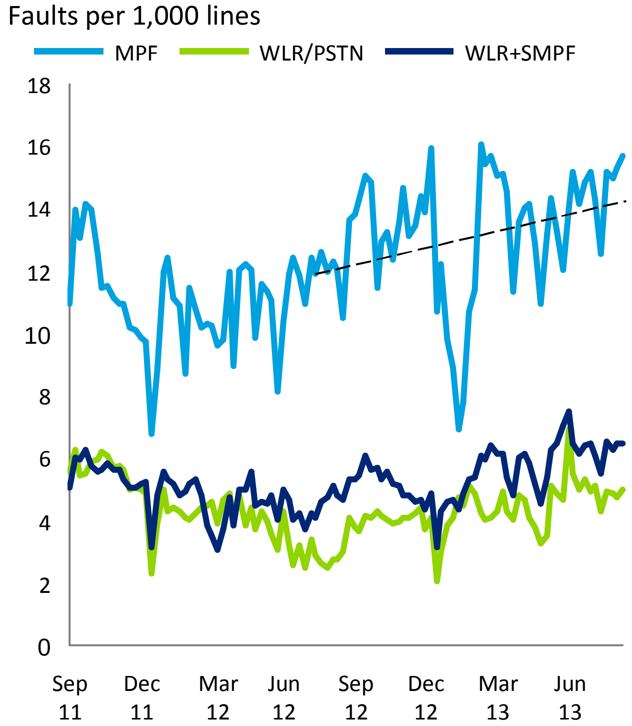
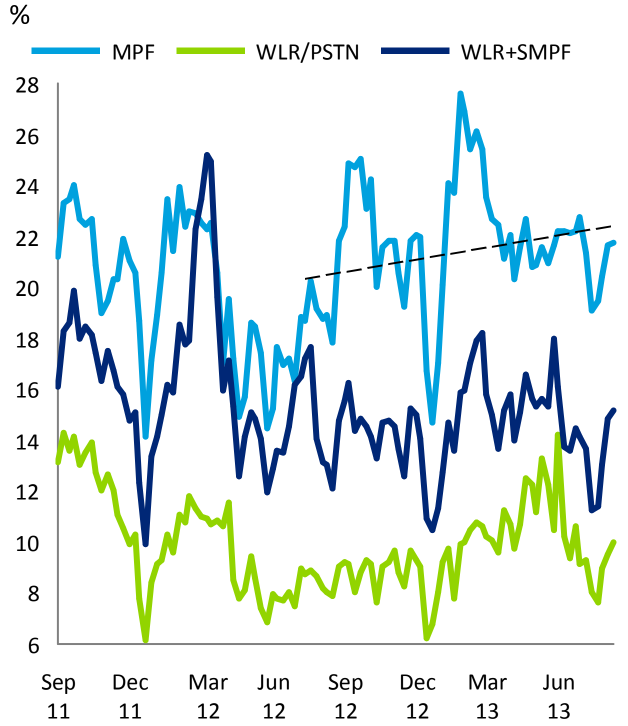


Figure 13: Share of faults that are early-life by line type



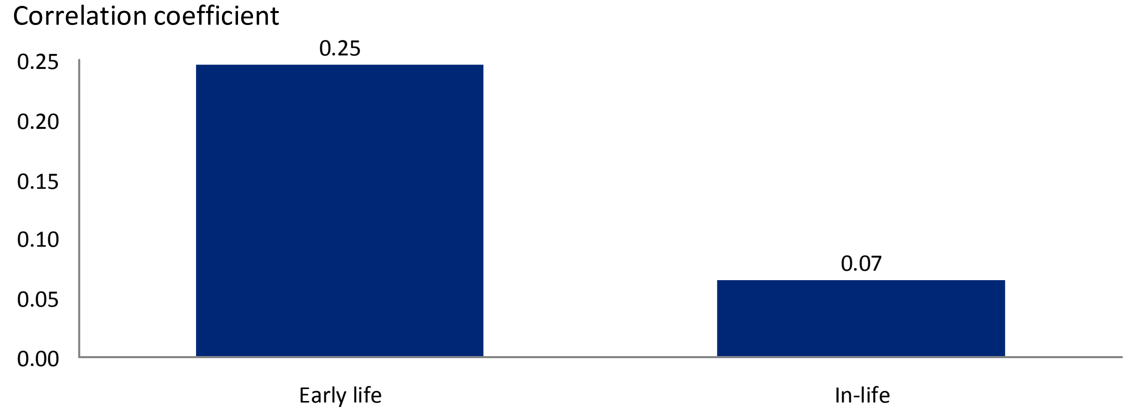
2.2 Correlation between customer switching and fault rates

Early-life fault rates have a degree of correlation with rates of customer switching

To determine the level of correlation between the rate of customer-driven interventions and the fault rate by type of fault, we calculated the correlation coefficient between the two metrics (Figure 14).

Our analysis showed that the correlation coefficient between in-life fault rates and the rate of customer switching is 0.07, indicating a very low level correlation. However, the correlation coefficient between early-life fault rates and the rate of customer switching is higher, at 0.25. This indicates that higher levels of customer switching can be linked to higher rates of early-life faults.

Figure 14: Fault rate vs. rate of customer switching



3 Weather

Deloitte explored whether certain weather conditions (particularly precipitation, humidity, temperature and strong winds) have an impact on parts of the network that are more exposed to the elements. Openreach has seen an increase in adverse weather conditions and anticipates that such conditions will continue and would result in an increase in specific types of faults.

In order to explore the possible influence of weather on fault rates, our analysis has reviewed:

- Fault rates and specific weather metrics
- Fault rate volatility and the volatility of specific weather metrics
- Task time and specific weather metrics

For a detailed explanation of the methods of analysis in this section, please refer to Appendix 2.

Our key findings were that 41 per cent of total faults analysed and 51 per cent of task time analysed exhibit some correlation (correlation coefficient of between 0.2 and 0.4) with weather metrics. Some categories of faults exhibit a stronger correlation with adverse weather than others, for example those associated with the overhead network. Our analysis also suggests that the volatility of faults may also be positively influenced by the volatility of weather.

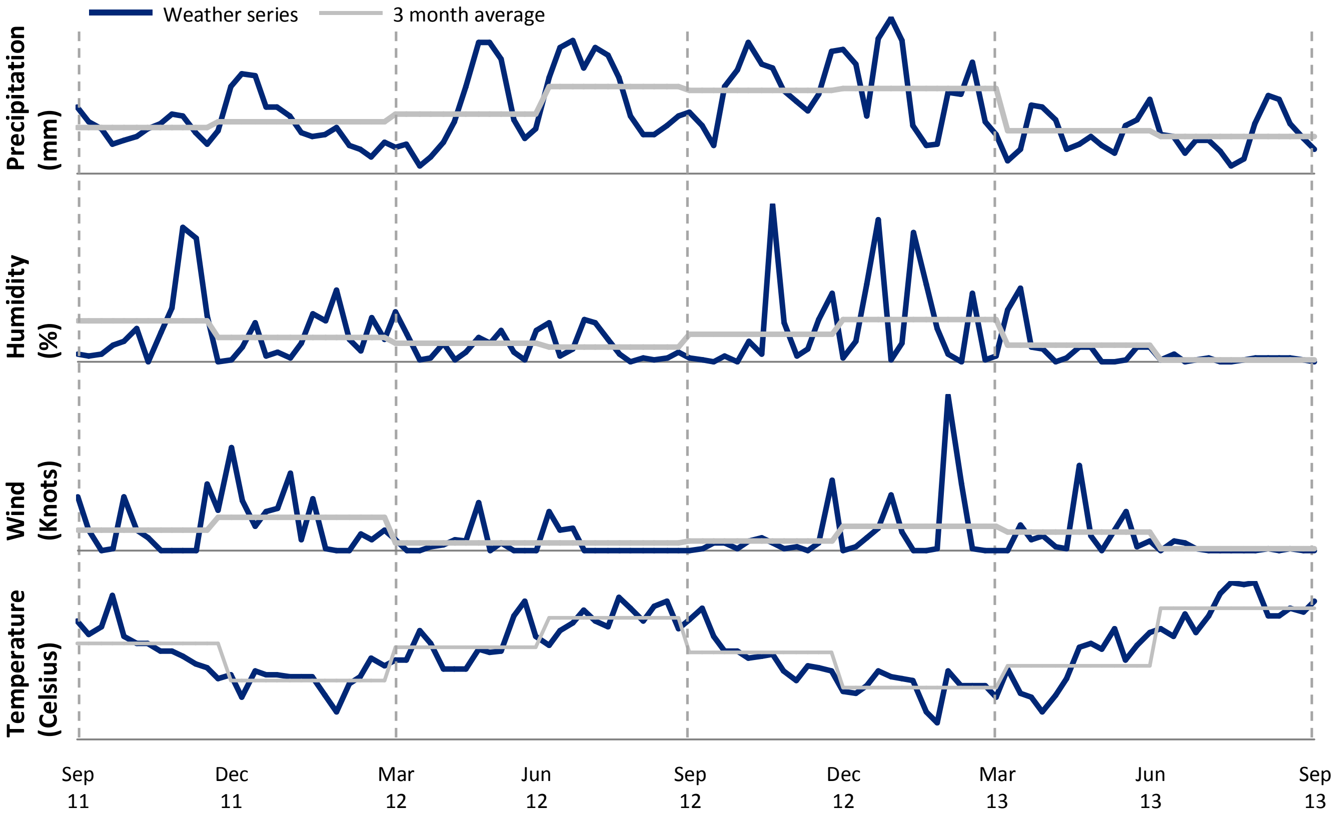
3.1 Relationship between weather conditions and fault rates

Some weather conditions have worsened, year-on-year

We analysed a set of weather data relating to precipitation, humidity, wind and temperature over the period from September 2011 to September 2013. The data indicates high volatility of weather conditions over the period, and seasonality of weather conditions (Figure 15).

Precipitation, humidity and wind have been more severe in winter 2012 than in winter 2011. The data indicates that, using a three month average, the December 2012 to February 2013 period saw 63 per cent higher precipitation levels, 76 per cent higher humidity levels, and 15 per cent lower temperatures than the same period the year before.

Figure 15: Weather time series



A subset of fault types has a degree of correlation with certain weather conditions

At a high level, the relationship between fault volumes and levels of precipitation, humidity, wind and temperature over time appears to indicate a relatively low level of correlation.

However, our analysis focused on determining whether there were specific fault types that have a higher level of correlation with the four weather metrics than others. In order to do this, we categorised faults using their Main Fault Location ('MFL'), i.e. the location of the fault as determined by the initial line test, and the Clear Code, i.e. the engineer's description of the fault at the time he or she resolves it. We then calculated the correlation coefficient between their fault rates and the four weather metrics. This is the purpose of the following charts (Figures 16, 17 and 18).

The results demonstrate a range of correlation coefficients between fault rates by type of fault and weather metrics. The correlation is mainly found in relation to precipitation and humidity, although wind has a level of correlation with certain types of faults in the overhead network. Overhead faults have the highest correlation coefficients with weather relative to other fault categories. Temperature has more correlation coefficients with faults in the exchange and internal wiring than faults in other categories.

To illustrate with specific examples: of the faults in categories with a Clear Code "D-side", indicating a location on the distribution side of the network, two fault types had a correlation coefficient with humidity levels of between 0.2 and 0.4. Of the faults in categories with a Clear Code "Exch", indicating a location at the exchange, two types had correlation coefficients with weather levels of between 0.2 and 0.4. Of the faults in categories with a Clear Code "OH", indicating a location on the overhead network, six types had correlation coefficients of between 0.2 and 0.4 with humidity, wind or precipitation levels, and two types had higher correlation coefficients (above 0.4), with wind and humidity respectively.

Figure 16: Correlation between fault rates by type and weather events

Clear Code	Initial Main Fault Location	Precipitation (mm)	Wind (knots)	Humidity (%)	Temperature (°C)
D_SIDE	CA	Between 0.2 and 0.4	Below 0.2	Between 0.2 and 0.4	Below 0.2
	CE	Below 0.2	Below 0.2	Below 0.2	Below 0.2
	FU	Below 0.2	[illegible]	Below 0.2	Below 0.2
	LN	Below 0.2	[illegible]	Between 0.2 and 0.4	Below 0.2
	OK	Below 0.2	[illegible]	Below 0.2	Below 0.2
E_SIDE	CA	Below 0.2	Below 0.2	Below 0.2	Between 0.2 and 0.4
	CE	Below 0.2	Below 0.2	Below 0.2	Below 0.2
	FU	Below 0.2	Below 0.2	Below 0.2	Below 0.2
	LN	Between 0.2 and 0.4	Between 0.2 and 0.4	Between 0.2 and 0.4	Below 0.2
	OK	Below 0.2	Below 0.2	[illegible]	Below 0.2
EXCH	CA	Below 0.2	Below 0.2	[illegible]	Between 0.2 and 0.4
	CE	Below 0.2	Below 0.2	[illegible]	Below 0.2
	FU	Below 0.2	Below 0.2	[illegible]	Below 0.2
	LN	Below 0.2	Below 0.2	Between 0.2 and 0.4	Between 0.2 and 0.4
	OK	[illegible]	[illegible]	Below 0.2	Below 0.2
MIW	CA	[illegible]	[illegible]	Below 0.2	Between 0.2 and 0.4
	CE	[illegible]	[illegible]	Below 0.2	Below 0.2
	FU	Below 0.2	Below 0.2	Below 0.2	Below 0.2
	LN	Below 0.2	Below 0.2	Below 0.2	Between 0.2 and 0.4
	OK	Below 0.2	Below 0.2	Below 0.2	Below 0.2
OH	CA	Between 0.2 and 0.4	Between 0.2 and 0.4	Between 0.2 and 0.4	Below 0.2
	CE	Below 0.2	Above 0.4	Below 0.2	Below 0.2
	FU	Below 0.2	Below 0.2	Below 0.2	Below 0.2
	LN	Between 0.2 and 0.4	Between 0.2 and 0.4	Above 0.4	Below 0.2
	OK	Below 0.2	Between 0.2 and 0.4	Below 0.2	Below 0.2
PCP	CA	Below 0.2	Below 0.2	Below 0.2	Between 0.2 and 0.4
	CE	Below 0.2	Below 0.2	Below 0.2	Below 0.2
	FU	Below 0.2	Below 0.2	Below 0.2	Below 0.2
	LN	Below 0.2	Between 0.2 and 0.4	Between 0.2 and 0.4	Below 0.2
	OK	Below 0.2	Below 0.2	Below 0.2	Below 0.2
RWT	CA	Below 0.2	Below 0.2	Below 0.2	Between 0.2 and 0.4
	CE	Below 0.2	[illegible]	Below 0.2	Below 0.2
	FU	Below 0.2	[illegible]	Below 0.2	Below 0.2
	LN	Below 0.2	[illegible]	Between 0.2 and 0.4	Below 0.2
	OK	Below 0.2	[illegible]	Below 0.2	Below 0.2

D-side affected by humidity

Exchange affected by temperature

Overhead plant ('OH') affected by precipitation, wind and humidity

PCP also affected by humidity

Focusing on specific combinations of these fault types and weather conditions, it is possible to illustrate the level of correlation between certain weather conditions and a sub-set of fault types. On the charts below, each dot represents a week's specific fault volumes and weather conditions.

Figure 17 illustrates the correlation coefficient of 0.4 between precipitation and E-side-LN faults (i.e. faults with both an MFL and a Clear Code indicating the fault location is at the exchange side of the network). The top right chart illustrates the correlation coefficient of 0.32 between wind and OH-LN faults (i.e. faults with a MFL indicating the fault is at the exchange side of the network and a Clear Code indicating the fault is with the overhead network). The bottom left chart illustrates the correlation coefficient of 0.36 between humidity and D-side-CA faults (i.e. faults with a MFL indicating the fault is with the customer apparatus, and a Clear Code indicating the fault is at the distribution side of the network). The bottom right chart illustrates the correlation coefficient of 0.38 between humidity and OH-CA faults (i.e. faults with a MFL indicating the fault is with the customer apparatus, and a Clear Code indicating the fault is with the overhead network).

Figure 17: Correlation between weather series and fault types

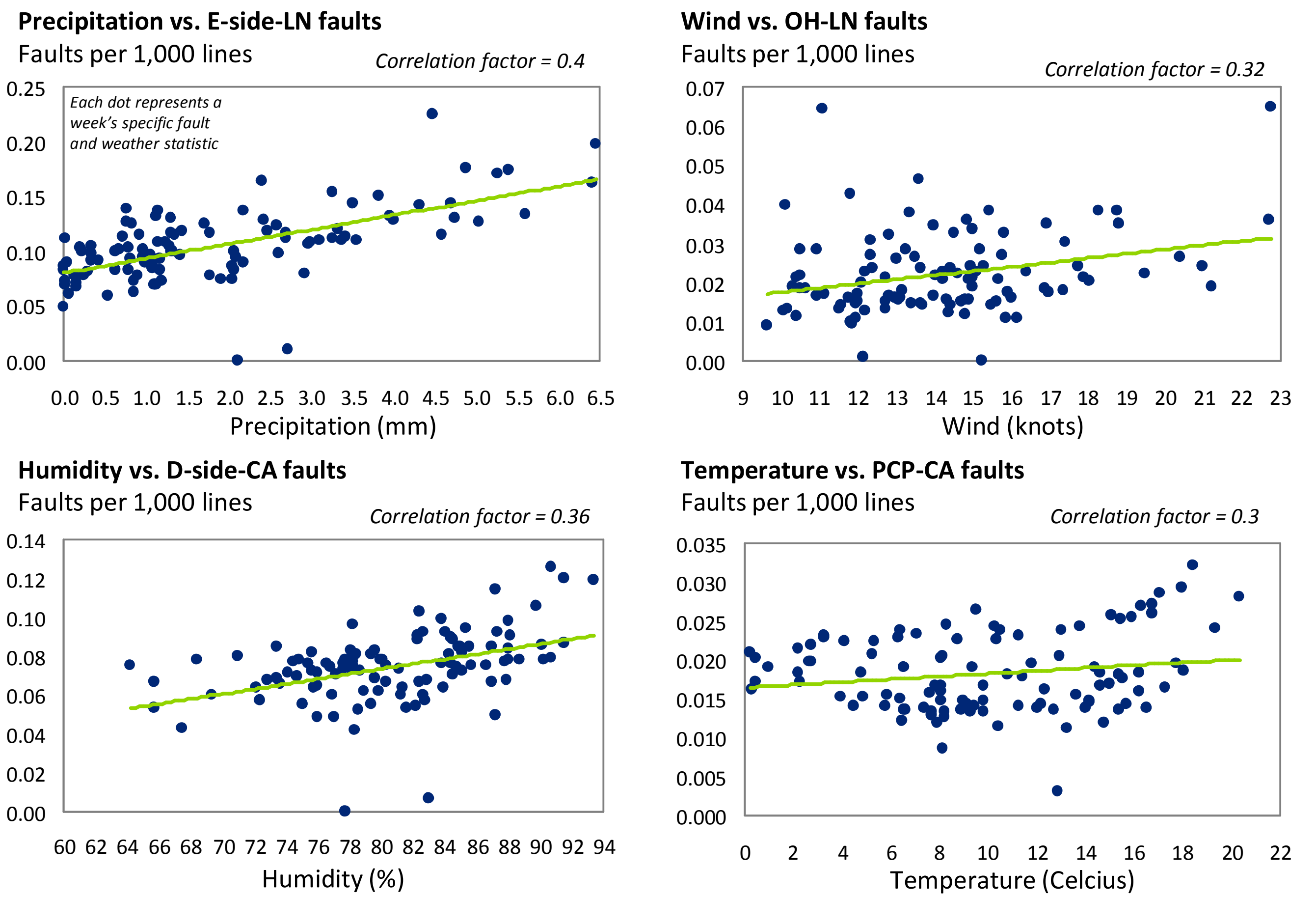
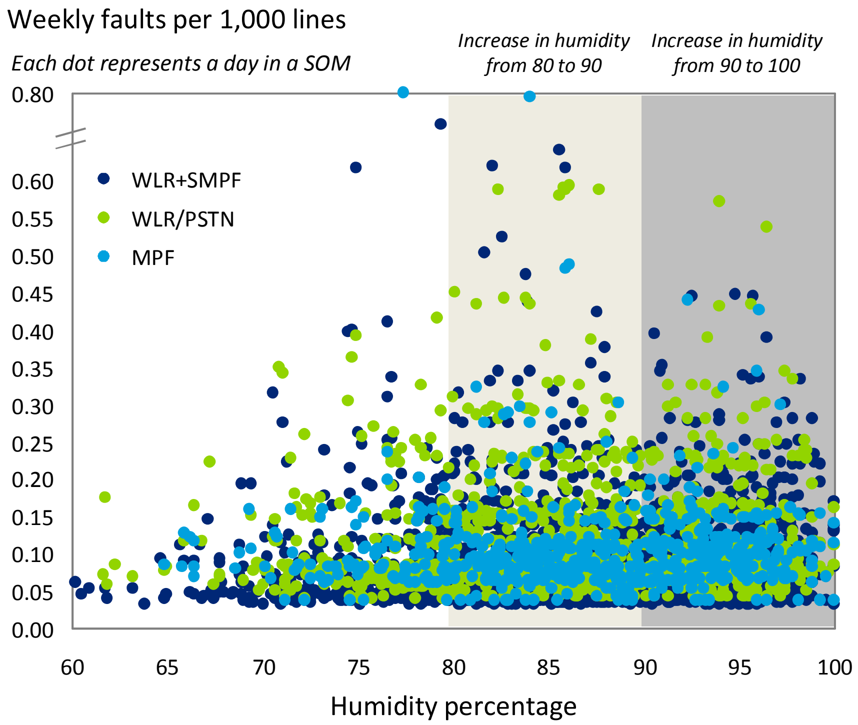


Figure 18 illustrates the correlation between levels of humidity and faults in the OH-LN category (i.e. faults with a MFL indicating the fault is at the exchange side of the network, and a Clear Code indicating the fault is with the overhead network). The increase in fault rates starts to be noticeable above 70% humidity for all line types. Between 80% and 90% humidity all types of products are only moderately affected by a higher average fault rates. The average increase in fault rate becomes more significant after humidity reaches 90%, in particular for MPF and WLR+SMPF line types.

Figure 18: OH-LN fault rates: Humidity vs. fault rate by product and SOM per day

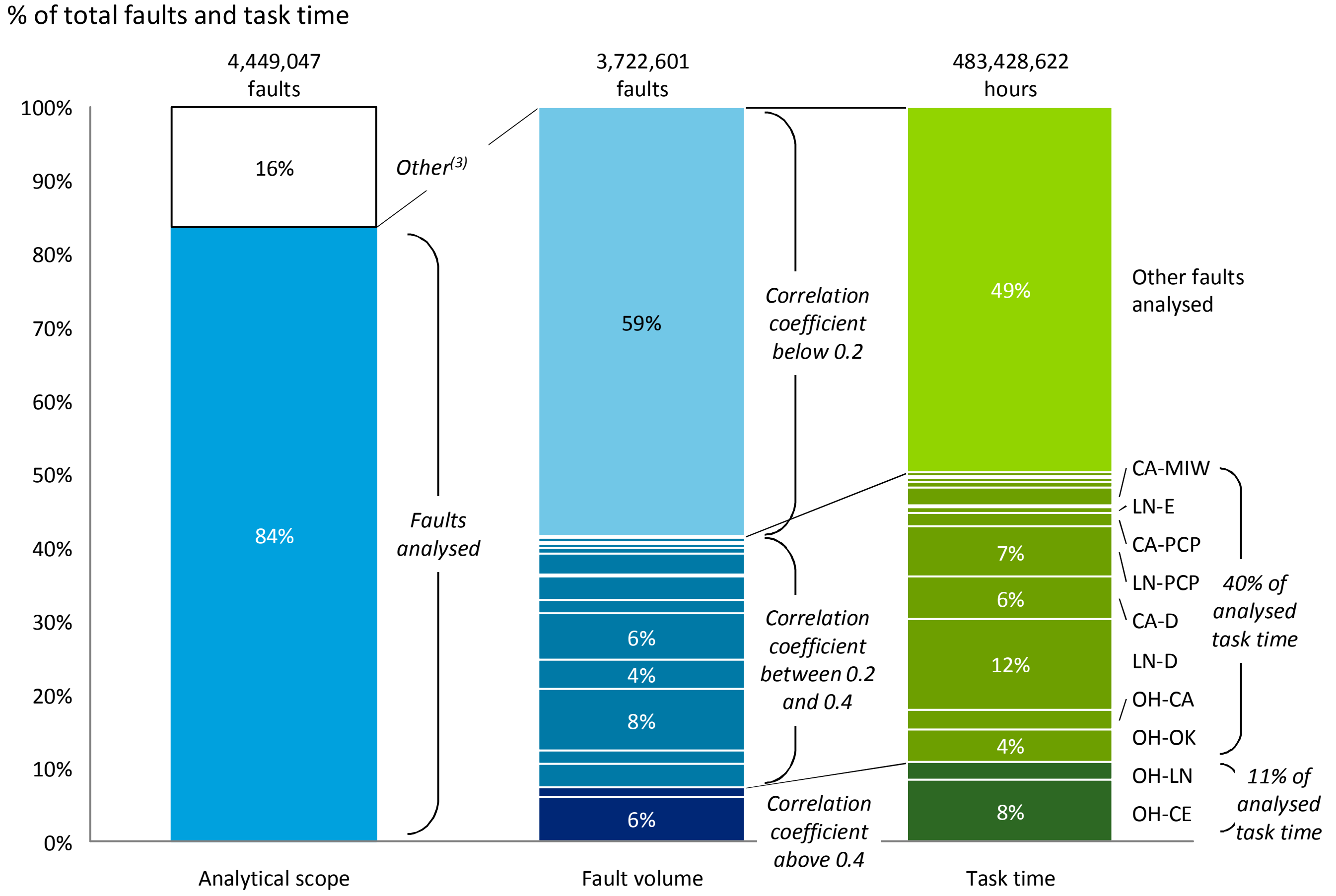


	% average increase in fault rate		
	WLR/ PSTN	**MPF**	**WLR + SMPF**
Increase in humidity from 80 to 90	+13%	+5%	+7%
Increase in humidity from 90 to 100	+37%	+70%	+78%

Faults in categories that are more highly correlated with weather metrics account for 40 per cent of Openreach fault volumes and 51 per cent of task time

When considering Openreach's total fault volumes and task time, our analysis shows that faults that are in categories that have a correlation coefficient of 0.2 or higher account for 41 per cent of fault volumes analysed and 51 per cent of total task time analysed. This is equivalent to 34 per cent of total fault volume, and 43 per cent of total task time (Figure 19).

Figure 19: Weather-correlated faults as a share of total faults and total task time



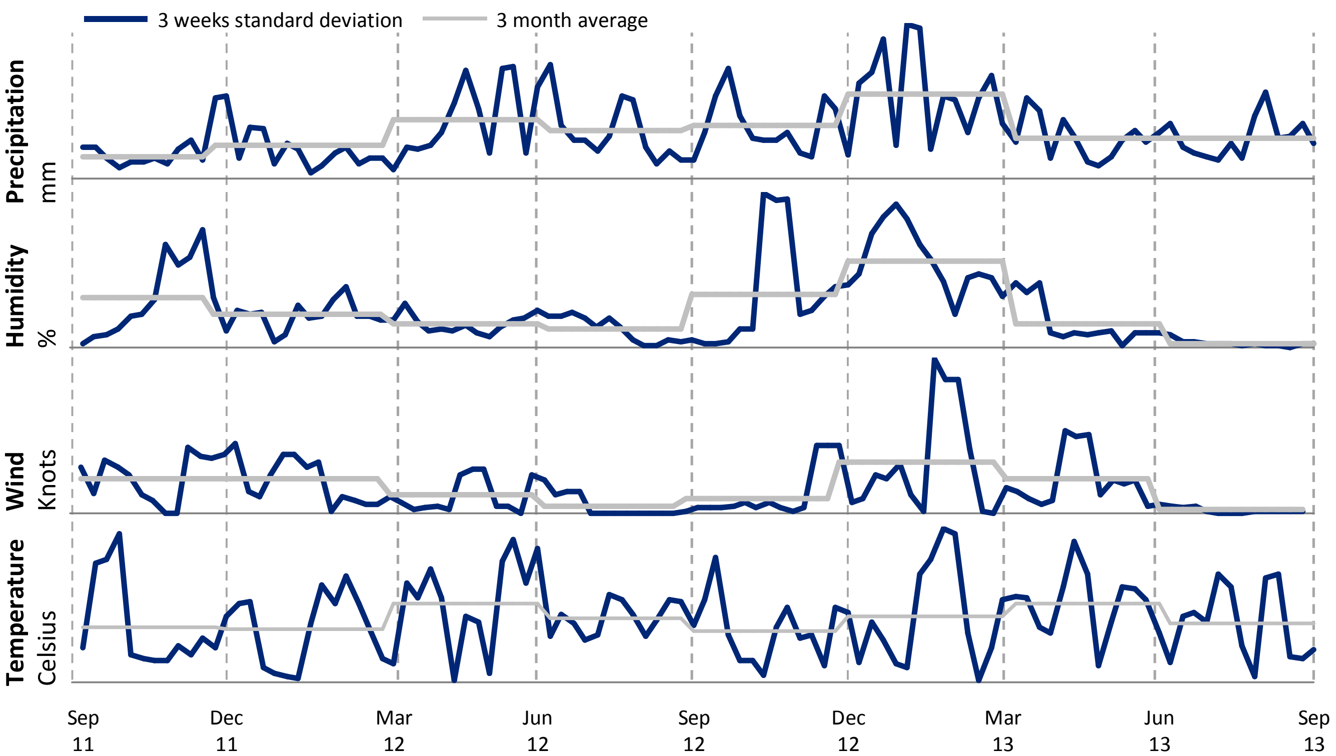
3.2 Relationship between weather volatility and fault rate volatility

Precipitation, humidity and wind appear to have increased in volatility in winter 2012/13

To calculate the level of change in volatility we plotted the evolution of standard deviation over time for precipitation, humidity, wind and temperature over three week periods. We then plotted the three month average for that standard deviation and compared the average standard deviation in the period December 2012 to February 2013 with the same period a year before.

This analysis (Figure 20) indicates higher levels of volatility in precipitation, humidity, wind and temperature in the more recent time period.

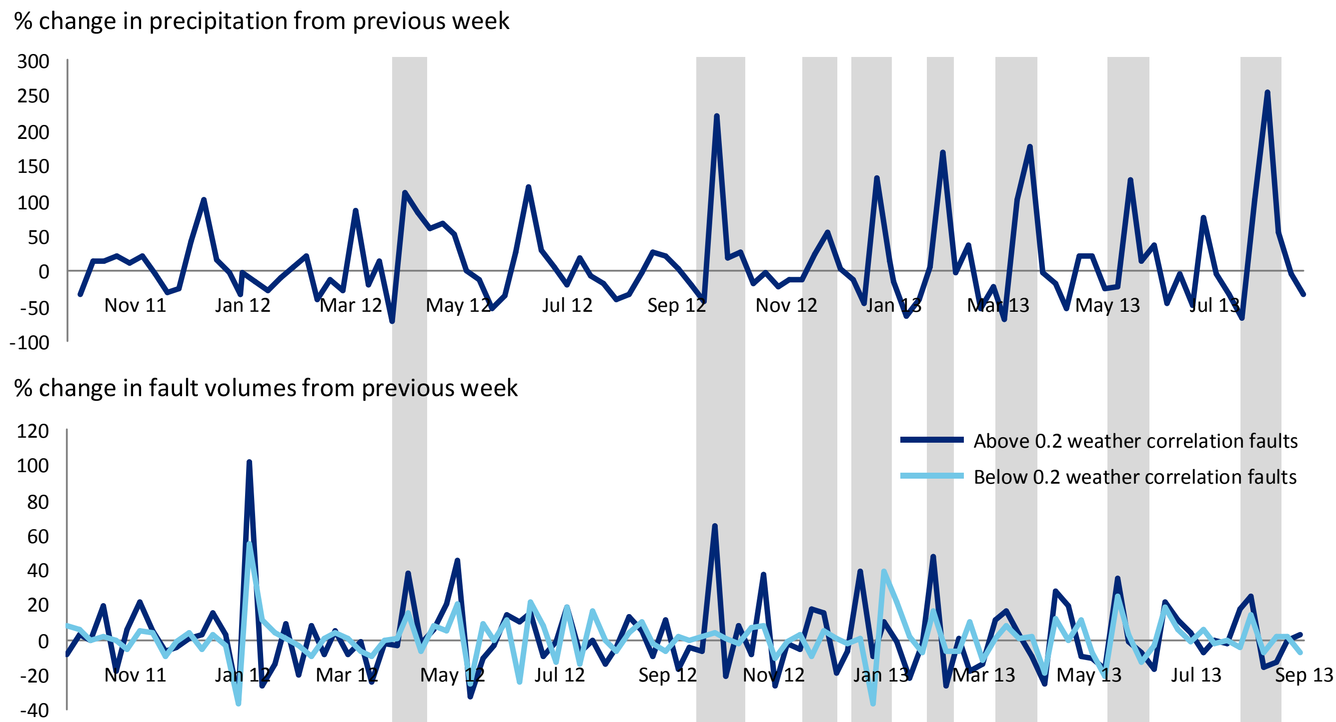
Figure 20: Weather series: 3 weeks standard deviation as % of average



There is some alignment between the volatility of some types of weather and the volatility of specific types of faults

An analysis of the volatility of precipitation levels over the period indicates that peaks in weekly fluctuations of precipitation levels appear to broadly align with peaks in weekly fluctuations of fault volumes (Figure 21).

Figure 21: Weekly fluctuations in precipitation vs. fault volumes



Analysis of the volatility of two specific fault types and the volatility of wind levels, as calculated using the evolution of standard deviation over time, using a rolling five-week average, indicates that peaks in wind volatility appear to align with peaks of fault volatility for those two fault types. (The fault types are OH-LN faults i.e. faults where the MFL indicates the fault was with the overhead network and the Clear Code indicates that it was on the external network closer to the exchange; and OH-CE faults i.e. faults where the MFL indicates the fault was with the overhead network and the Clear Code indicates that it was on the external network, closer to the customer). These examples are illustrated in Figures 22 and 23.

Figure 22: OH-CE: Volatility of wind vs. volatility of faults

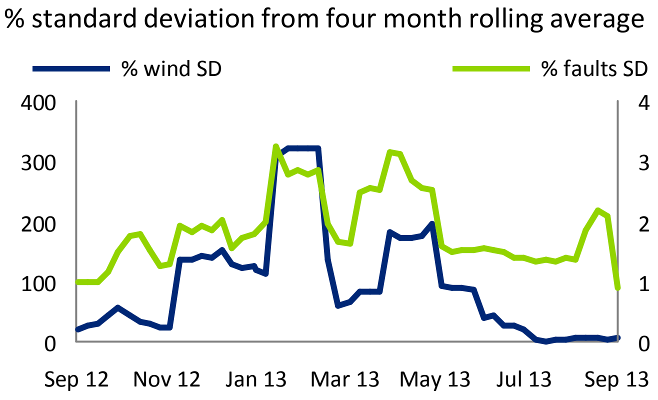
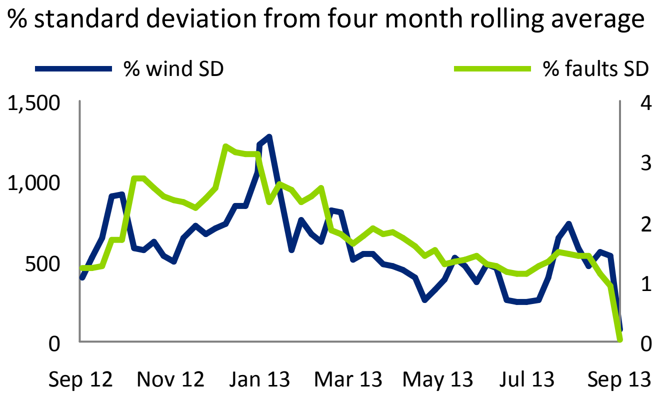


Figure 23: OH-LN: Volatility of wind vs. volatility of faults



3.3 Weather and task time

Faults in categories correlated with weather have higher average task times than other fault types

On average, faults in categories that are correlated with weather have task times that are 20 per cent higher than faults in other categories (Figures 24 and 25).

Figure 24: Average task time per fault by task type

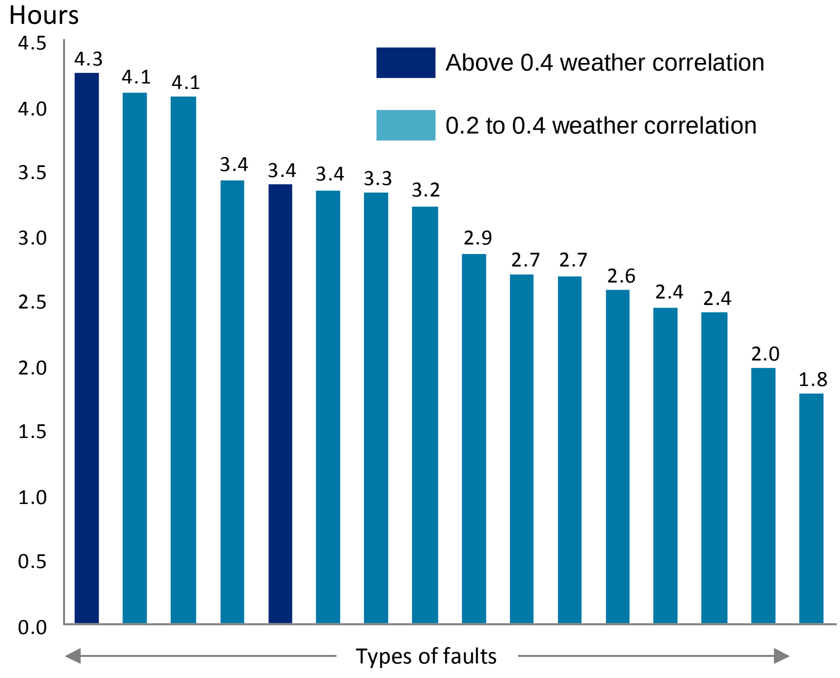
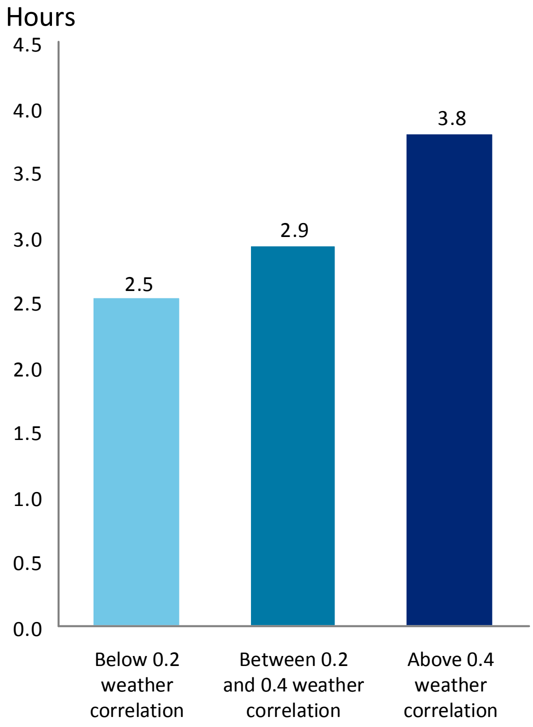


Figure 25: Average task time per fault



4 Fault reporting

Openreach believes that changes in fault reporting are putting increased pressure on its ability to meet its SLAs. In addition, there may be evidence to support the hypothesis that higher levels of data usage are increasing the volume of chargeable faults in its network, in particular special fault investigations.

In order to explore the potential influence of fault reporting patterns on Openreach SLA compliance and customer data usage on the volume of special fault investigations, our analysis reviewed:

- Fault reporting by time of day and its impact on SLA compliance by type of line
- Data usage levels and the incidence of faults and special fault investigations

Volumes of special fault investigations may also be influenced by CPs' approaches to customer service or the mix of customers they serve, which have not been analysed as part of this report.

Our key finding is that the profile of fault reporting varies for different CPs. Faults are increasingly reported late in the day, and faults that are reported later in the day have a higher proportion of SLA breaches. In addition, we found no direct connection between higher data usage and incidences of fault reporting but there is an increase in the usage of fault investigative products by CPs for higher usage end customers.

4.1 Fault reporting time and SLA breach

We analysed the relationship between the time of day a fault is reported, and the proportion of faults that breach their SLA.

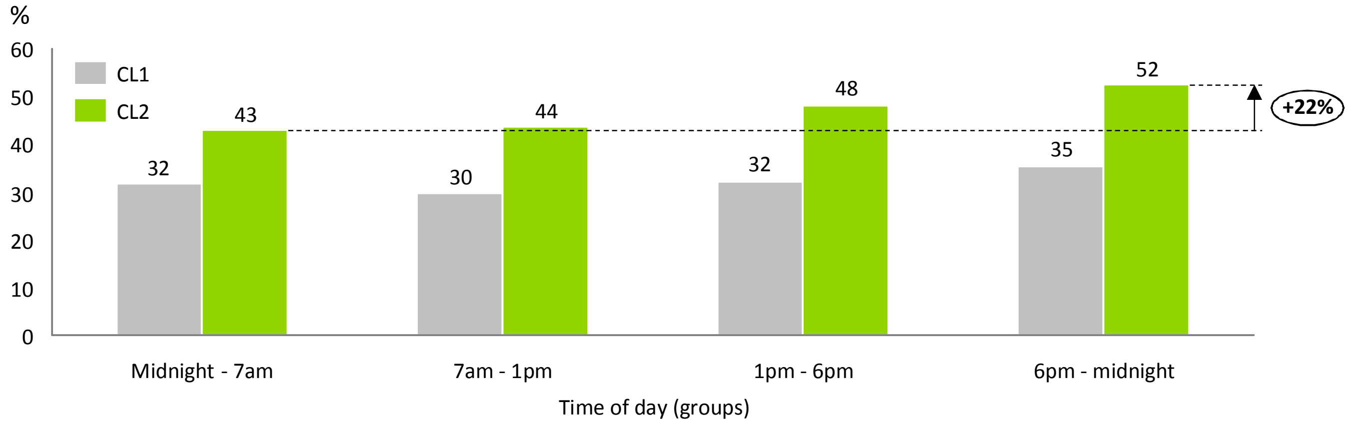
We analysed two care level categories. Faults with a Care Level 2 ('CL2') are the highest priority and have a one-day SLA, i.e. faults need to be resolved before the end of the next working day. MPF faults are in this category. Other faults are categorised as Care Level 1 ('CL1') and have a two-day SLA.

Faults with higher SLAs breach those SLAs more frequently. SLA breaches are higher when faults are reported later in the day

The results of our analysis show that, on average, there is a greater proportion of high priority faults (CL2) that breach their SLA than there are lower priority faults (CL1) that breach their SLA (Figure 26).

Of those higher priority CL2 faults, those that are reported to Openreach later in the day have a higher proportion that breaches the SLA. CL2 faults that are reported between 6pm and midnight have a 22 per cent higher proportion of faults breaching the SLA than faults reported between midnight and 7am.

Figure 26: Proportion of faults breaching their SLA by time fault received and care level



Faults are increasingly reported later in the day

In addition, when reviewing the time of day when faults are reported and how this has changed over time, the results show that the proportion of faults that are received after 6pm have increased from 19 per cent of reported faults in Q3 FY11 to 22 per cent of reported faults in Q1 FY13 (Figure 27).

Figure 27: Proportion of faults received after 6pm

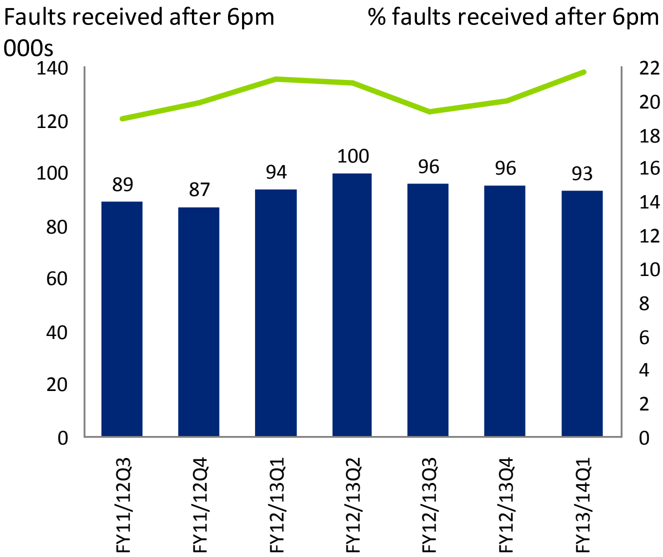
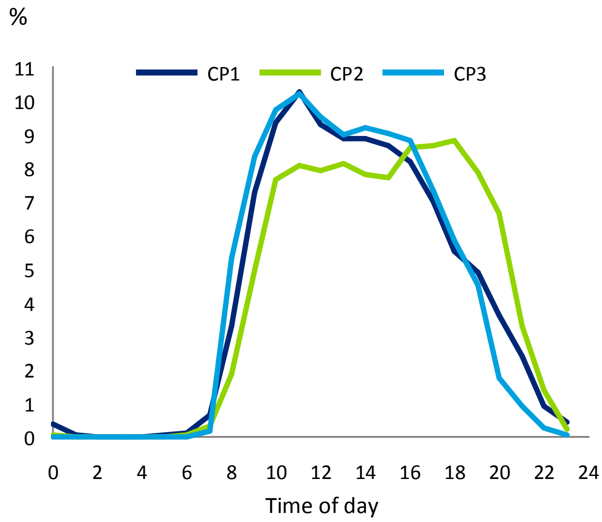


Figure 28: Faults received by time of day and CP



The profile of fault reporting time varies for different CPs

Reviewing fault reporting by time of day and by CP indicates that the average time of day of fault reporting varies by CP (Figure 28).

4.2 Impact of customer data usage on fault reporting

There is no apparent relationship between data usage and fault rates

Openreach considers the request for a special fault investigations (including products called Special Fault Investigation ('SFI') and Broadband Boost ('BBB')) to be equivalent to a fault. This is because they are situations when the customer has identified a problem with their service and, even though the initial line test does not indicate a fault, the CP has requested additional investigative work to determine the potential cause for the issue. These types of special fault investigations are chargeable. The presumption is that customers with high data usage report more faults as they are more sensitive to the quality of their broadband service.

In order to interrogate the potential relationship between the level of customer data usage and the incidence of faults and of special fault investigations, Openreach provided Deloitte with data for a subset of lines from a single CP.

We categorised the lines into usage quintiles, from low to high data usage, and then analysed the weekly fault rate for those usage quintiles. The results indicate that the fault rate on high data usage lines is not higher than the fault rate on low usage lines (Figure 29).

Incidences of chargeable special fault investigations appear to increase as data usage levels increase

When analysing the incidence of special fault investigations on the lines in the same usage quintiles, however, it is apparent that the rate of special fault investigations is higher for the higher usage quintiles compared to the low usage quintiles (Figure 30).

Figure 29: Lines fault rates by usage level

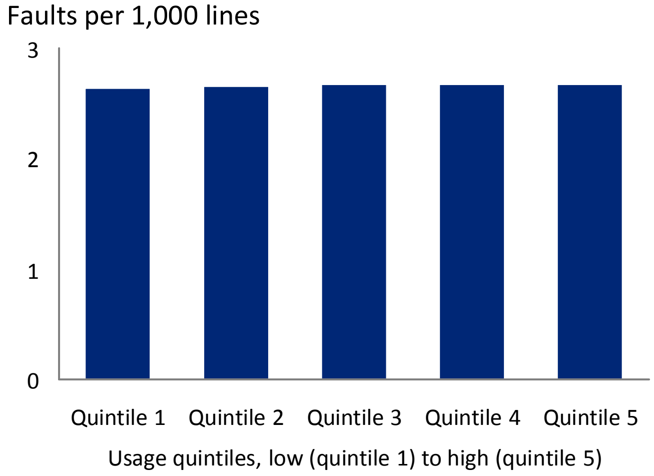
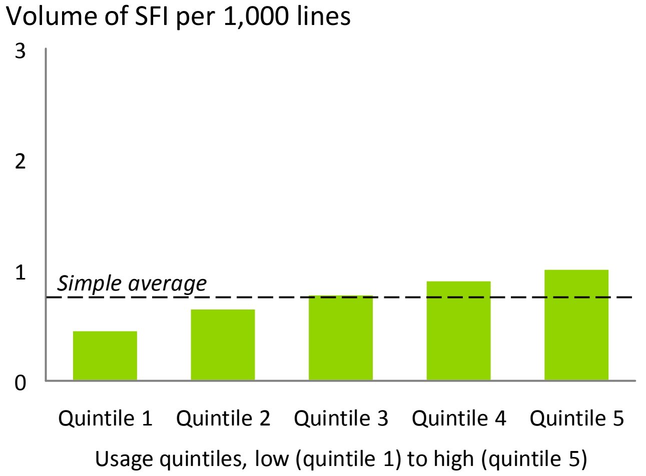


Figure 30: SFI and BBB rates by usage level



Appendix 1: Data sources

Schema	Table name	Description
CDTA	FAULT	Base fault table containing details of all fault requests received from 16 September 2011 onwards including line type, CP, age, etc.
CDTA	OLD_FAULT	Table used to extend CDTA.Fault back to April 2011
CDTA	LINEBASE	Table containing history of each line stored as 'chapters, which record any change to the product or ownership of a line. Contains data back to June 2006
CDTA	EXCH	Table containing information about telephone exchanges
CDTA	ENG_VISIT2	Table containing information about engineering visits for provision and repair activities. This data is originally sourced from Work Manager
SCARDB	CALENDAR	Table containing central calendar used for cutting data into weeks
LINEBASE	EDGE_GEOTYPES	Table containing geographic information for exchanges, e.g. whether an area is urban or rural
TASK_TIME	CLEAR_CODE_MATRIX_MK	A reference table which contains a mapping of clear codes to whether these are hard or soft faults. A hard fault is one where the clear code indicates that a genuine fault has been cleared
TASK_TIME	NK_CUPID_FINAL	A reference table which contains a mapping of CUPID ids to CPs
SD_BMU	PROD_MUKLCMPWA	A reference table which contains mappings of updated SOM patches
TASK_TIME	PB_CLEAR_CODE_CAT_MAPPING	Mapping table for decoding WM clear codes
WEATHER	CST_WEATHER	Table containing weather data by CST/SOM and week
WEATHER	EXCHANGES	Table containing exchange information including name, location and geotype
CDTA	PROVISION	Table containing records of all provision orders

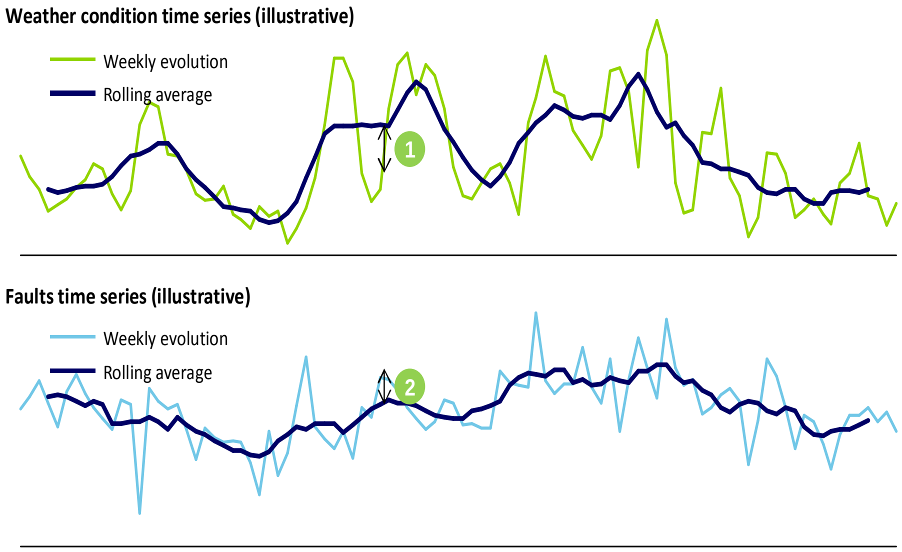
Appendix 2: Weather correlations

The association between weather conditions and key Openreach metrics such as fault rate and task time can be measured by calculating correlation coefficients. Our objective has been to test the influence of short term variations of weather to fault rate rather than how much the overall absolute level of precipitation, wind, humidity or temperature influence faults.

As a result our approach to calculating correlation coefficients has been to investigate the correlation between short term weather variations and short term variation of fault rates rather than to investigate the correlation between overall weather metrics and fault rates. In other words, instead of looking at how many more faults there are because temperature is high, we have looked at how many more faults there might be compared to average because temperature is higher this week than what it has been over recent weeks.

More specifically, we calculated weekly weather variations as the difference to the interpolating weekly average level of each weather metric. We then calculated the Pearson correlation coefficient between this difference and the difference in weekly fault rate to its rolling average. This approach is illustrated in Figure 1 below.

Figure 1: Correlation approach



Parameter 1 measures the difference between the weather metric and the rolling average at a particular point in time. Parameter 2 measures the difference of the fault rate from the rolling average of fault rates at a particular point in time. A correlation coefficient is then calculated between Parameter 1 and Parameter 2.

The correlation analysis carried out between fault rates and weather metrics was carried for each specific type of fault, defined as the combination between a Clear Code and an MFL (e.g. OH-CE).

Pearson correlation coefficients in absolute terms can range from zero (perfect independence) to one (perfect correlation). Such correlation coefficients only measure the level of linear relationships between two metrics and hence do not account for other potential relationship patterns (e.g. one metric evolving as the square of the other).

Appendix 3: Technical Annex

Chart Ref.	Filters	Analytical Methodology
Figure 1: Number of lines by line type	**Line Types** WLR/PSTN Only WLR/PSTN+SMPF MPF Only Other (e.g. including NGA) **Fault Types** Excluding SFI,BBB and Exchange faults **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Sep 2011 – Jul 2013	Calculate proportion each Asset Category makes up of overall total number of lines by week Identify overall average, In-Life and Early-Life fault rates for each of the Line Types
Figure 2: Total faults breakdown	**Dates** Sep 2011 – Jul 2013	Calculate the overall split of the faults which are faults into categories of interest e.g. categories which are excluded in some analyses such as BBB or SFI faults
Figure 3: Total faults by line type	**Dates** Oct 2011 – Aug 2013 **Fault Types** Excluding SFI,BBB and Exchange faults **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear	Calculate the overall split of faults by line type over time (using a three month average) and calculate the percentage change period-on-period
Figure 4: Average fault rates by line type	**Dates** Sep 2011 – Aug 2013 **Fault Types** Excluding SFI,BBB and Exchange faults **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear	Calculate the number of faults per 1,000 lines in the working system size of lines by week for each line type
Figure 5: In-life fault rates by line type	**Line Types** WLR/PSTN Only WLR /PSTN+SMPF MPF Only	Calculate the number of faults per 1,000 lines in the working system size of lines by week for

	Fault Types Excluding SFI, BBB and Exchange **Chargeable** Excluding chargeable faults **Age** Excluding Early-Life faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Sep 2011 – Jul 2013	each line type for in-life lines
Figure 6: In-life fault rate above WLR/PSTN	**Line Types** WLR/PSTN Only WLR /PSTN+SMPF MPF Only **Fault Types** Excluding SFI and BBB **Chargeable** Excluding chargeable faults **Age** Excluding Early-Life faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a hard clear **Dates** Sep 2011 – Jul 2013	Calculate the ratio of the number of faults per 1,000 lines in the working system size of lines per week for each asset category compared to the WLR/PSTN only rate
Figure 7: In-life fault rates by line CP and line type	**Line Types** WLR/PSTN Only WLR /PSTN+SMPF MPF Only **Fault Types** Excluding SFI, BBB and Exchange faults **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear. **Dates** Q2 FY11, Q2 FY12, Q2 FY13	Calculate the number of faults per 1,000 lines in the working system size of lines for each line type and CP
Figure 8: MPF Share of lines	**Dates** Apr 2011 – Aug 2013 **Line Types** 4.3 MPF Only	Calculate the total number of MPF lines per week and compare this to the total number of lines per week to calculate the percentage share of all lines
Figure 9: Customer driven interventions by line type	**Line Types** WLR/PSTN Only WLR /PSTN+SMPF MPF Only **Fault Types** Excluding SFI, BBB and Exchange faults	Calculate the volume of Provision Orders of different types or sub-types per 1,000 lines in working system size by week Label a specific set of order sub-types as 'customer driven' interventions – orders

	Chargeable Excluding chargeable faults **Age** Excluding Early-Life faults (less than 28 days since a chapter change in CDTA.Linebase) **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Jan 2012 – Jul 2013	that drive disruption, intervention or reconnection within the network. Provision data is sourced from the CDTA.Provision table Specifically, 'Customer driven interventions' are defined as provision orders where at least one frame or field activity has taken place, plus start of a stopped line, Working Line Takeover, Transfer Migrations (a change of owning CP), Conversions (change of product), Cease orders with engineering activity
Figure 10: Customer driven interventions by geo-code	**Line Types** WLR/PSTN Only WLR /PSTN+SMPF MPF Only **Fault Types** Excluding SFI, BBB and Exchange faults **Chargeable** Excluding chargeable faults **Age** Excluding Early-Life faults (less than 28 days since a chapter change in CDTA.Linebase) **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Jan 2012 – Jul 2013	Calculate the number of provision interventions and the number of fault interventions for each line type and geo-type
Figure 11: Early-life fault vs. In-life fault rates	**Line Types** WLR/PSTN Only WLR /PSTN+SMPF MPF Only **Fault Types** Excluding SFI, BBB and Exchange faults **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Sep 2011 – Jul 2013	Calculate the number of In-life and Early-life fault rates for each Asset Category; weighted by the number of lines
Figure 12: Early-life weekly fault rates by line type	**Line Types** WLR/PSTN Only WLR /PSTN+SMPF MPF Only **Fault Types** Excluding SFI, BBB and Exchange faults **Chargeable** Excluding chargeable faults	Calculate the number of faults per 1,000 lines in the working system size by week for each asset category where the line is in early life

	Age Excluding In-Life faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Sep 2011 – Jul 2013	
Figure 13: Share of faults that are early-life by line type	**Line Types** WLR/PSTN Only WLR /PSTN+SMPF MPF Only **Fault Types** Excluding SFI, BBB and Exchange faults **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Sep 2011 – Jul 2013	Calculate the proportion of all faults which are on early-life lines by week for each asset category
Figure 14: Fault rate vs. rate of customer switching	**Line Types** **All** **Geotype** Suburban	Calculate the order and fault rates on a weekly basis per exchange. Calculate the correlation between the fault rate and order rate – both normalised per 1000 lines and per week. Compare correlations for exchanges in suburban areas (geotype) by line age
Figure 15: Weather time series	**Dates** Sep 2011 – Sep 2013	Extract data from WEATHER.CST_WEATHER, split by week, averaged over CSTs Calculate three month average for each time series
Figure 16: Correlation between fault rates by type and weather events	**Line Types** None **Fault Types** Initial Main Line Location (MFL) = CA, CE, FU, LN, OK Clear Code = D_SIDE, E_SIDE, PCP, OH, MIW, EXCH, RWT BBB, SFI and MBORC faults excluded **Chargeable** None **CDTA/Hard Clear** None **Weather** None **Dates** Sep 2011 – Sep 2013	**Weather** Rain: Sum over week then average over 3 weeks Humidity: 95% threshold, averaged over 3 days then sum over week Wind: Threshold of mean and 2*SD over 3 days, average over 3 days and sum over week **Correlation** Correlation over fault counts per week and the difference between the weather metric and a 25 week (3 months either side) rolling average

Figure 17: Correlation between weather series and fault types	**Line Types** None **Fault Types** Clear Code and MFL combinations of E Side + LN, OH + LN, D Side + CA or CA + OH **Chargeable** None **CDTA/Hard Clear** None **Dates** Sep 2011 – Sep 2013	Plot weekly weather metric vs. fault rate
Figure 18: OH-LN fault rates: Humidity vs. fault rate by line type and SOM per day	**Line Types** WLR Only WLR/PSTN+SMPF MPF Only **Fault Types** Excluding SFI and BBB. LN + OH faults only **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** None **Line Types** **Age** In-Life only, Sep 2011 – Sep 2013	Plot weekly fault rate and humidity percentage by CST and asset category Calculate average increase in faults as humidity percentage moves from 80% to 90% and from 90% to 100% for each product
Figure 19: Weather-correlated faults as a share of total faults and task time	**Line Types** WLR Only WLR + SMPF MPF Only **Fault Types** Excluding SFI and BBB **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Line Types** **Age** In-life only **Dates** Sep 2011 – Sep 2013	Class faults excluded from BT Openreach's weather analysis as "Other", these are: Fault Not Found, Other, NA, NGA, Payphones and blanks Identify faults that have relatively high and low correlation in correlation tables (ref) Calculate share of total faults and total task time by these weather-correlated faults and other faults
Figure 20: Weather series: 3 weeks standard deviation as % of average	**Line Types** WLR Only WLR + SMPF MPF Only **Fault Types** Excluding SFI and BBB **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear	Calculate % change from previous week, averaged over CST for precipitation and low and high weather-correlation faults

	Line Types **Age** In-life only **Dates** Sep 2011 – Sep 2013	
Figure 21:Weekly fluctuations in precipitation vs. fault volumes	**Line Types** WLR Only WLR + SMPF MPF Only **Fault Types** Excluding SFI and BBB **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Line Types** **Age** In-life only **Dates** Sep 2011 – Sep 2013	Calculate the percentage change in level of precipitation and fault volumes from the previous week. Separate fault volumes where there is more or less than a 0.2 correlation to weather events
Figure 22: OH-CE: Volatility of wind vs. volatility of faults	**Line Types** None **Fault Types** Clear Code = CE MFL = OH **Chargeable** None **CDTA/Hard Clear** None **Dates** Sep 2011 – Sep 2013	**Weather** Wind: Threshold of mean and 2*SD over 3 days, average over 3 days and sum over week **Standard Deviations** Calculated standard deviation over rolling 5 week period (2 weeks preceding and following) for both wind speed and faults count
Figure 23: OH-LN: Volatility of wind vs. volatility of faults	**Line Types** None **Fault Types** Clear Code = LN MFL = OH **Chargeable** None **CDTA/Hard Clear** None **Dates** Sep 2011 – Sep 2013	**Weather** Wind: Threshold of mean and 2*SD over 3 days, average over 3 days and sum over week **Standard Deviations** Calculated standard deviation over rolling 5 week period (2 weeks preceding and following) for both wind speed and faults count
Figure 24: Average task time per fault by task type	**Line Types** WLR Only WLR + SMPF MPF Only **Fault Types** Excluding SFI and BBB **Chargeable**	Isolate fault types that display correlation with weather (as per correlation table, ref) Calculate average task time per fault type over time period

	Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear Line Types **Age** In-life only **Dates** Sep 2011 – Sep 2013	
Figure 25: Average task time per fault	**Line Types** WLR Only WLR + SMPF MPF Only **Fault Types** Excluding SFI and BBB **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear Line Types Age In-life only **Dates** Sep 2011 – Sep 2013	Calculate the average task time per fault splitting faults by those which are between 0.2 and 0.4 correlated to weather and those which are above 0.4 correlated to weather
Figure 26: Proportion of faults breaching their SLA by time fault received and care level	**Line Types** WLR Only WLR + SMPF MPF Only **Age** In-life only **Fault Types** Excluding SFI and BBB **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Care Level** Care levels 1 and 2 **Dates** Sep 2011 – Jul 2013	Calculate the proportion of faults which breached their SLA by the time of day the fault was reported for each Care Level
Figure 27: Proportion of faults received after 6pm	**Line Types** WLR Only WLR + SMPF MPF Only **Age** In-life only **Fault Types** Excluding SFI and BBB	Calculate the proportion of faults received after 6pm split by quarter and the total number of faults received

	Chargeable Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Care Level** Care levels 1 and 2 **Dates** Sep 2011 – Jul 2013	
Figure 28: Faults received by time of day and CP	**Line Types** WLR Only WLR+ SMPF MPF Only **Age** In-life only **Fault Types** Excluding SFI and BBB **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a hard clear. **Line CP** CP1 CP2 CP3 **Dates** Sep 2011 – Jul 2013	Calculate the proportion of faults received by hour through the day for each CP
Figure 29: Line fault rates by usage level	**Line Types** WLR/PSTN Only WLR+SMPF/PSTN+SMPF MPF Only **Age** **Fault Types** Excluding SFI and BBB **Chargeable** Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Sep 2011 – Jul 2013	Calculate the fault rate for each level of usage for non-SFI/BBB faults
Figure 30: SFI and BBB rates by usage level	WLR+SMPF/PSTN+SMPF MPF Only **Age** **Fault Types** Only SFI and BBB **Chargeable**	Calculate the fault rate for each level of usage for SFI/BBB faults

	Excluding chargeable faults **CDTA/Hard Clear** Excluding faults which are CDTA unless they are a Hard Clear **Dates** Sep 2011 – Jul 2013	

Appendix 4: Glossary

Term	Description
NGA	**Next Generation Access**. A BT network technology aimed at replacing the copper pair access to customer premises with fibre technology. This requires modifications of the network infrastructure between the local exchange and the customer premises, albeit depending on each local configuration (FTTC/FTTB/FTTH). In most cases this requires modifications at the street cabinet level.
CP	**Communication Provider**. An organisation that provides an Electronic Communications Network or provides an Electronic Communications Service
WLR	**Wholesale Line Rental**. A wholesale product from Openreach for voice service
MPF	**Metallic Path Facility.** A wholesale product from Openreach for both voice and data service
SMPF	**Shared Metallic Path Facility**. A wholesale product from Openreach for data service
WLR+SMPF	Combination of two wholesale products (WLR and SMPF) on a same line, purchased together alongside one another.
ELF	**Early-life Fault**. Fault ,which has happened within less than 28 days from a new service provision
ILF	**In-Life Fault**. Fault, which has occurred more than 28 days after a new service provision.
MFL	**Main Fault Location**. Initial diagnostic for the reason and location of the reported fault
CC	**Clear Code.** Final diagnostic for the reason why the fault occurred
Chargeable	**Chargeable Faults**. Includes CDTA, SFI, BBB
CDTA	**Conscious Decision To Appoint**.
SFI	**Special Fault Investigations.** Standard Line test has been returned as ok but the CP wants to carry out a more detailed line test
BBB	**Broadband Boost**. A service product whereby a chargeable engineering visit can be ordered when a broadband line tests OK but the end user remains not satisfied with the service.

CL	**Care Level.** Openreach products are associated with different levels of service. CL1 is associated with a response time of 2 days to clear the fault. CL2 is associated with a response time of 1 day. The MPF product is associated with a CL2 response time.
PCP	**Primary Connection Point**. Street cabinet
LE	**Local Exchange**. Local building where interconnection for BT lines is done. There are c. 5,000 local exchanges
MDF	**Main Distribution Frame**. Main point of line interconnection within the Local Exchange

Appendix 5: Disclaimers

Our consent to disclosure of this report is on the following basis:

1. The reader acknowledges and agrees that:

(a) The report was prepared solely for the use of Openreach;

(b) The report was prepared from information and explanations provided to us by the management of Openreach;

(c) Matters may exist in the Information that might have been assessed differently by you;

(d) The information contained herein is not designed to form the basis of any decisions made by you; and

(e) We have not updated the report for any events or transactions which may have occurred subsequent to the date of the report

(f) Our consent that the report is made available to you does not establish any client relationship or any other contractual or other relationship between us;

(g) You will not use the report for any purpose other than to supplant other enquiries or procedures you might undertake for your purpose;

(h) We do not warrant the suitability or sufficiency of the report for your purpose;

(i) We have no duty to, and will not:

(i) Monitor the subject matter of the report

(ii) Update the Information in respect of any events or transactions that (a) might have occurred subsequent to the Report's completion or (b) may in future occur;

(iii) Provide you with any other or additional information, or;

(iv) Correct any inaccuracies in the report that might become apparent to us in the future.

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(k) You agree not to bring, or threaten to bring, any actions, proceedings or claims against any of the DTTL Parties in any way arising out of or in connection with the report or its use; and

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