

# Why we have OPFs and don't use them



**Martin Bradley**

**17/1/2018**

## The short answer...

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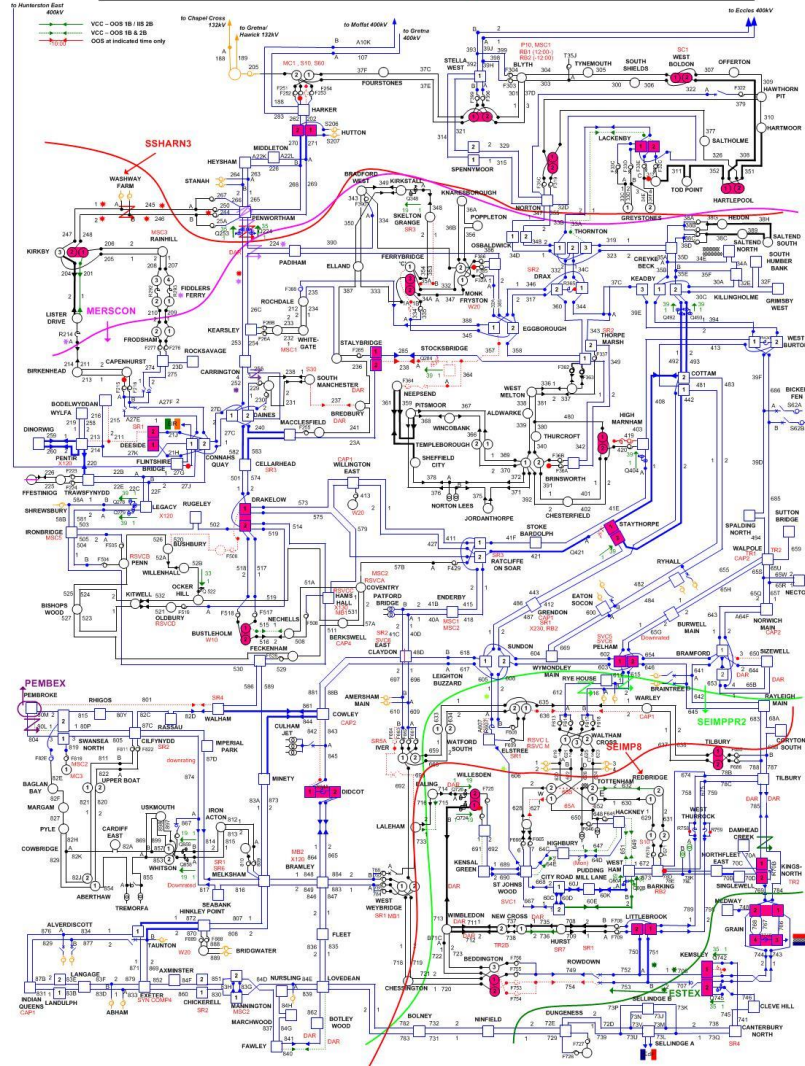
- Data!
- And the problem...
- And the people factors...
- And the processes...
- And the reliability requirements...
- And the time pressure...
- But mostly the data – so I'll concentrate on that.

(Actually, we do use an Optimal Power Flow, but only in planning and system design, not in operations).

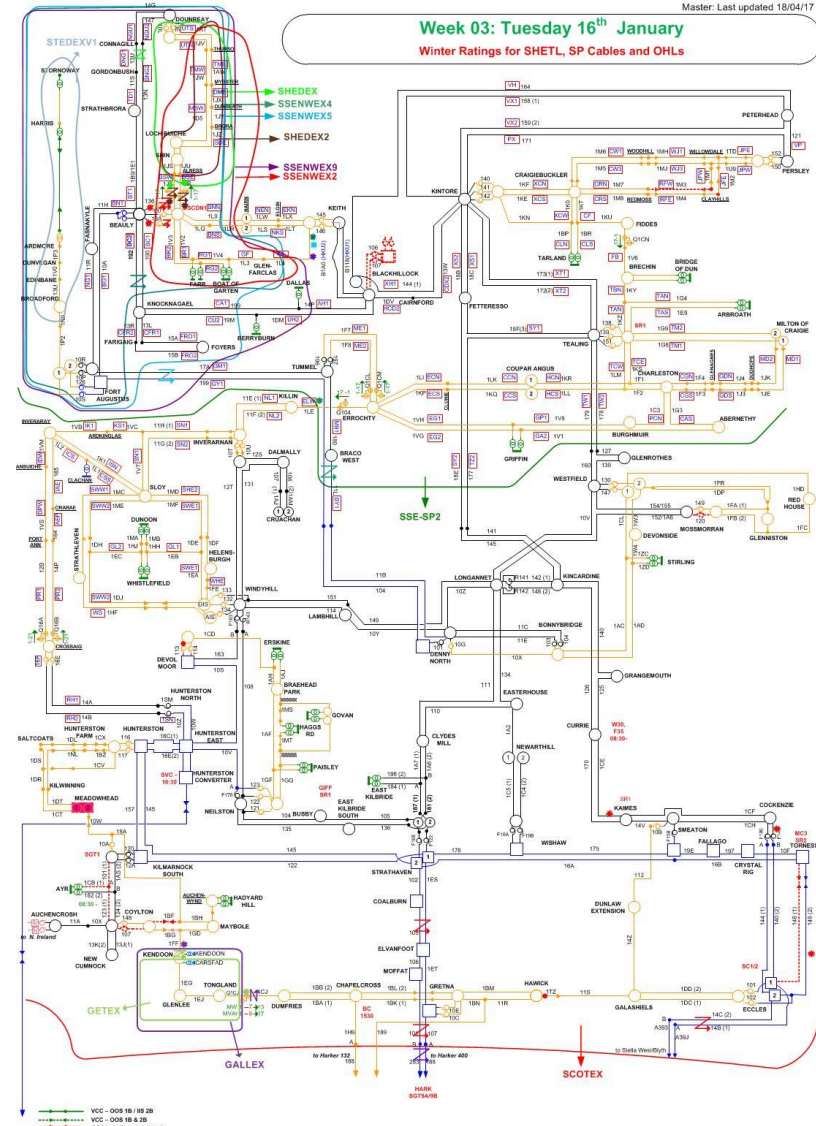
“IEMS” = Integrated Energy Management system

# The Transmission Network: E&W and Scotland

Week 03: Monday 15<sup>th</sup> January 2018  
Winter Ratings

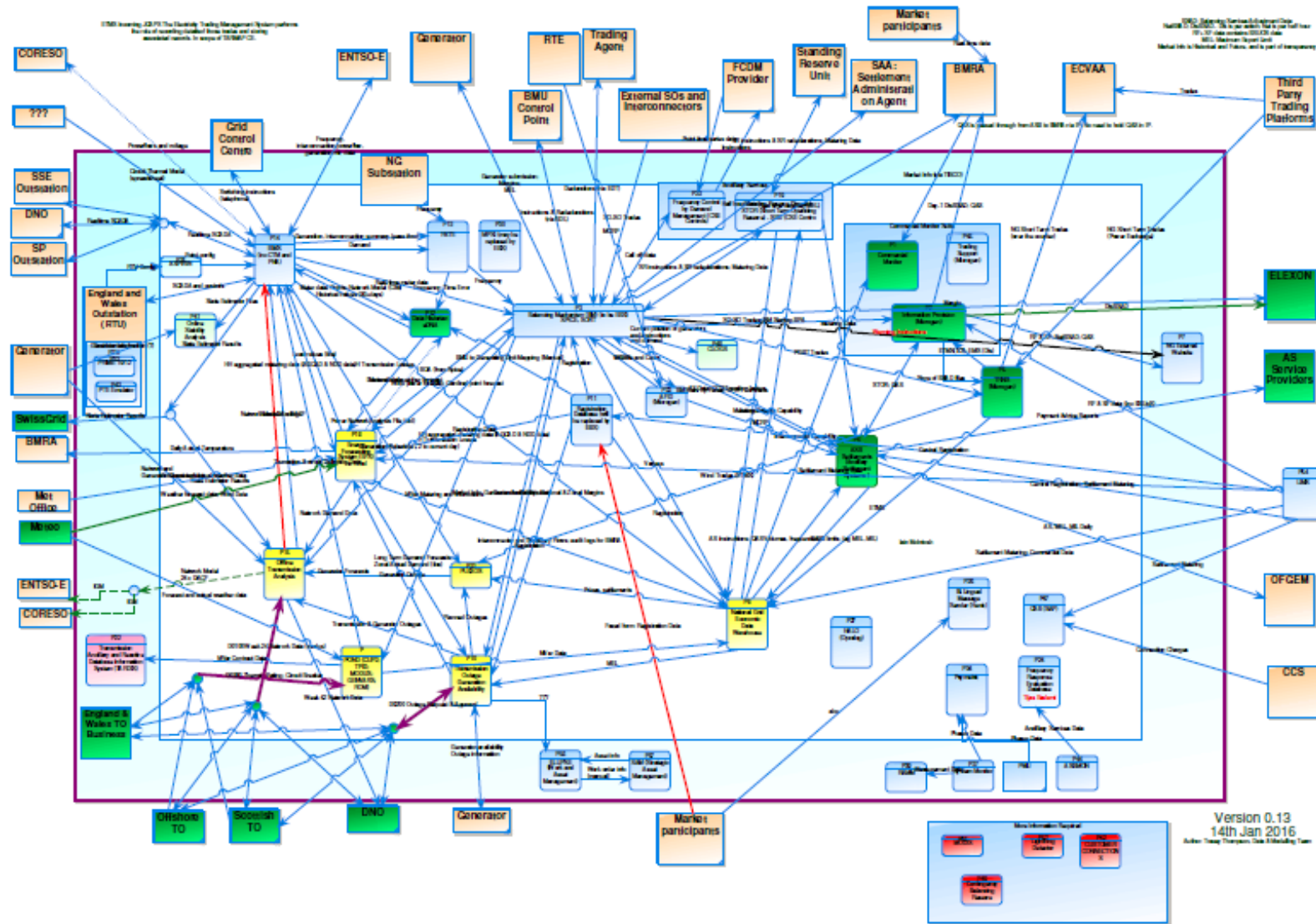


Week 03: Tuesday 16<sup>th</sup> January  
Winter Ratings for SHETL, SP Cables and OHLs

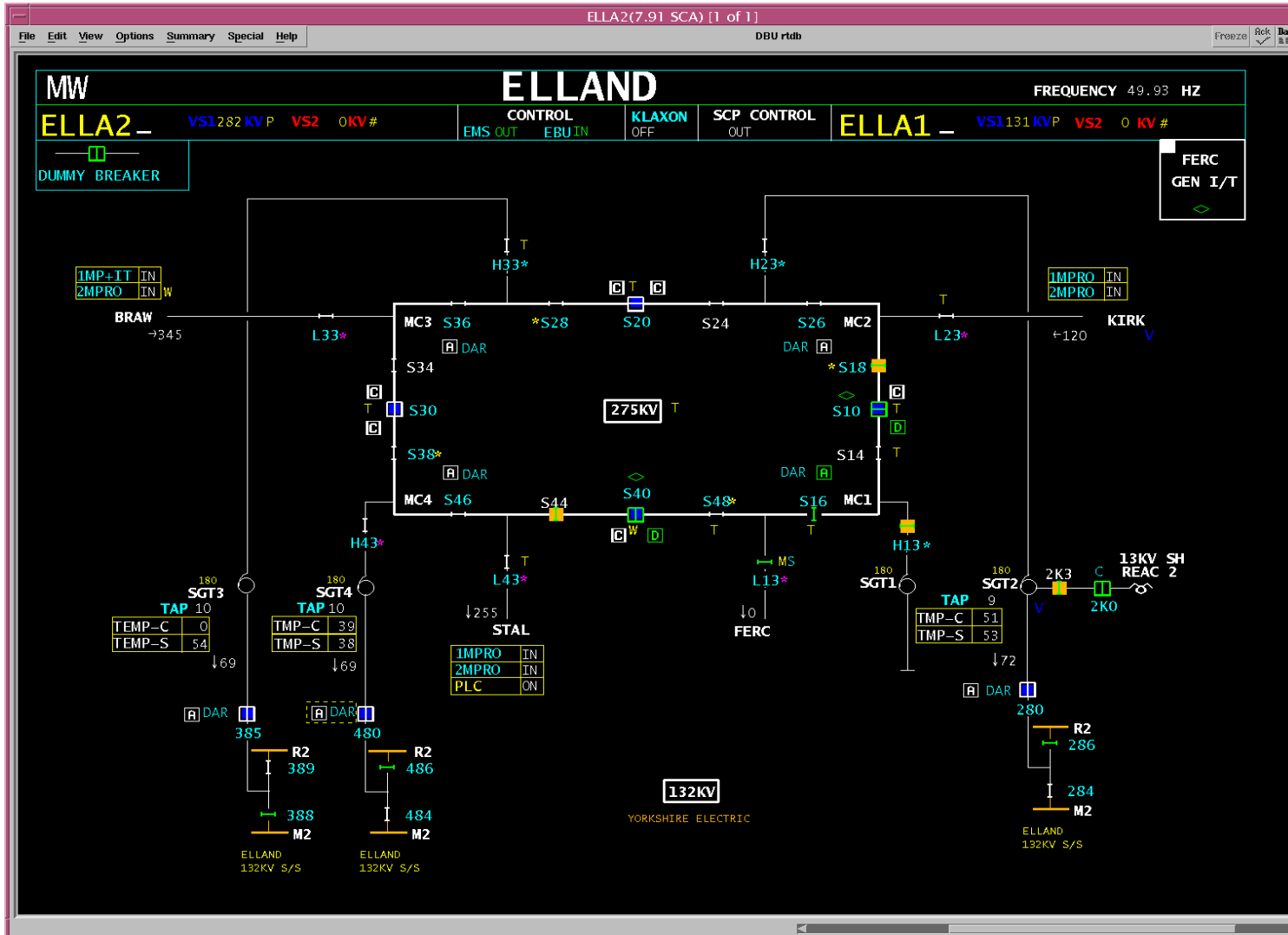


Master: Last updated 18/04/17

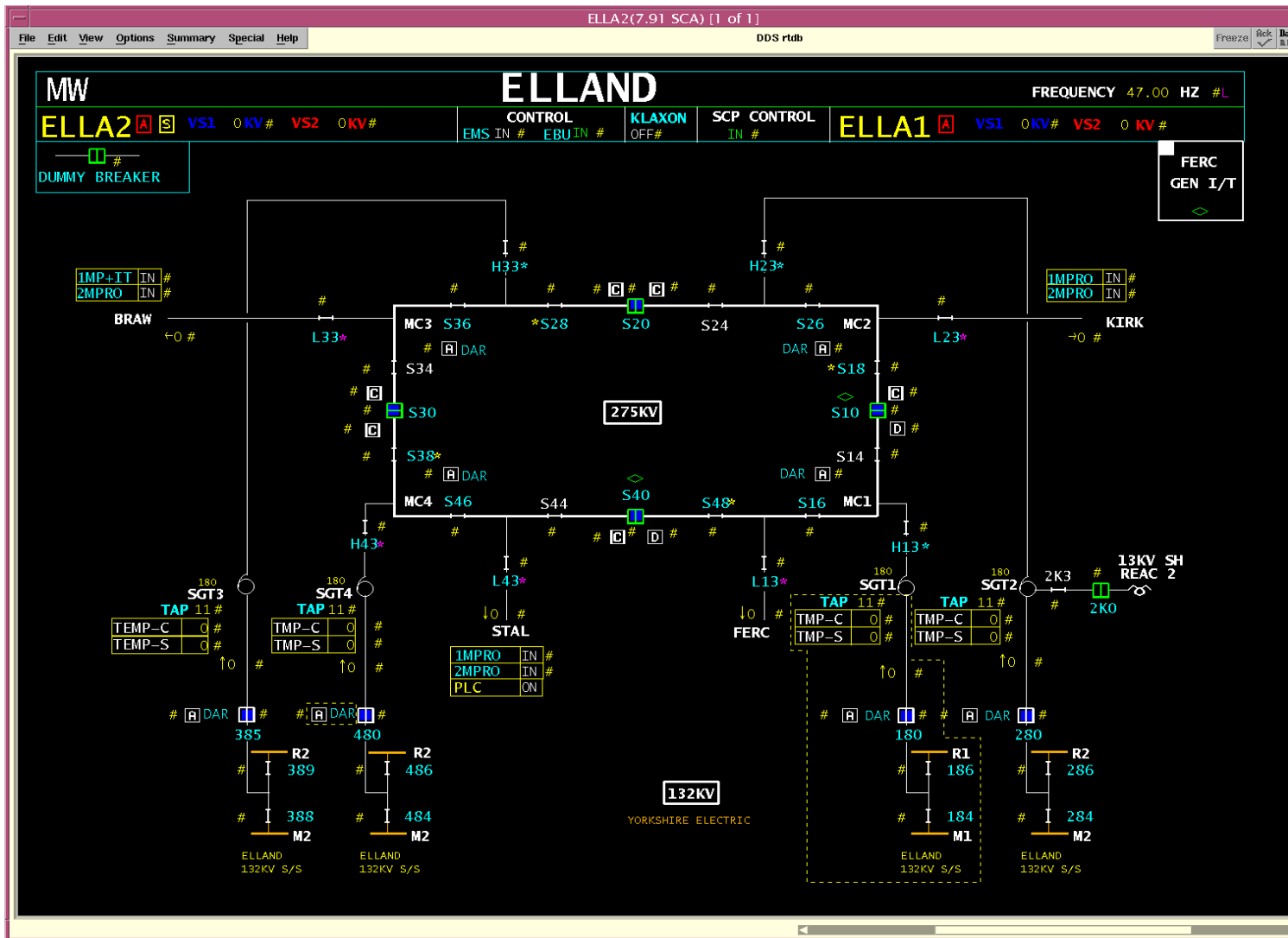
# The Logical Data Flow network...



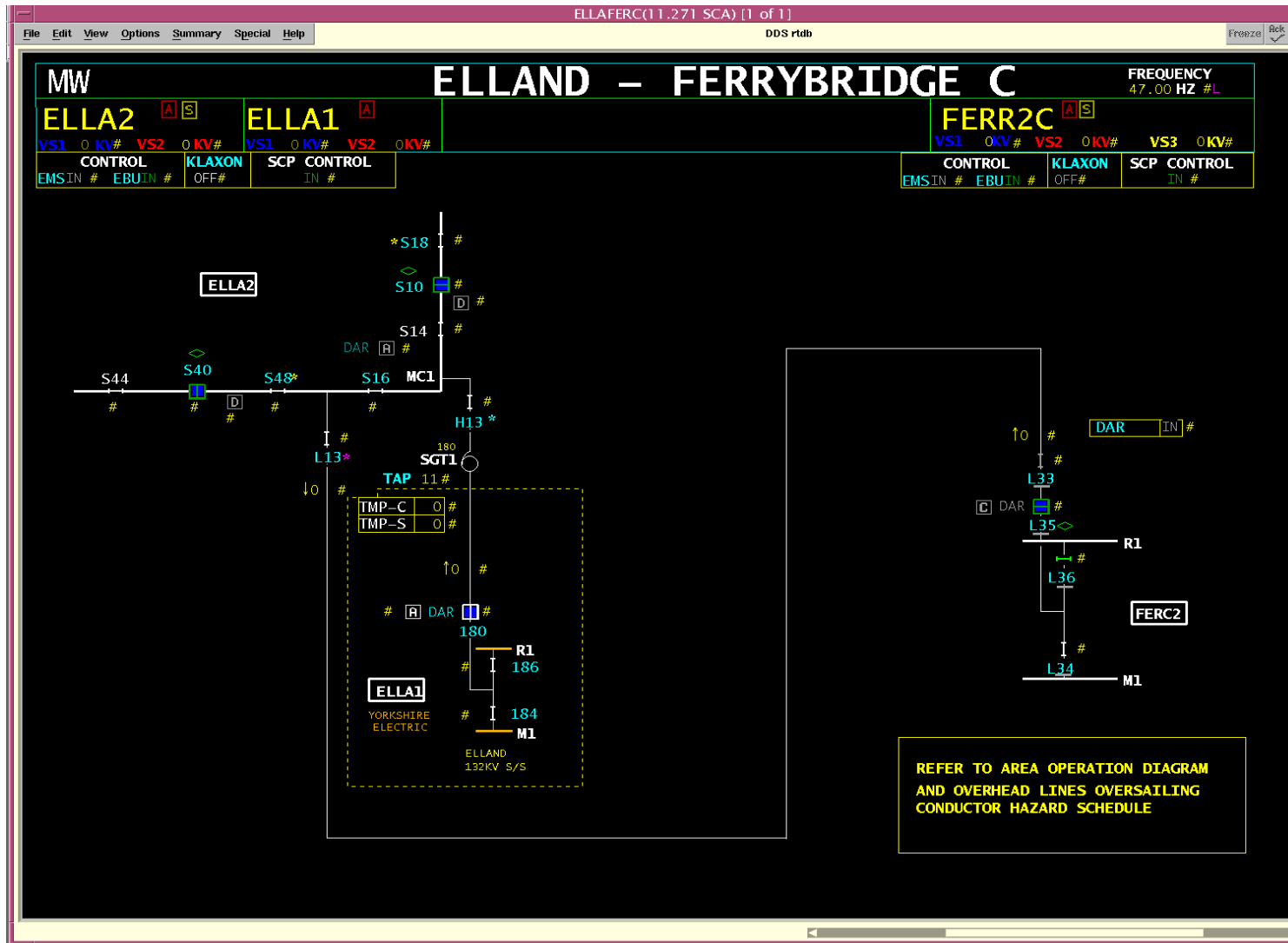
# Adding a transformer at Elland 275kV substation



# Revised Operational Substation diagram



# Revised Operational Circuit diagram



# Tabular Displays: SCADA

**Display Index**

Sort Key:  
 Set  Description

View Filter:  
 SCA  CME  APP  PSS

Description Filter:  
 Description:

**(13) SCADA Power System**

Set View	Description
17	GRAPHICAL SYMBOLS
112	NORTH CAP/COMP
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106	NORTH SPARE CIRCUITS
1	POWER SYSTEMS MENU
3230	SCOT ALCAN/WESTERN ISLES ISLAND

Selection: **13.17.S**

Ok Dismiss

NORTH PROTECTION SUMMARY

CIRCUIT	END 1	END 2	END 3	CIRCUIT	END 1	END 2	END 3	CIRCUIT	END 1	END 2	END 3
DAIM - KEAR4	IMP IN	IMP IN		ELL42 - STAL2	IMP IN	ZMP IN		HARK4 - HUTT4-2	IMP IN	IMP IN	IMP IN
DAIM - MAC04	ZMP IN	ZMP IN		FERR2B - FERC-1	IMP IN	IMP IN		HARK4 - STHA4-1	IMP IN	IMP IN	IMP IN
DAIM - CA/PE4	IMP IN	IMP IN	IMP IN	FERR2B - FERC-2	IMP IN	IMP IN		HARK2 - STEW2	IMP IN	IMP IN	IMP IN
DEES4 - LEG/TRA1	IMP IN	IMP IN	IMP IN	FER2C - MONF2	IMP IN	IMP IN		HARM2 - HATL2	IMP IN	IMP IN	IMP IN
DEES4 - LEG/TRA2	IMP IN	IMP IN	IMP IN	FER2C - FERB/MON	IMP IN	IMP IN		HARM2 - HAWP2	IMP IN	IMP IN	IMP IN
DEES4 - PENT4-1	IMP IN	IMP IN		FER2C - FB/SKL1	IMP IN	IMP IN		HATL2 - SALL2	IMP IN	IMP IN	IMP IN
DEES4 - PENT4-2	IMP IN	IMP IN		FER2C - SKLGC-2	IMP IN	IMP IN					
DRAXA - EOGB4-1	IMP IN	IMP IN		FFES2							
DRAXA - EOGB4-2	IMP IN	IMP IN		FIDF2							
DRAXA - THOM4	IMP IN	IMP IN		FIDF2							
DRAXA - THO4-1	IMP IN	IMP IN	IMP IN								
DRAXA - THO4-2	IMP IN	IMP IN	IMP IN								
EOGB4 - FERR4	IMP IN	IMP IN	IMP IN								
EOGB4 - MONF4	IMP IN	IMP IN	IMP IN								
EOGB4 - NEE/ST54	IMP IN	IMP IN	IMP IN								
EOGB4 - ROCH4	IMP IN	IMP IN	IMP IN								
EOGB4 - THOM4	IMP IN	IMP IN	IMP IN								
ELL42 - KIRK2	IMP IN	IMP IN									

NORTH - SUPER GRID TOTALS

STN	MW	MVAR	MVA	STN	MW	MVAR	MVA	STN	MW	MVAR	MVA
ALDW3	-94	-76	120	JORD3	-40	-7	41	SKLG2	-413	-104	426
BIRK1	-175	12	176	KEAD1	-344	-135	370	SMANI	-253	-30	255
BLYT6A	-103	-7	103	KEAR3	-67	-19	70	SSH13	-35	-8	36
BREDD	-322	48	326	KEG01	-399	52	402	SPEN1	-195	-54	203
BRED2	-228	-25	229	KIBY1	-210	-41	222	STAHI	-206	-116	237
CAML6	-18	-5	19	KIRK1	-109	-68	209	STALL	-292	-115	314
CAPE1	-126	-40	132	LACK6	-178	-19	179	STEN1	-191	-40	195
CAR1	-175	-68	187	LEGA1	-240	-92	257	STES1	-156	-15	157
CHIE1	-337	-121	364	LTSO1	-207	2	202				
CORR6	-45	-11	46	MACC3	-62						
CREB1	-236	-94	253	NORT1	-330						
DEES1	-197	-79	212	NORL3	-38						
DRAK1	-92	-57	108	OFFE3	-45						
ELL41	-210	-109	236	OSBA1	-220						
FERR6A	-40	-15	43	PAD11	-207						
FERR1B	-276	-120	301	PENT1	-104						
FIDF1	-194	-81	210	PERH1	-256						
FROD1	0	0	0	PENE1	-130						
GR1W1	-119	Q	127	PENW1	-84						
HRK/HUTT	-443	-178	478	PITS3	-78						
HARM6	-69	-13	70	POPP3	-33						
HAWP6	-82	-20	84	POPP8	5						
HEYS1	-110	-48	121	RATN1	-308						
INCE1	-102	-48	114	ROCH1	-198						
				SALH1	-64						
				SHEC3	-68						

NORTH REACTORS

STAT	PLANT	OUT	N/A	SIZE	STAT	PLANT	OUT	N/A	SIZE
BIRK2	SR4A	■		-30	LEGA4	SR1	■		-60
BIRK2	SR4B	■		-30	LEGA4	SR2	■		-60
BROW2	SR3	■		-60	LTSO2	SR	■		-100
BROW2	SR4A	■		-30	PEN14	SR5	■		-200
BROW2	SR4B	■		-30	PENW1	SR6	■		-60
BRED2	SR101	■		-30	PITS2	SR3	■		-60to-30
BRED2	SR102	■		-30	PITS2	SR4	■		-60to-30
BRED2	SR301	■		-30	SKLG2	SR3	■		-100
BRED2	SR302	■		-30	SKLG2	SR4	■		-100
CHIE2	SR4	■		-60	SPEN2	SR2	■		-60
DEES4	SR101	■		-30	THOM4	SR2	■		-200
DEES4	SR102	■		-30	TYNE2	SR2	■		-60
DRAXA	SR1	■		-60	WBUR4	SR1	■		-200
DRAXA	SR2	■		-60	WIKCA2	SR4A	■		-30
ELL42	SR2	■		-60	WIKCA2	SR4B	■		-30
JORD2	SR2	■		-60to-30					
KEAR2	SR3A	■		-60					
KIRK2	SR2	■		-60					
KIRK2	SR4	■		-60					

NORTH CAP/COMP  
NORTH REACTIVE DESPATCH

KEY: OUT ■  
N/A ■ (HANDRESSED)



# Tabular Displays: Power System

**Sort Key:**

Set  Description

**View Filter:**

SCA  CME  APP  PS

**Description Filter:**

Description: \*

**(15) Network Power System**

Set View	Description
41	NETA SORT SUMMARY
25	NORTH AVC SUMMARY
6	NORTH HV DAR SUMMARY
7	NORTH LV DAR SUMMARY
3	NORTH ZONE BALANCING/CCGTS
21	PUMP STORAGE SUMMARY

**Selection**

**NORTH AVC SUMMARY**

STN	DESCRIPTION	STATUS
ALDW2	SGT1B	IN
	SGT1A	IN
	SGT2	IN
	SGT3	IN
	SGT4	IN
BIRK1	MB1	IN
	MB2	IN
	RB1	IN
	RB2	IN
BLYT1	A/L-1	IN
	A/L-2	IN
BLYT6	MB1	IN
	MB2	IN
	MB3	IN
	RB1	IN
	RB2	IN
	RB3	IN
BRAW1	MB1	IN
	MB2	IN
	RB1	IN
	RB2	IN
BRED1	MB1	IN
	MB2	IN
	RB1	IN
	RB2	IN
CAPE1A	SGT1A	IN
	SGT3A	IN
CARR1	MB2	IN
	MB3	IN
	MB4	IN
	RB3	IN
	RB4	IN

**NORTH LV DAR SUMMARY**

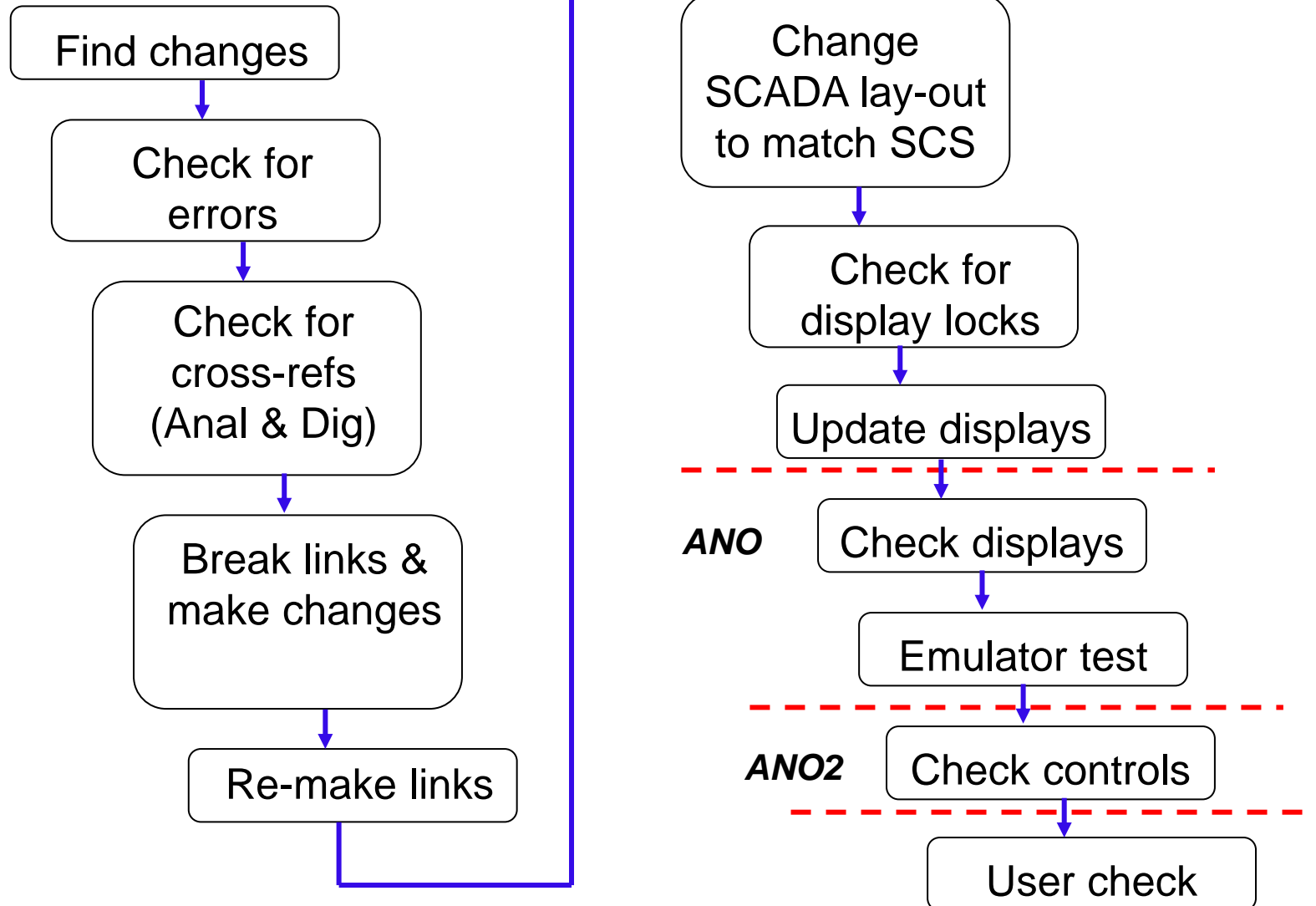
STN	DESCRIPTION	STATUS	STN	DESCRIPTION	STATUS
BIRK1	SGT2A	IN	INCE1	505	IN
	SGT3	IN		605	IN
	SGT4	IN	JORD3	SGT1	IN
BRAW1	180	IN		SGT2	IN
	280	IN	KIRK1	180	IN
	380	IN		280	IN
	480	IN		480	IN
BRED1	SGT1	IN	LISD1	SG	IN
	SGT2	IN		SG	IN
	SGT3	IN	MACC2	SG	IN
CAPE1A	SGT2A	IN	NORL3	SG	IN
CAPE2	H20	IN	NORT1	SGT	IN
CARR1	780	IN		SGT	IN
CHTE1	SGT1	IN	OFFE3	SGR	IN
	SGT2	IN		SGR	IN
	SGT3	IN	OSBA1	180	IN
	SGT4	IN		280	IN
ELLA1	180	IN	PERH1	10	IN
ELLN1	280	IN		20	IN
	385	IN	PITS3	SG	IN
	480	IN		SG	IN
FERR1B	580	IN		SG	IN
	480	IN		SG	IN
FROD1	280	IN	POPP3	SGI	IN
	380	IN		SGI	IN
	480	IN	RAIN1	180	IN
GR1W1	180	IN		380	IN
	280	IN		480	IN
HARK1	180	IN	ROCH1	180	IN
	280	IN		280	IN
	380A	IN		380	IN
	380B	IN		480	IN
	480	IN	ROCK1	180	IN
	505	IN		180	IN
HUTT1	180	IN	SAEN1	SG	IN
	380A	IN		SG	IN

**NORTH HV DAR SUMMARY**

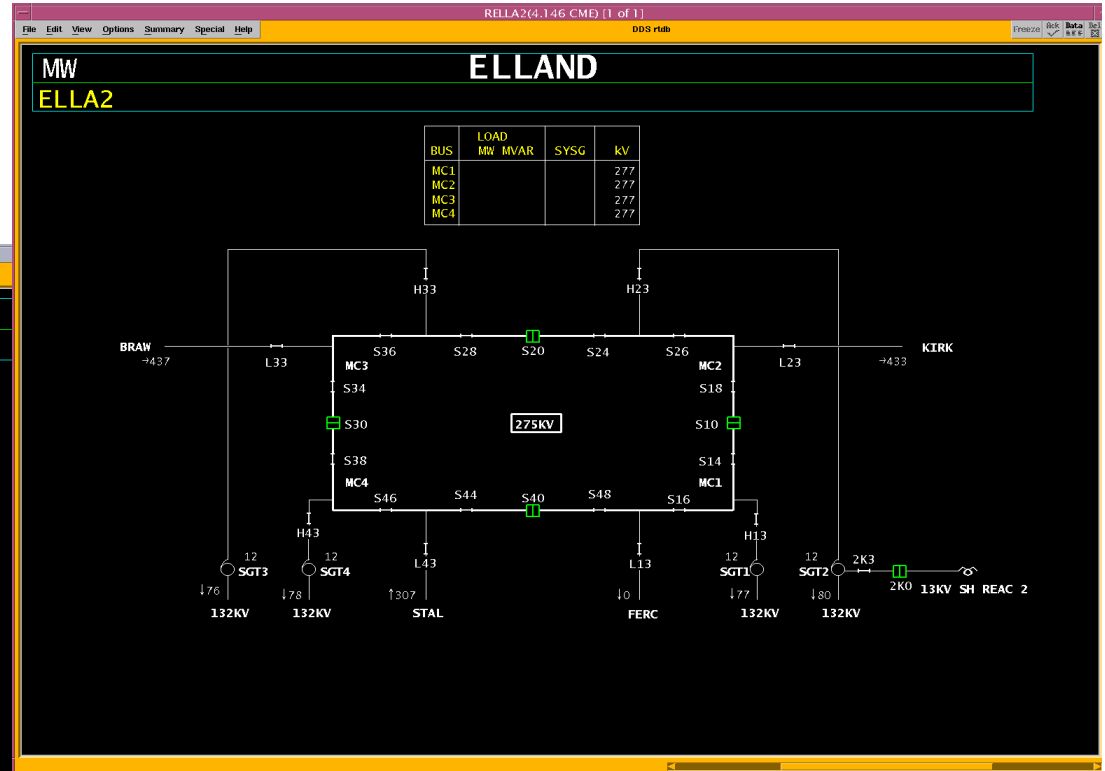
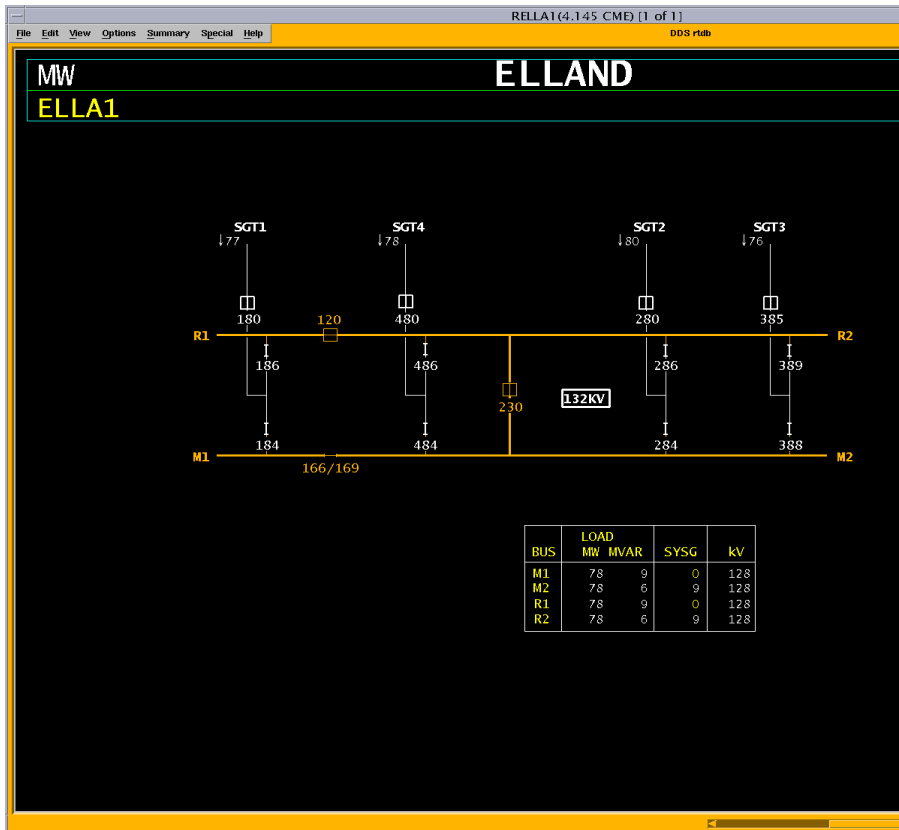
STN	DESCRIPTION	STATUS	STN	DESCRIPTION	STATUS	STN	DESCRIPTION	STATUS
ALDW2	MC1	IN	CAPE4	X505	IN	DEES4	PENT4-1	IN
	MC2	IN		X605	IN		PENT4-2	IN
	MC3	IN	CAPE2	BIRK2-2	IN		CAPE4-1	IN
	MC4	IN		BIRK2-1	IN		CAPE4-2	IN
BIRK2	MC2	IN		SGT5A	IN		DAIN4-1	IN
	MC3	IN		SG16A	IN		DAIN4-2	IN
	MC4	IN		INCE-2	IN		LE/TR-1	IN
BLYT2	STEW2-2	IN					LE/TR-2	IN
	STEW2-3	IN						
	SGT2A/2B	IN	CARR2	SMAN2-1	IN	DIN04	SITE	OUT
	TYN2	IN		SMAN2-2	IN		PENT4-2	IN
	FOUR2	IN		DAIN2-1	IN	DRAX4	THTO4-2	IN
	SSH/TYN	IN		DAIN2-2	IN		THTO4-1	IN
	SWI/SN3	IN	CARR4	X710	IN		THRM4	IN
	SGT3	IN					BR/KE4	IN
BRAW2	MC1	IN	CHTE2	MC1	IN		EGGB4-2	IN
	MC2	OUT		MC2	IN		EGGB4-1	IN
	MC3	IN		MC3	IN			
	MC4	IN		MC4	IN			
BRED2	MC1	OUT	COTT4	STAY4-2	IN	EGGB4	DRAX4-1	IN
	MC2	IN		KEAD4-1	IN		DRAX4-2	IN
	MC3	IN		KEAD4-2	IN		ROCH4	IN
	MC4	IN		STAY4-1	IN		ST/NE4	IN
BRIN4	MC1	IN		EASO4-1	IN		FERR4C	IN
	MC2	IN		ES/RY-2	IN		THRM4	IN
	MC4	IN					MONF-2	IN
BRIN2	ALDW2	IN	CREB4	SAEM4	IN		MONF-1	IN
	CHTE2-1	IN		SAES4	IN			
	CHTE2-2	IN		HU/KE	IN			
	CHD2	IN		TH104-1	IN	ELLI2	MC1	IN
	JORD2	IN		TH104-2	IN		MC2	IN
	NOR/SHE	IN		KE/K1	IN		MC3	IN
	TEMP2-1	IN	DAIN4	DEES4-1	IN		MC4	IN
	TEMP2-2	IN		DEES4-2	IN	FERR2	ELLA2	IN
	THUR2	IN		CARR4-1	IN		MONF2	OUT
	TINP2-1	IN		CARR4-2	IN		MF/FB-5	OUT
	TINP2-2	IN		CELL4	IN		SK/FB-4	IN
	SGT1	IN		KEAR4	OUT		SKLGA-2	IN
	SGT4	IN		CARR/PEWO	IN		SGT1A	OUT
				MACC4	IN		SGT1B	OUT

Ok
Dismiss

# Adding an SGT into SCADA



# Network Analysis displays



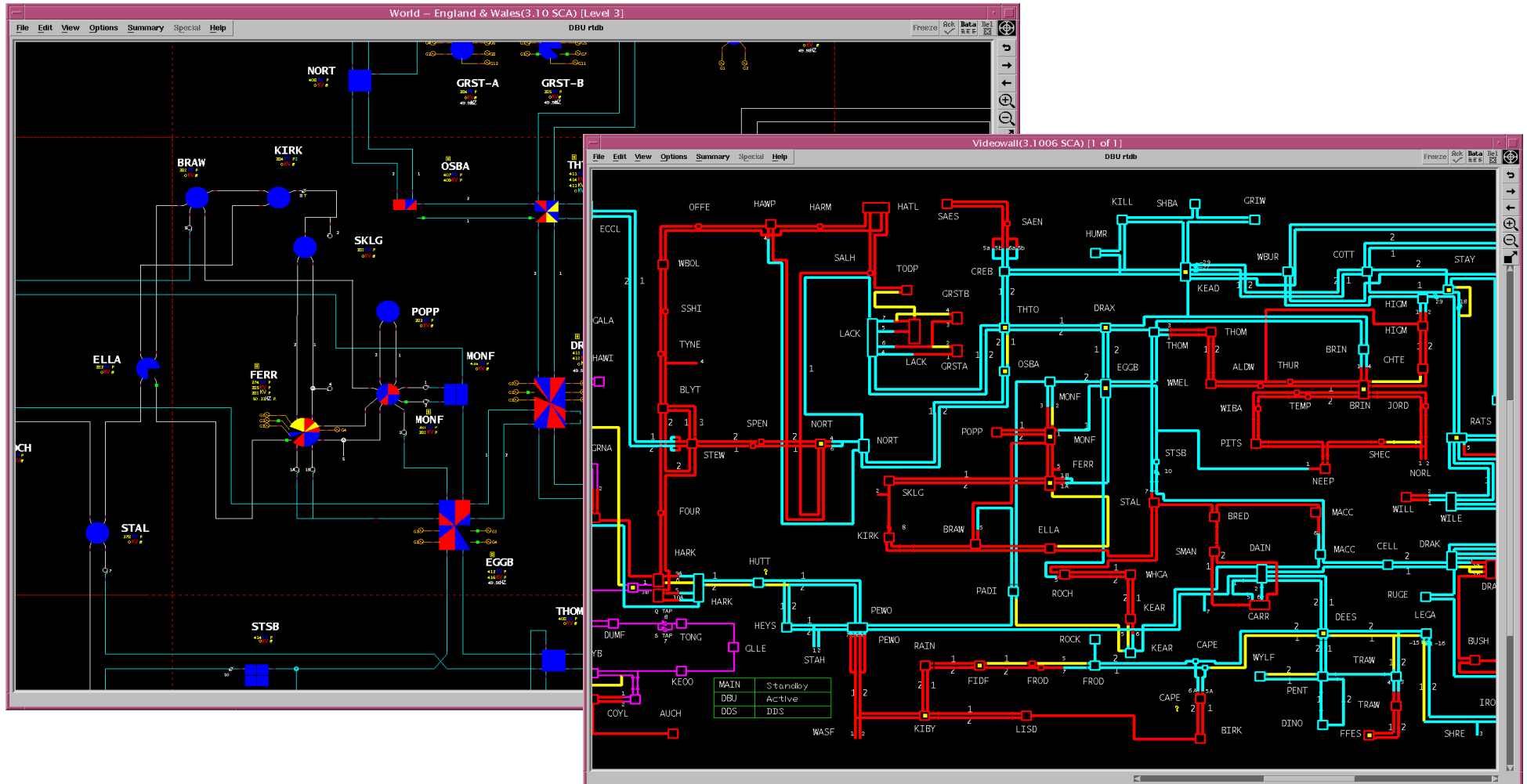
# Adding an SGT into Network Analysis

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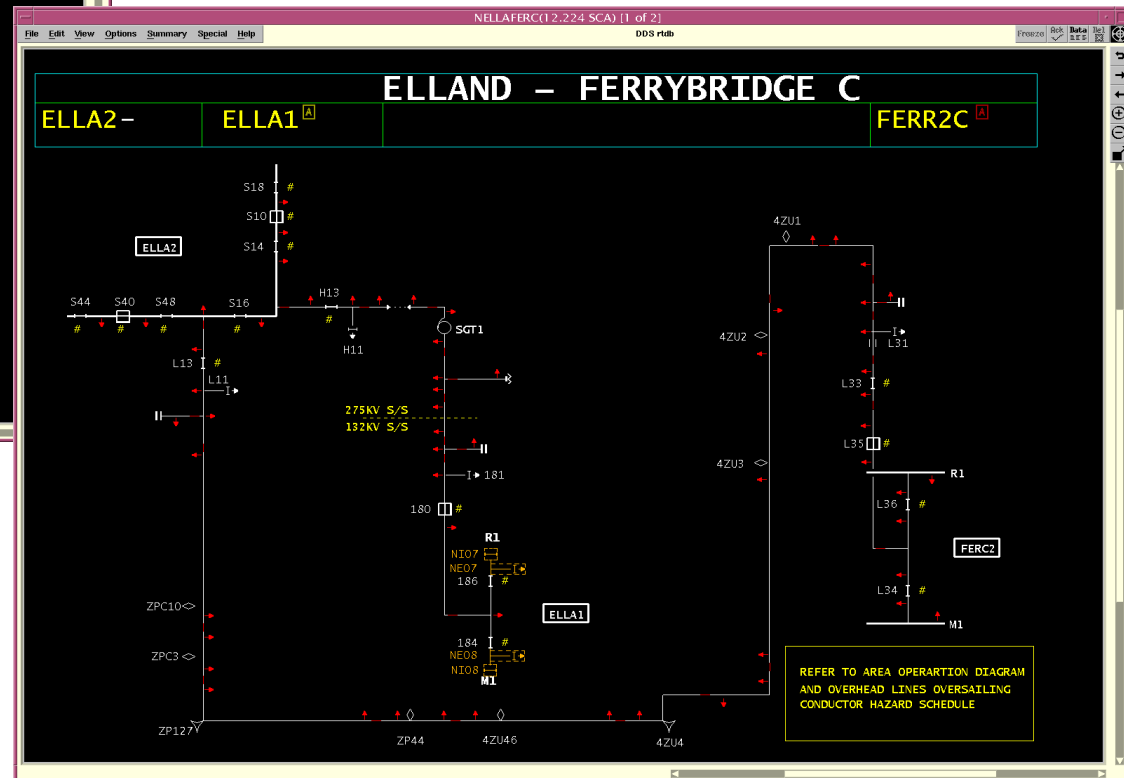
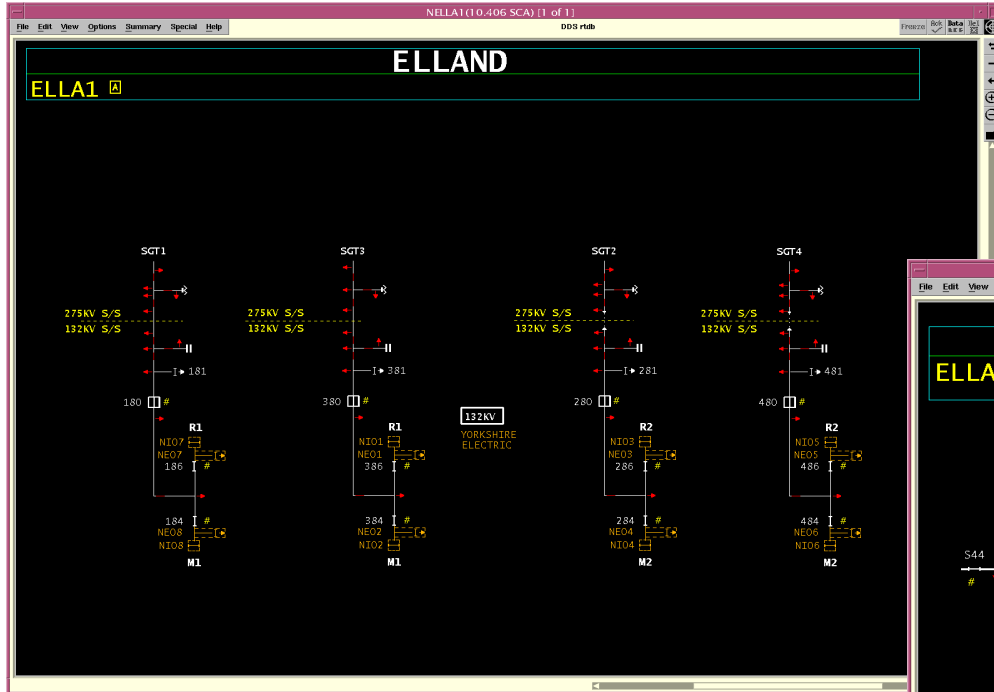
Similar process to SCADA, but with added data, eg:

- Tap range, thermal limits and impedances
- Bus section numbering scheme
- Create points for State Estimator output and calculated values (eg MVA)
- Create points for voltage selection scheme
- Add MW, MVA<sub>r</sub> and MVA calculations into summations
- Update contingency list
- Line End Open calculations
- Data for external interfaces (EFS, Data Historian, Scottish TOs, DNOs, Coreso, ENTSO-E, Swissgrid, BM)
- Video wall display.

# World and Videowall Views



# And Safety....



## Changes made in adding SGT

- 200 Status Points for GI74 (3-5 times more for IEC protocol).
- 30 Analogue Points.
- 1 Synchrocheck Assignment.
- 1 GI74 RTU layout
- Complex changes for Network Analysis
- 4 Calculations
- 4 CME Points
- Data transfer to external systems

So all in all:

- **~10 days work over 4 weeks**
  - **Almost the same amount of work to back out the change**  
**(displays backed out for delay >1 week; database changes >1 month)**

This is why we have 32 people working on real-time data management...



## IEMS “Commit” room

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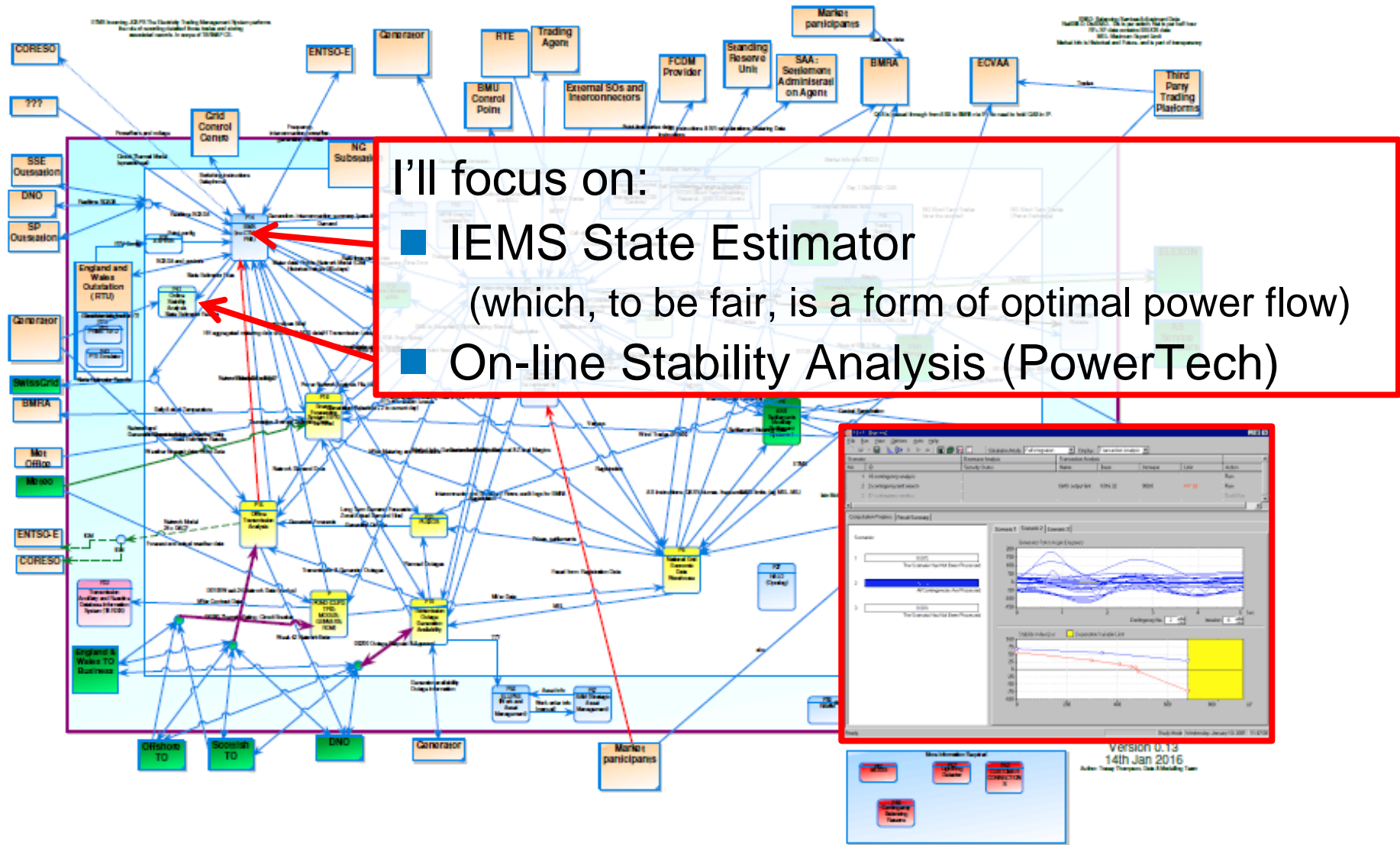


Data changes are made on a separate instance of the IEMS and tested with an emulator.

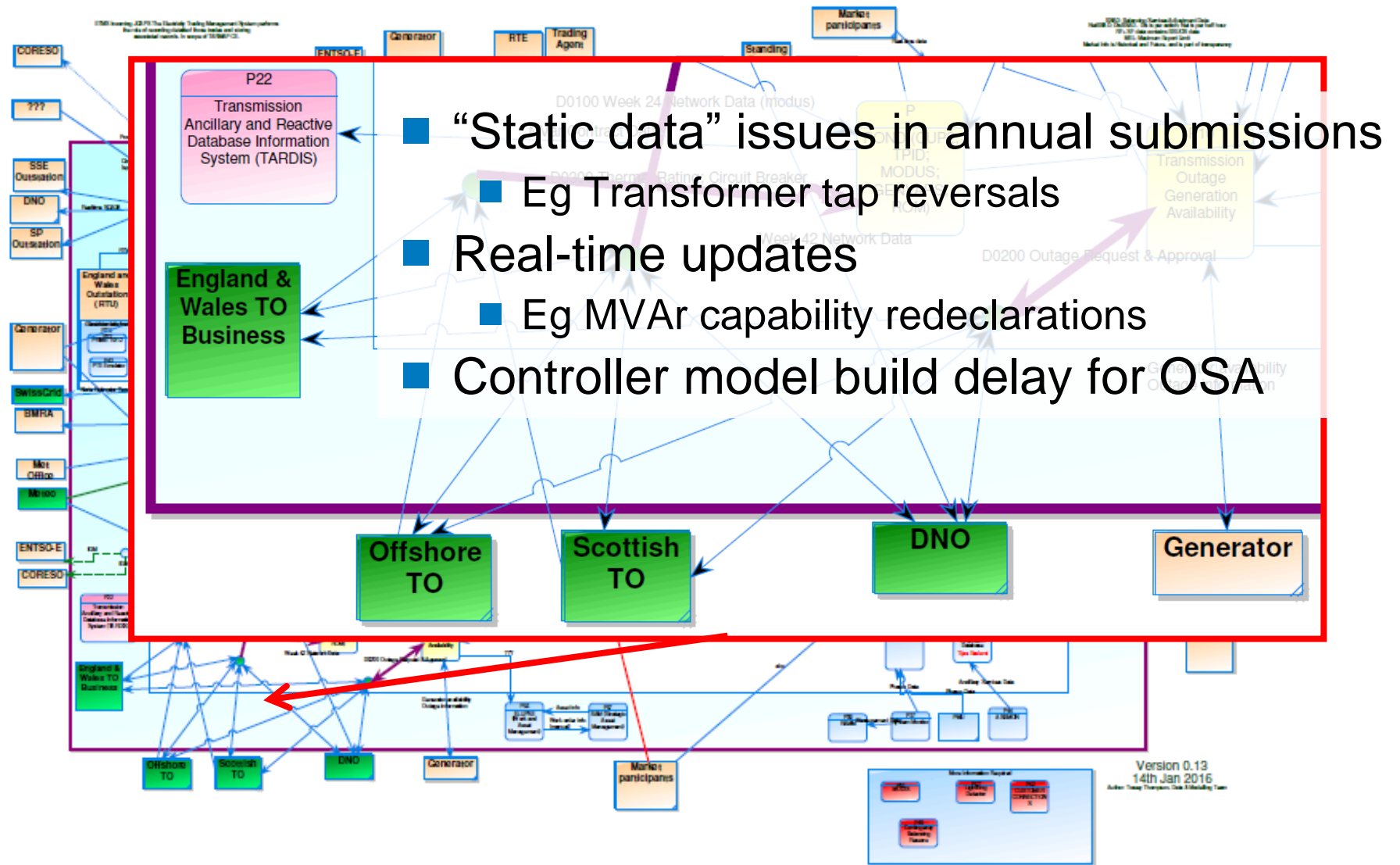
Then commit to Active first, followed by Standby the next day. Changes being committed 9+ hours per day, 5 days/week. (A full substation takes about 2½ hours)



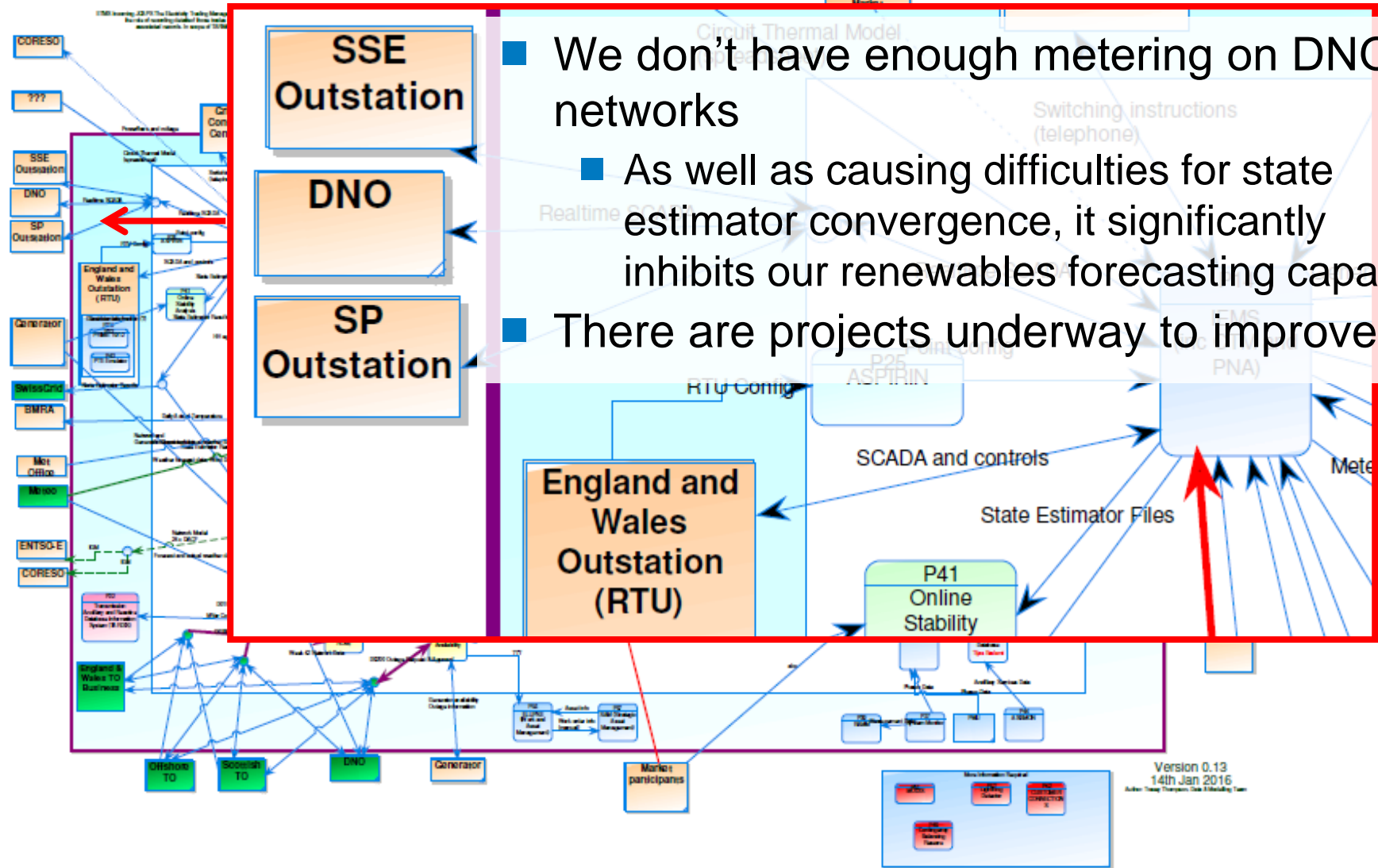
# So what kind of data problems do we have?



# External data providers

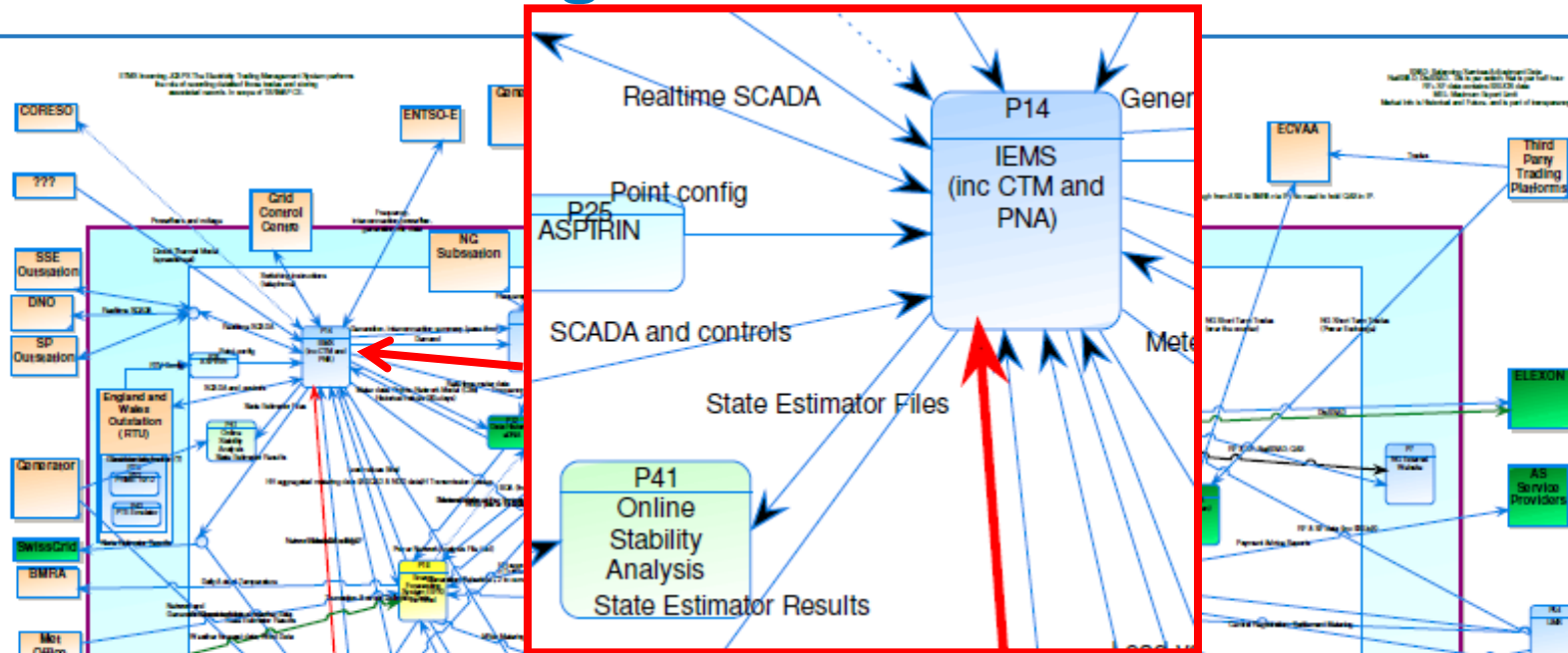


# Real-Time Metering deficit



- We don't have enough metering on DNO networks
  - As well as causing difficulties for state estimator convergence, it significantly inhibits our renewables forecasting capability
- There are projects underway to improve this

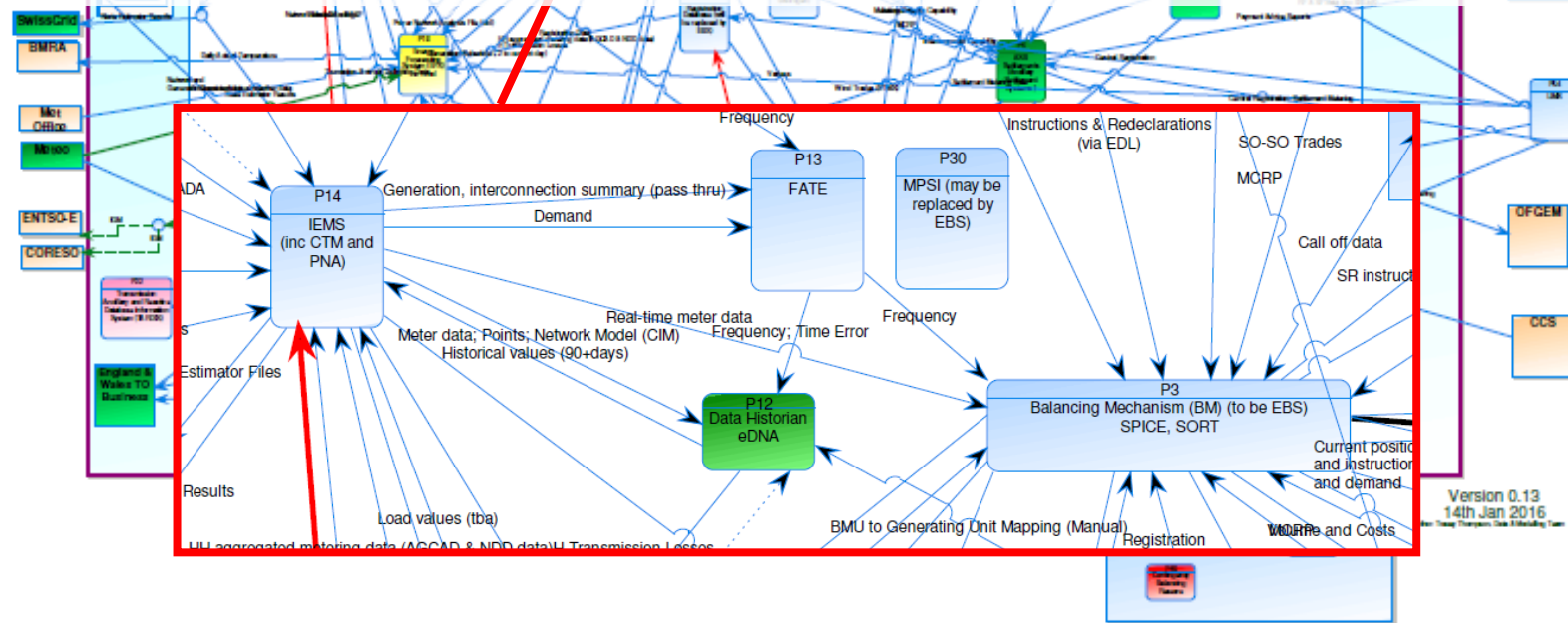
# Bad data handling



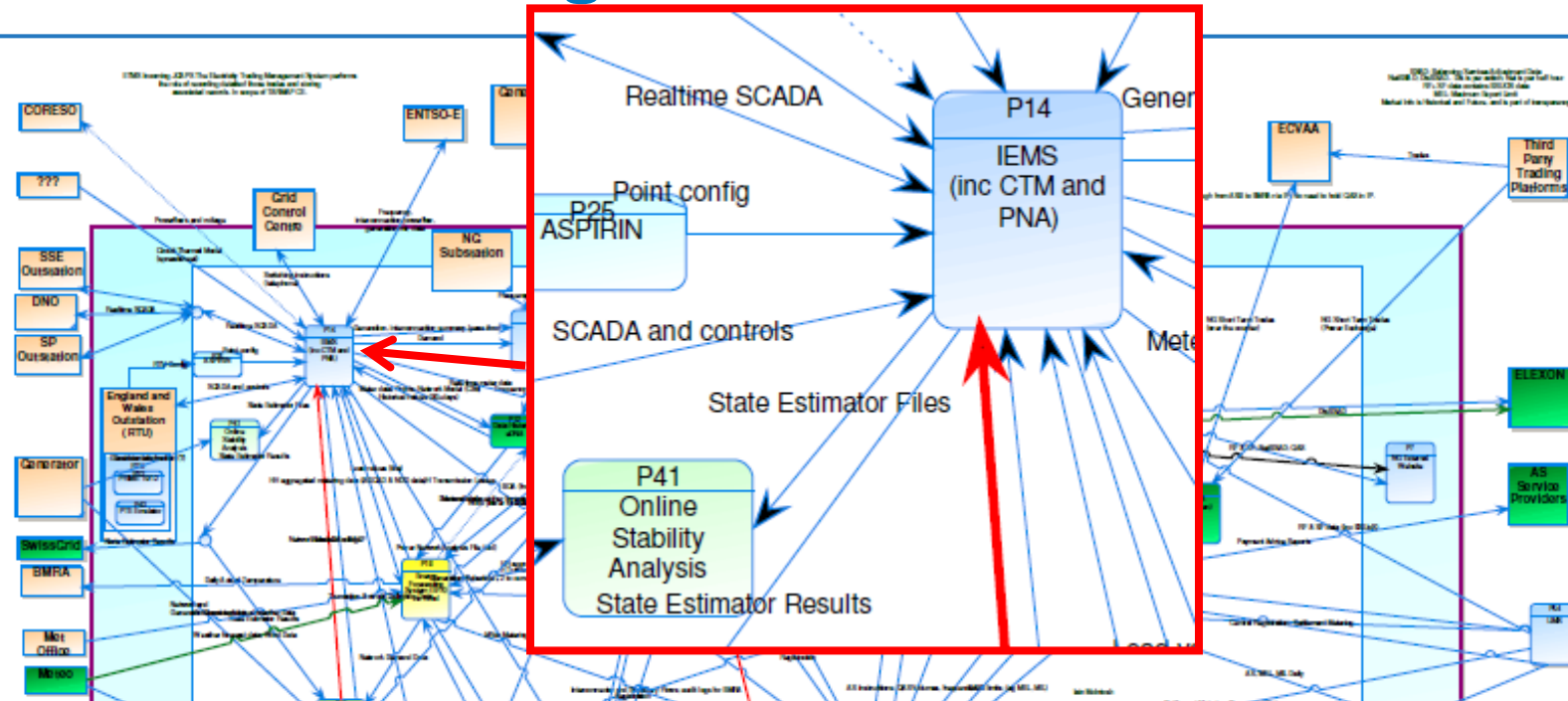
- “Error dumping, eg on generator auxiliary loads or The Great West Weybridge Circulation
  - Ok for a loadflow, but doesn’t work in a stability program!
  - Now solved by a fix from GE
- Hand dressing delays/errors for switch states or manual over-ride of bad data
  - DNO network without metering; wind farms with zero or reversed metering
- Generators solving just above Pmax; problems for the stability program.

# No system is designed to be a master repository

- Legacy situation: each system just holds its own data
  - Often with its own naming convention and modelling approach.
- We are using the IEMS as a master in some respects
  - 50,000 data points added for new balancing system model (EBS)
  - EBS needs to know about small generators that IEMS doesn't care about
  - CIM transfer was harder than we expected!
- Enterprise Service Bus being deployed

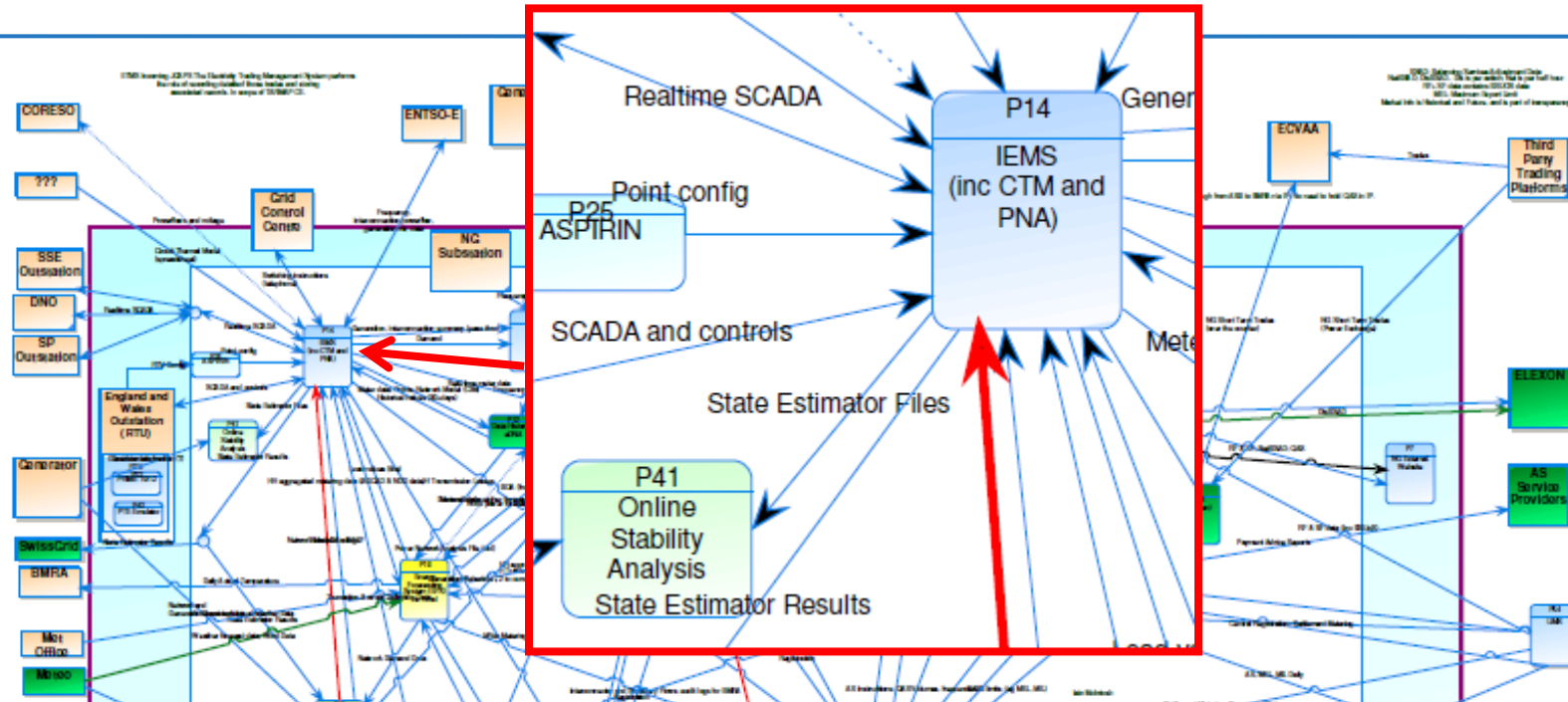


# Various modelling issues



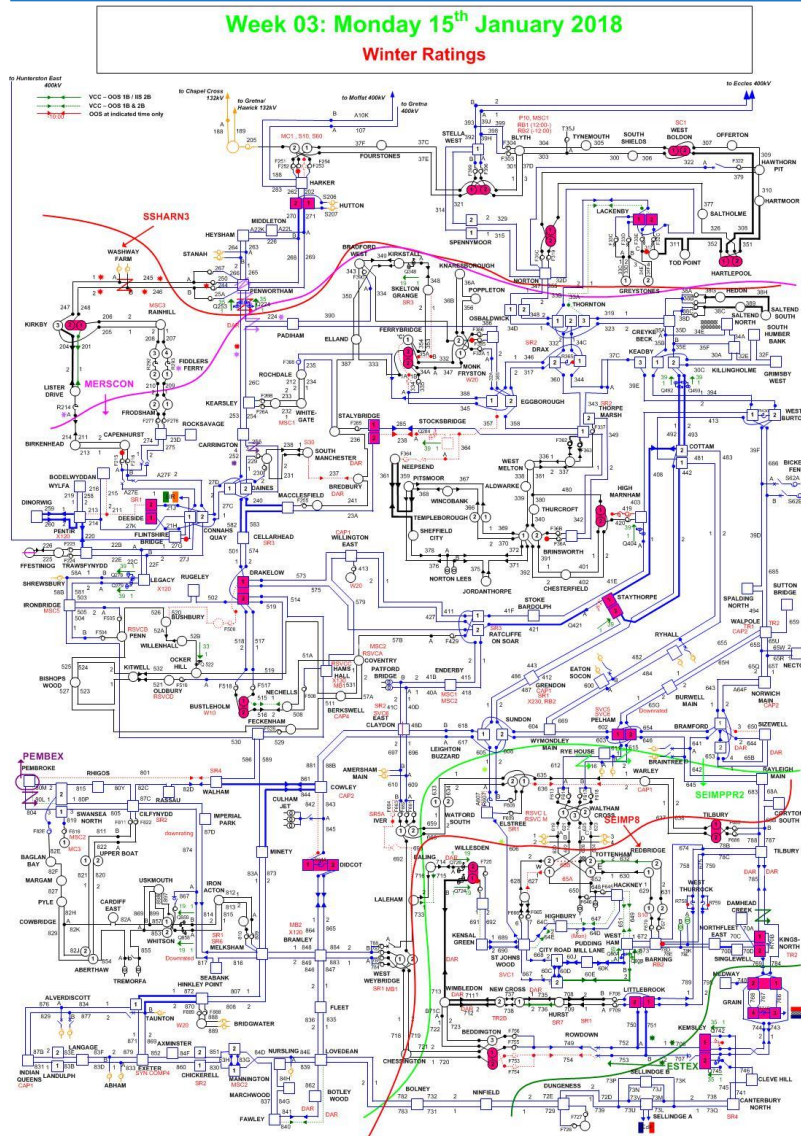
- Mutual impedances; very hard to import from the off-line analysis suite
- SVCs: metering is at LV, but the model is at the HV.
  - The slope correction has proved problematic...
- Intertrips that create islands can be troublesome
- The Voltage-Dependent Load Model in OSA doesn't work well for high voltages

# Process issues



- The contingency list includes multiple versions of faults, for example with and without intertrips or reactor switching.
- This helps the control engineers decide which intertrips to arm etc.
- But if you just export the contingency list into an optimiser, it will try to secure the most onerous version of the fault, even if that is not the prevailing condition.

# The problem itself isn't straightforward...



Pre-fault



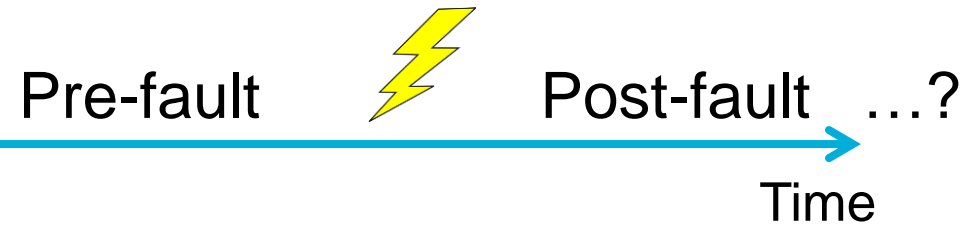
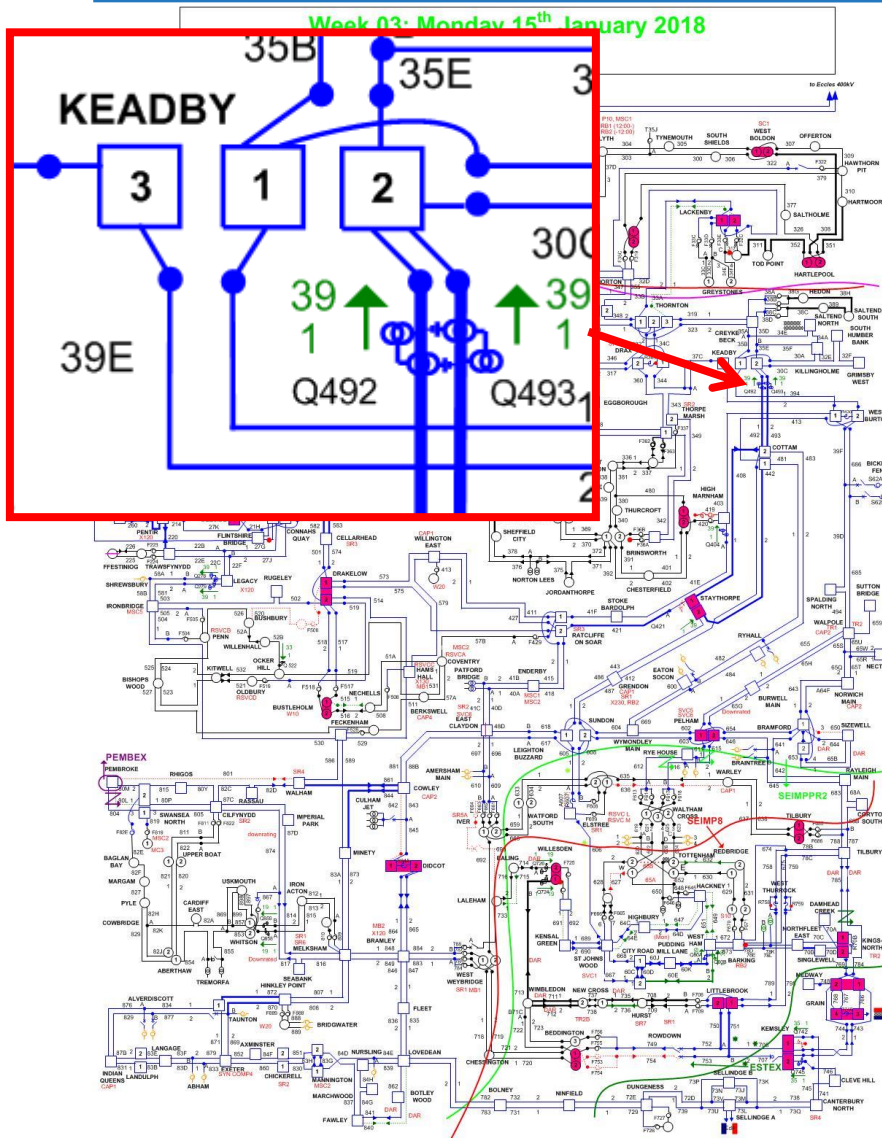
Post-fault ...?

Time

- When does “post-fault” become “pre-fault” again? How long do I have before the system must be re-secured?
- If you run an optimiser immediately after a fault, it will try to secure the system again straight away, which is equivalent to securing the system to N-D-D or N-1-1.



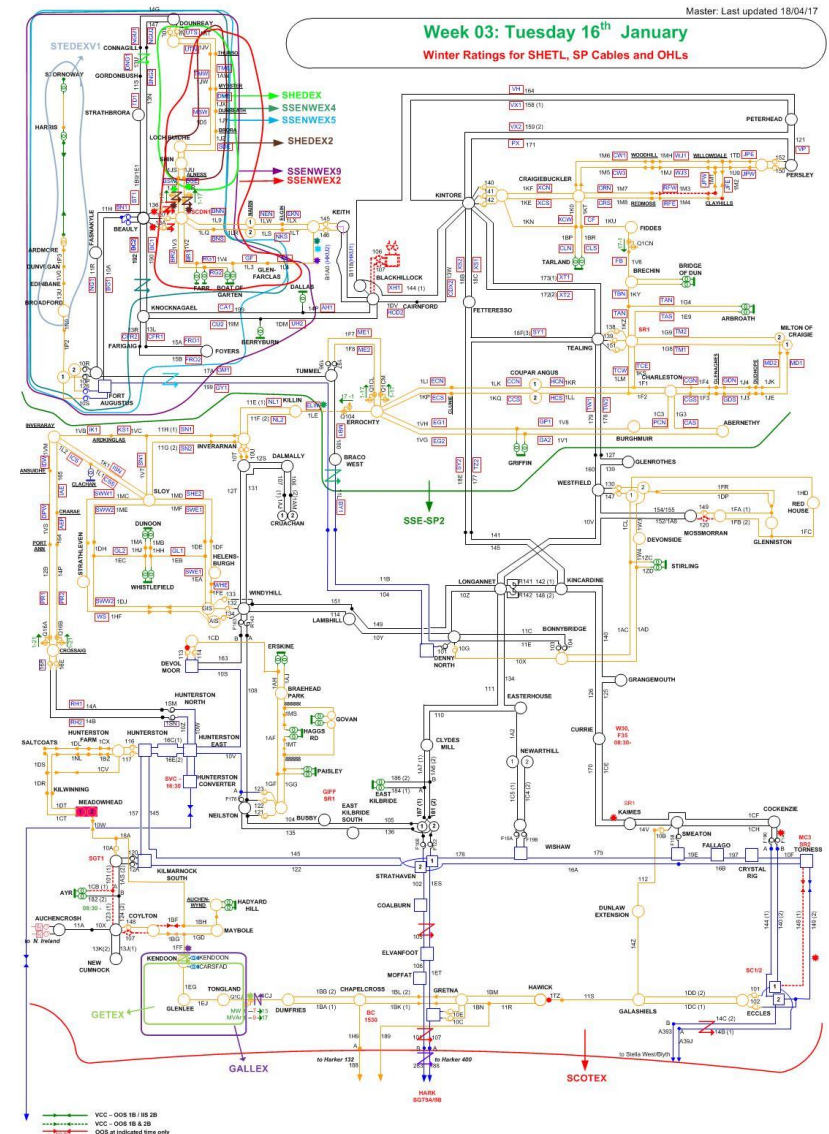
# The problem itself isn't straightforward...



- If the fault wasn't the critical fault, can I use my post-fault ratings?
- If I implement local automatic control of QB tap position, how does the QB controller know that a fault has occurred? (reliably?)
- If you get it wrong, automatic control could make the problem worse.
- This is why we still use manual control for QBs...

# The problem itself isn't straightforward...

- In high wind conditions, with a BMU inside an active Constraint Management Zone (“ANM” or Active Network Management scheme):
- If we issue an economically optimal instruction to pull back the BMU, the ANM scheme will replace its output from another wind farm.
- => costs have been incurred with no net effect
- A similar situation arises if we start a STOR generator inside an active CMZ.



## The people factor...

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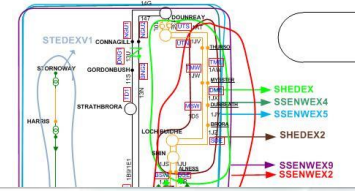
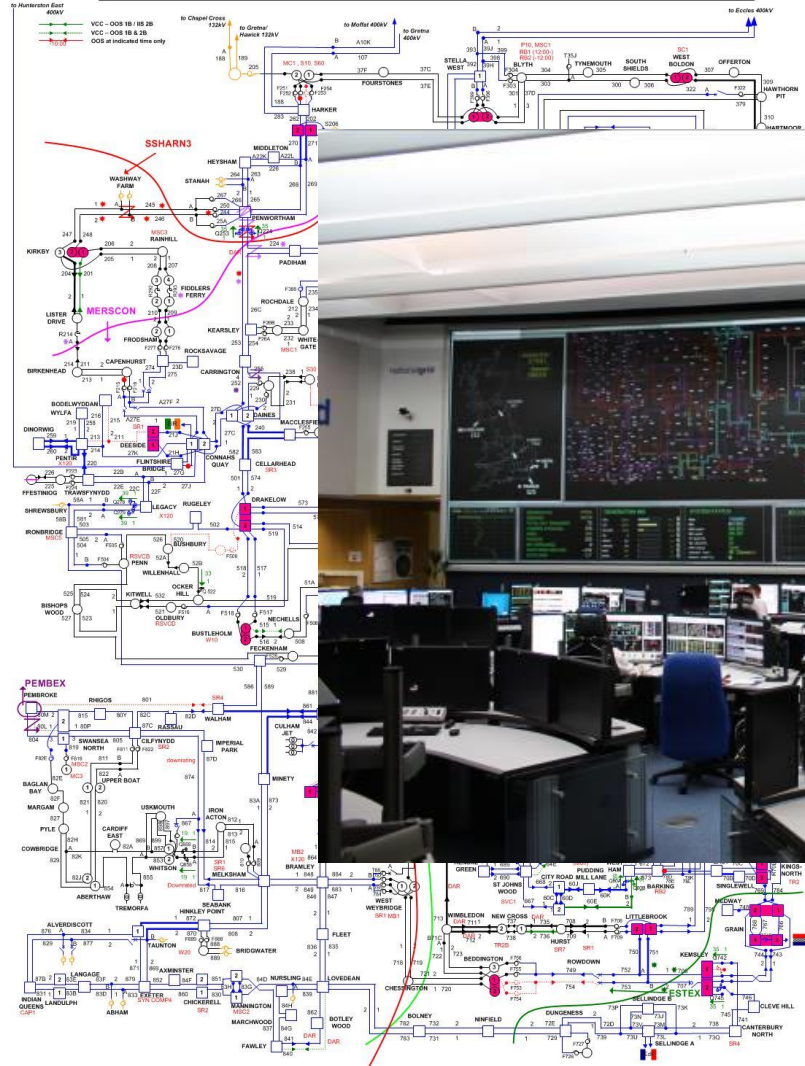
- Does it tell me something I don't already know?
- Is it easy to use?
- Does it explain why it's done what it's done?
- In terms I can understand?
- Can I trust it?
- Is it quick?
- Is it always available?
- Is the advice usable?
- Is the advice stable?
  - I don't want a different answer every five minutes...

User confidence is essential.

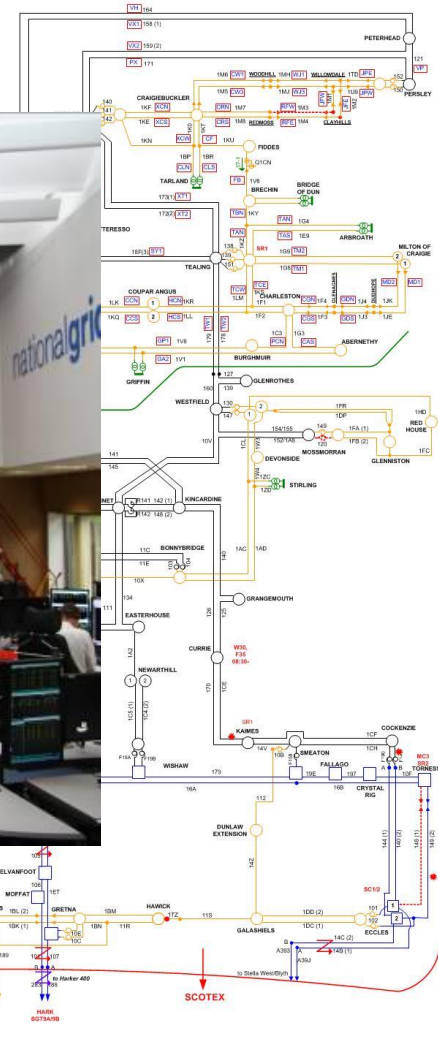


# Time is a constrained commodity...

Week 03: Monday 15<sup>th</sup> January 2018  
Winter Ratings



Week 03: Tuesday 16<sup>th</sup> January  
Winter Ratings for SHETL, SP Cables and OHLs



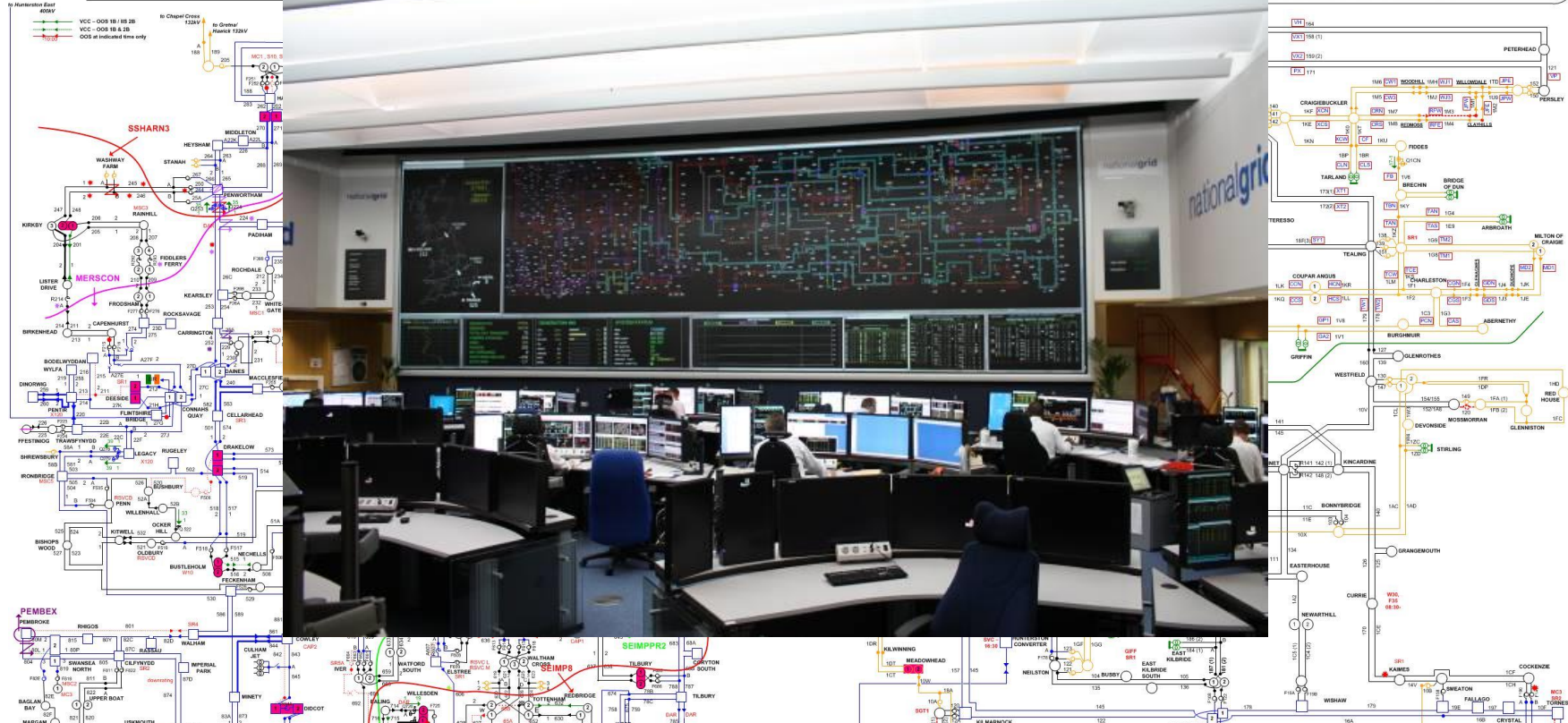
Master: Last updated 18/04/17

# But the good news is...

Week 03: Monday 15<sup>th</sup> January 2018

Week 03: Tuesday 16<sup>th</sup> January

Outages for SHETL, SP Cables and OHLs



... after years of chipping away at the problems, and with a full-time person monitoring and tuning the State Estimator, its availability is >99%. (And OSA is pretty reliable too 😊 )