Constraint Management

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GB Electricity Transmission System

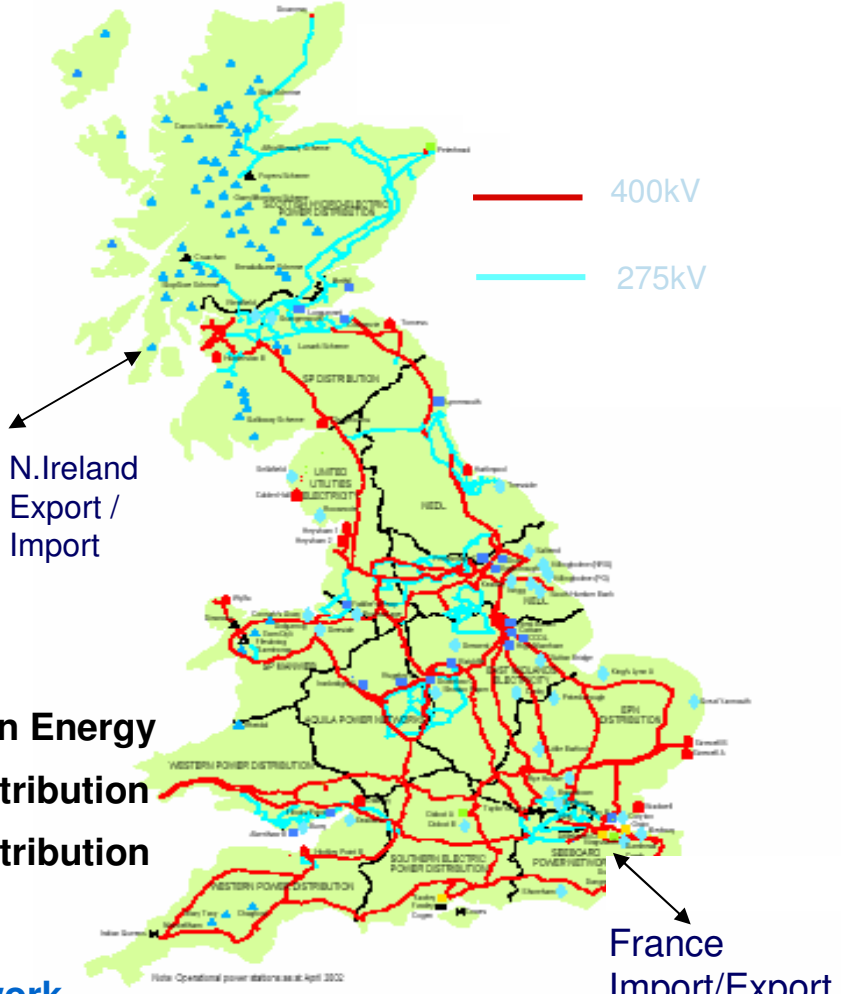
National Grid

Great Britain System Operator ('GBSO')

Transmission Owners ('TOs')

- Scottish Hydro Electric — SHEPDL
- Scottish Power — SPDL
- National Grid
  - CE Electric
  - Central Networks
  - EdeF Energy
  - Scottish & Southern Energy
  - Scottish Power Distribution
  - Western Power Distribution
  - United Utilities

Distribution Network Operators ('DNOs')



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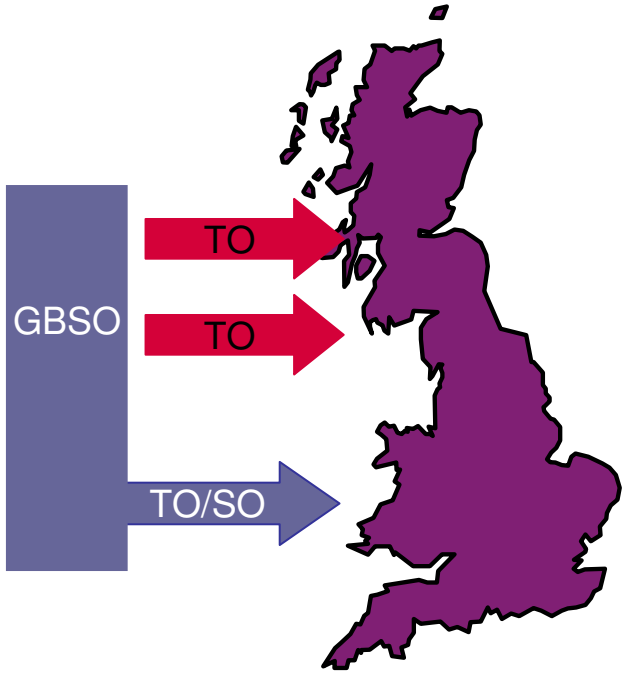
The GB Electricity Transmission System



	National Grid	Scottish Power	S & SE
Circuit km	14,000	4,000 Inc 132 kV	5,000 Inc 132 kV
Substations	300	80 Inc 132 kV	40 Inc 132 kV
Max GW Demand	54.3	4.39	1.65

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GB Metrics

Item	England & Wales	Scotland	GB % increase over E&W
Network metrics			
No. of site locations	300	260	86 %
Number of Buses	1,060	1,000	94 %
Number of Switches	12,441	10,000	80 %
Number of Lines	853	650	76 %
Demand points	350	250	71 %
No. of Transformers & Quadboosters	1,172	570	49 %
Circuit Route km	7,000	8,700	124 %
Other metrics			
Generating Units	257	130	50 %
Demand max (GW)	55,000	7,000	13 %
Outage requests (year ahead)	3,500	1,500	43 %

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GBSO - TO interface

Scottish Transmission Owner

- Build and own
- System design
- Project Manage
- Engineering and maintenance
- Operate assets to GBSO direction

GB System Operator

- Provides Customer Interface
- System planning
- System operation
- Market facilitation
- Energy trading

The STC (SO - TO Code)
Manages the interface - Scottish TOs & GBSO

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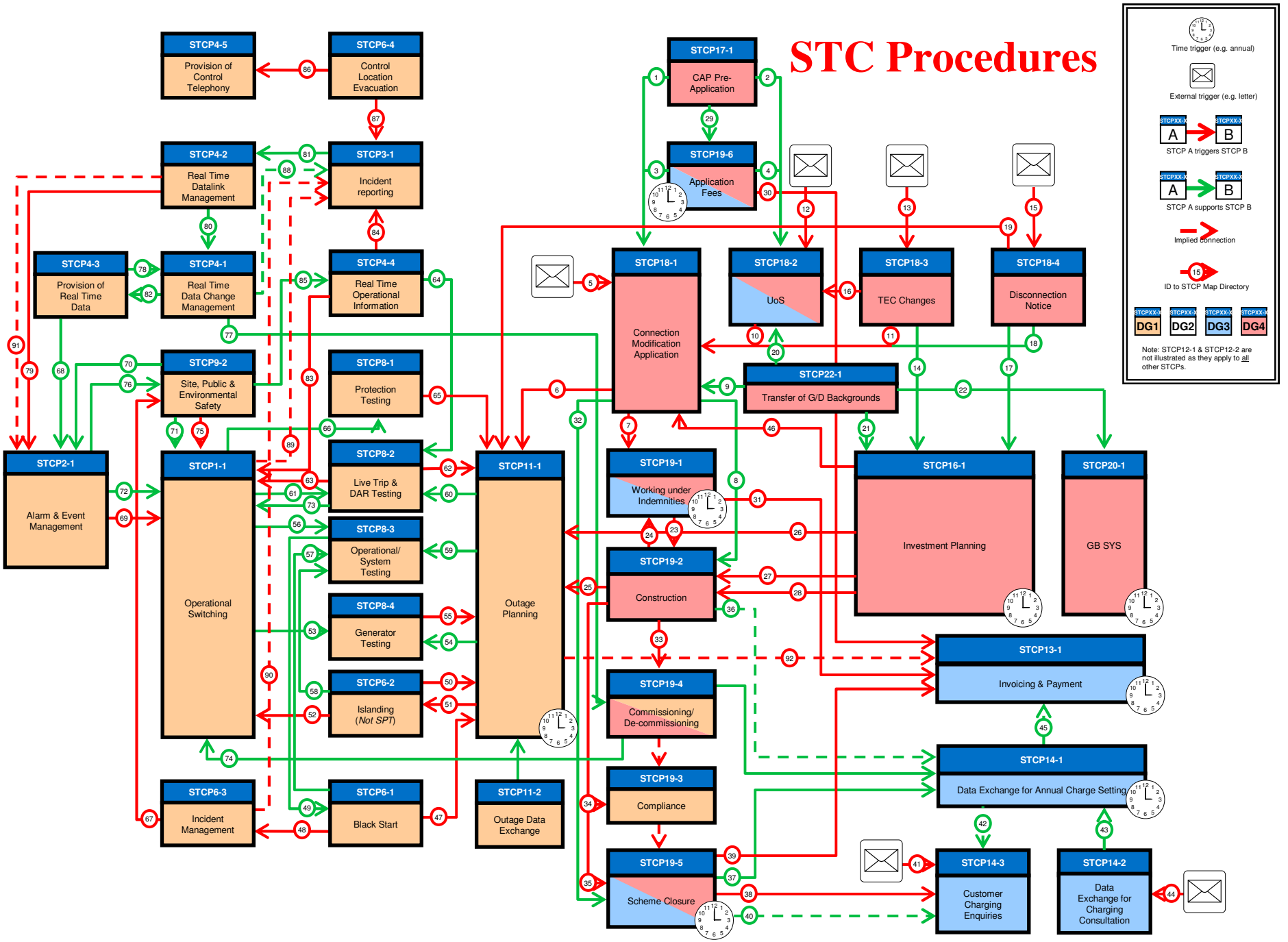
STC Procedures



GBSO - TO Responsibility

Scottish Transmission - 400/275KV and 132KV

GBSO		TO
	Investment Planning	
Customer Agreements/ Charging		DNO planning interface
	New Connection Offers	
Outage Co-ordination		Asset Maintenance requests
Energy Balancing		Switching to GBSO direction
		Fault Repairs
Operational Security		Safety Management

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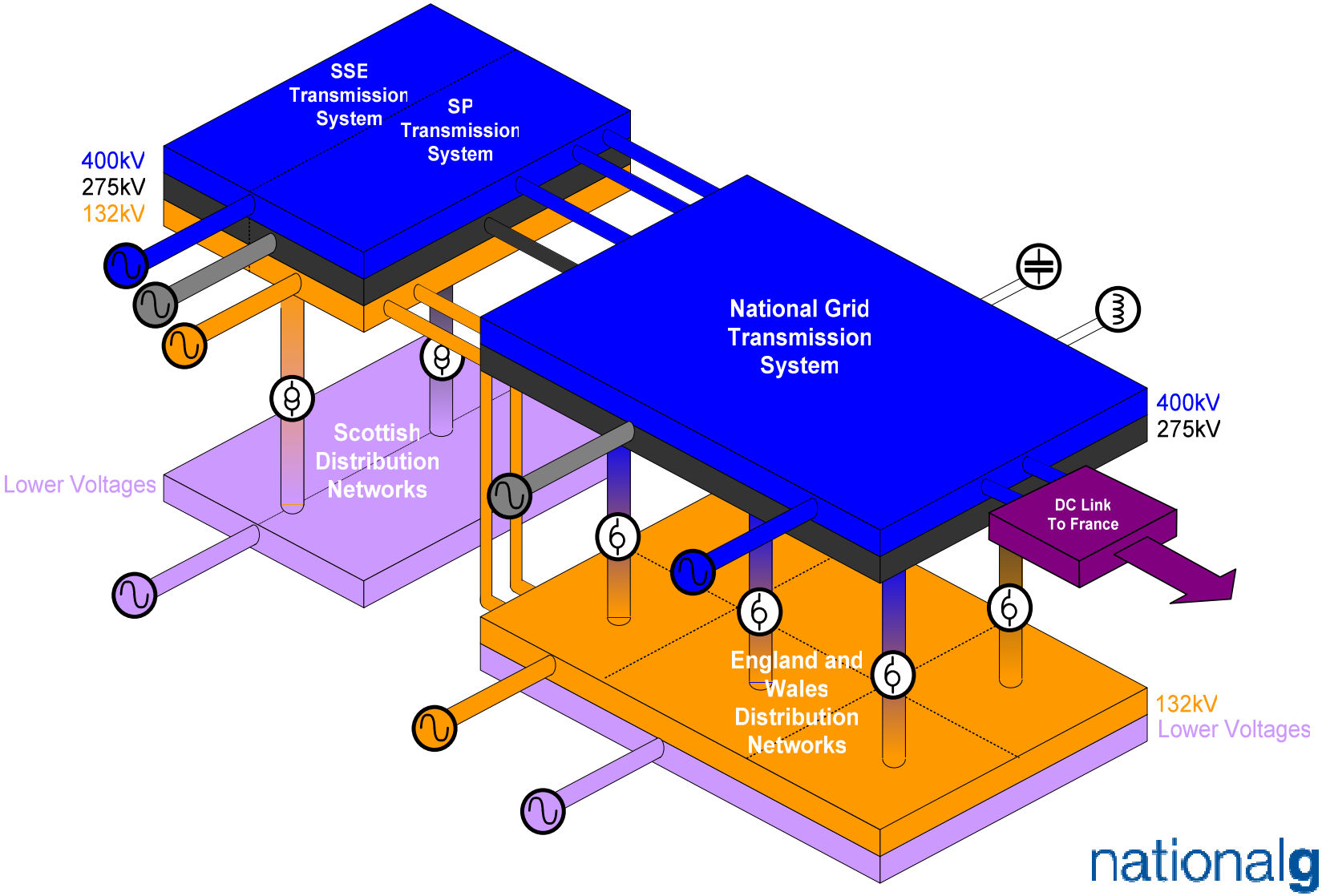
Responsibilities



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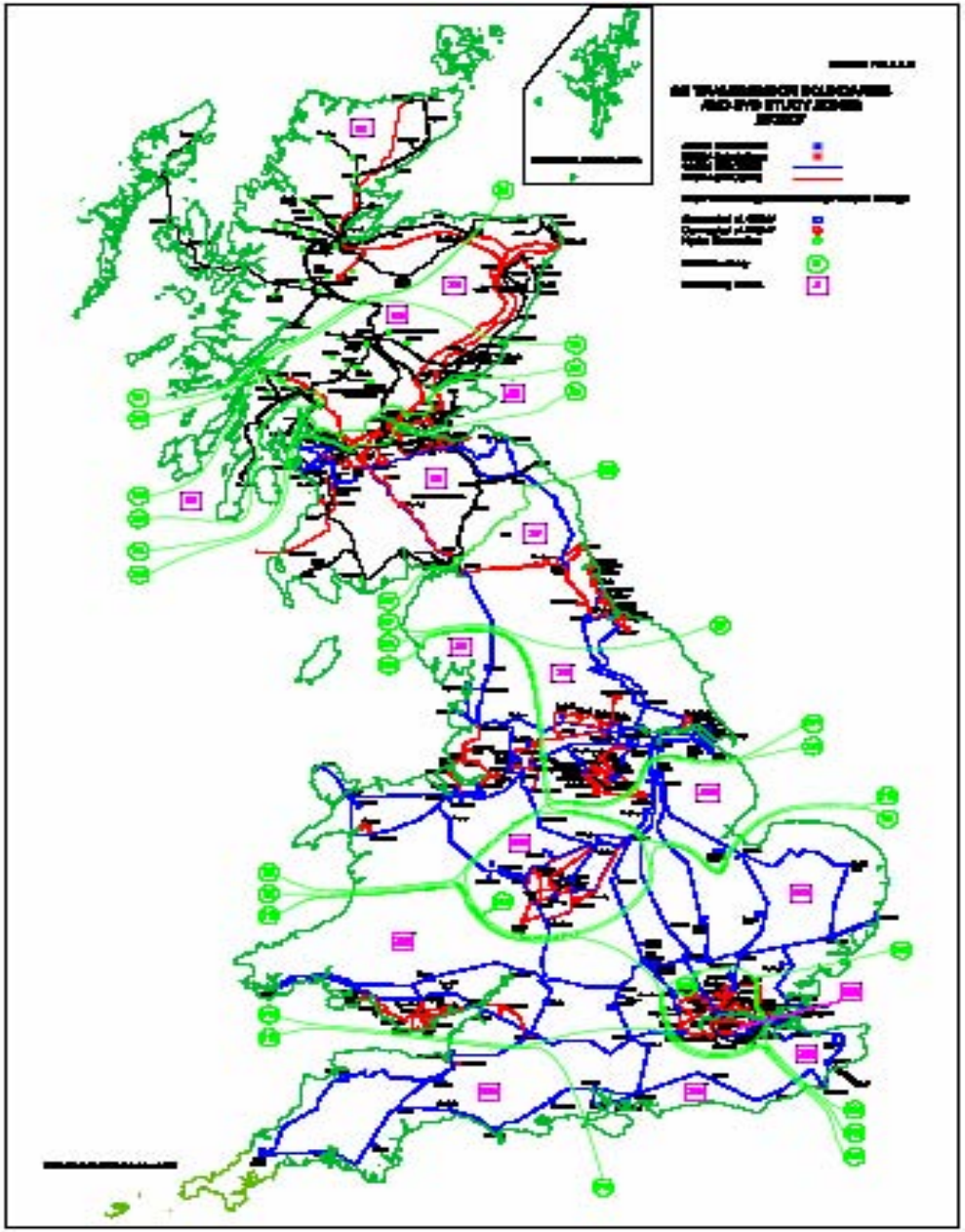
Typical System Constraints



- The system is not geographically balanced for generation and demand
- Bottle-necks arise that require power flows to be "Constrained"
- Innovative solutions need to be adopted to minimize any power flow restrictions

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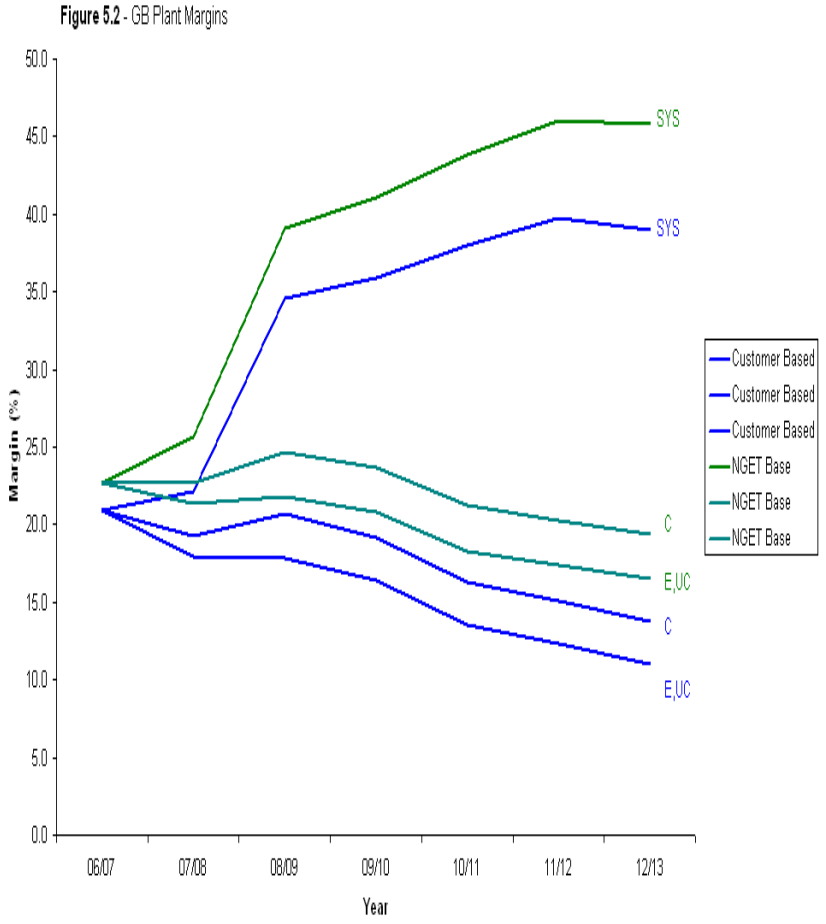
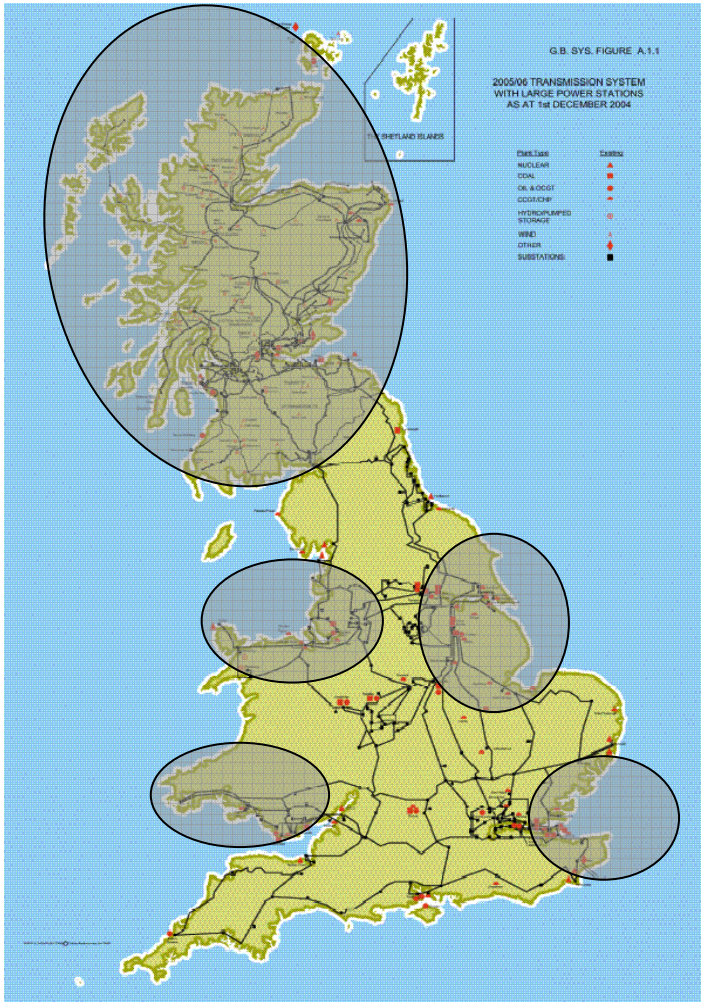
Generation Uncertainty

- Closures
  - 2.4 GW of nuclear closed or due t close over next 5 years
  - Potentially reduced running of about 11GW of coal / oil station from 2008 and closure post 2015
- Challenges
  - Planning consent uncertainty for new build
  - Potentially a wide range of scenarios for Plant Margins
  - Maintain security standards while being economic and efficient
  - Constraint management following change of plant disposition



Significant Growth in Renewables

- Renewables
  - 2010: ~10% of UK electricity renewable
  - Predominantly wind – some tidal
  - UK has the largest potential wind energy resource in Europe
- Challenges
  - Planning consent key determinant for access to Grid System
  - Development of offshore networks
  - Intermittency issues – impacts energy market and increases constraint management complexity



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Rewiring the System

- Electricity System
  - System installed in early 1960's
  - New infrastructure to connect and transport new generation
  - Increase in capital expenditure:
    - ~ £3bn over 5 years
    - from ~£400m to ~£600-700m per annum

- Challenges
  - All year round working – subject to outage placements
  - Incentivised constraint management
  - Maintaining world class reliability (incentive scheme)

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System complexity issues

- A number of factors confirm that the network is getting increasingly more complex to plan and operate:
  - The number of ‘complex’ devices (which require consideration when planning and operating the network) installed on the system have increased by between a factor of 1.5 and 2.5 since 1996.
  - The models the off-line analysis tools use have increased in complexity by 2.5 since 1996.
  - The number of system studies carried out in operational timescales are increasing year on year and have increased from 6760 in 1990 to 174,066 in 2004/5 – that’s ~ 500 system studies a day in operational timescales.

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Outage drivers

- Maintenance
- Asset replacement
- Asset refurbishment
- Growth in demand
- New generation/demand connections
- Network changes
  - Market driven

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Outage Planning Principles

- 5 year ahead planning horizon – increasing in detail towards real time
- Alignment of construction and maintenance works
- Minimising of outage requirements (in the way that work is planned)
- Nesting of National Grid (Scottish TO)/Customers work (through Grid Code OC2 process)
- Maximising the ratio of Work Completed / Outage Days required

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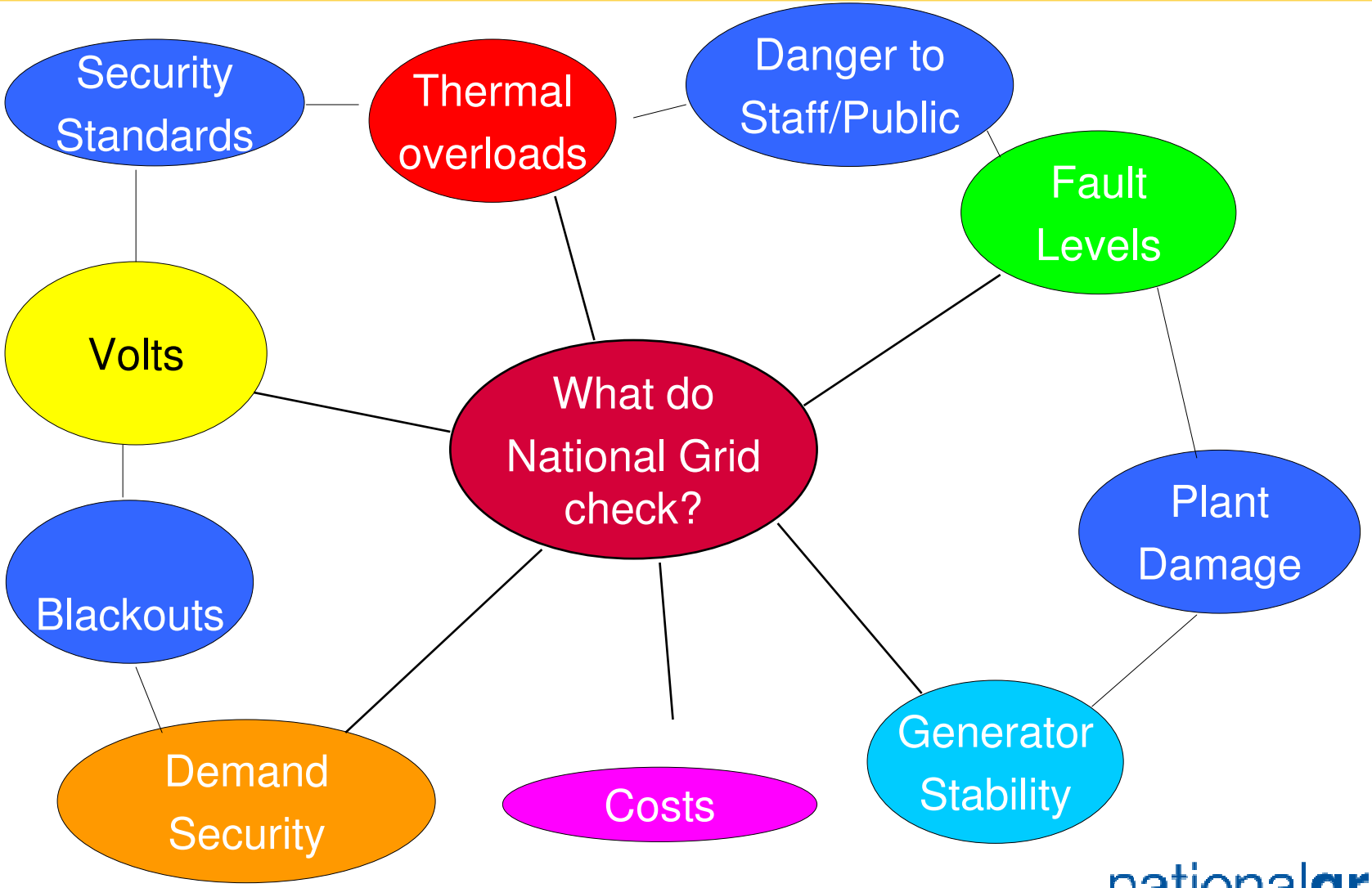
Considerations for every outage



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How do we identify problems with outages? *-The Ella model*

- Bespoke power system analysis software - Ella
- From the Ella model the following can be established for every credible fault that can occur on the GB system:
  - Steady state voltage, MW, MVAr & MVA flows
  - Post fault voltages, MW, MVAr & MVA flows
  - Post fault voltage step changes
  - Generator stability
  - Fault level infeed
- Ella presents this information to the engineer in a format that facilitates confirmation of compliance against security standards.

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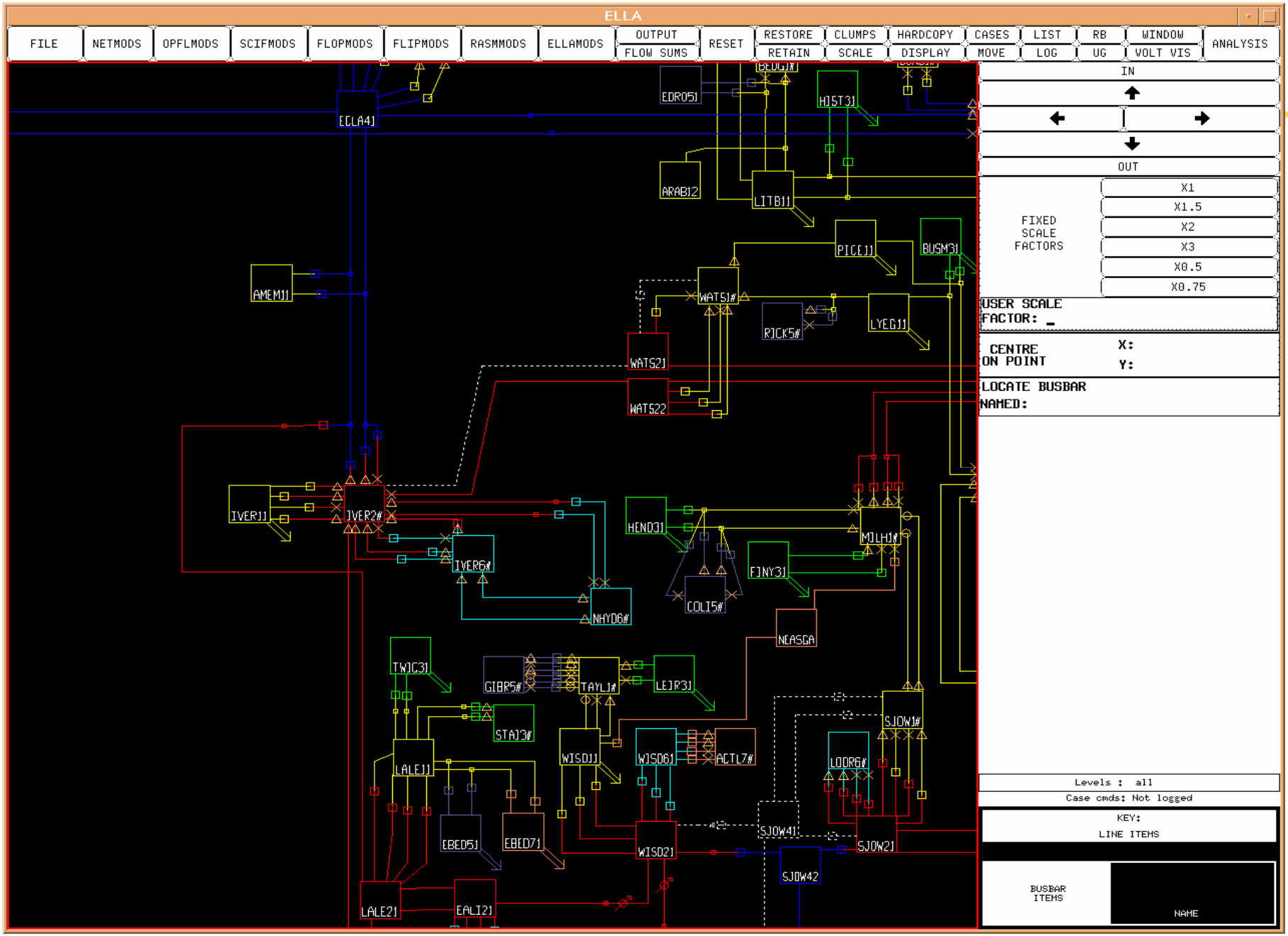
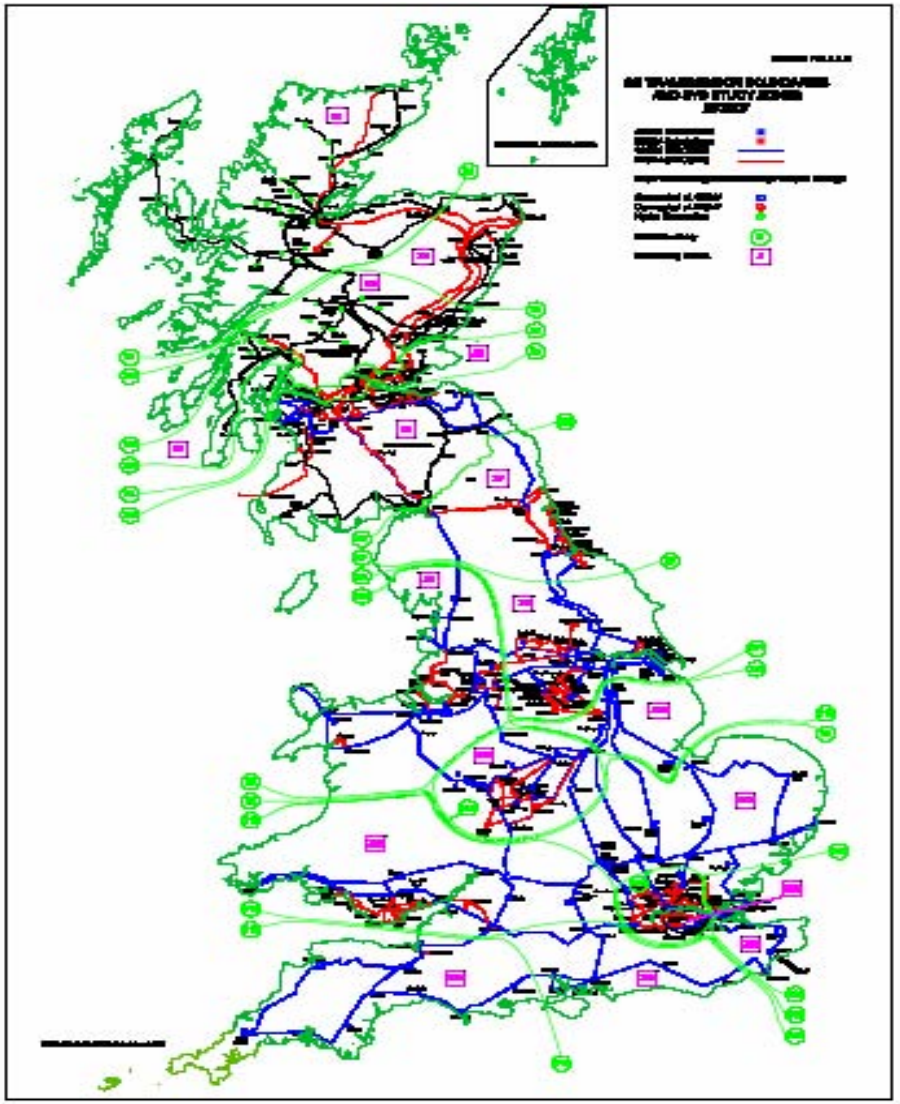

ELLA
FILE
NETMODS
OPFLMODS
SCIFMODS
FLOPMODS
FLIPMODS
RASMMODS
ELLAMODS
OUTPUT
FLOW SUMS
RESET
RESTORE
RETAIN
CLUMPS
SCALE
HARDCOPY
DISPLAY
CASES
MOVE
LIST
LOG
RB
UG
WINDOW
VOLT VIS
ANALYSIS
IN
OUT
FIXED SCALE FACTORS
X1
X1.5
X2
X3
X0.5
X0.75
USER SCALE FACTOR:
CENTRE ON POINT
X:
Y:
LOCATE BUSBAR NAMED:
Levels : all
Case cmds: Not logged
KEY:
LINE ITEMS
BUSBAR ITEMS
NAME
ECLA4J
EDRO5J
HJST3J
ARAB12
LITB1J
PICEJJ
BUSM3J
AMEM1J
WAT51#
RICK5#
LYEGJJ
WATS2J
WAT522
IVERJJ
IVER2#
IVER6#
NHYD6#
HEND3J
COLI5#
FINY3J
MILH1#
NEASGA
TWIC3J
GIBR5#
TAYL1#
LEJR3J
STAJ3#
LALEJJ
WISDJJ
WISD6J
ACTL7#
LODR6#
SJOW1#
EBED5J
EBED7J
WISD2J
SJOW41
SJOW2J
SJOW42
LALE2J
EALI2J

Typical System Congestion

- 20-25 limits typically monitored on any day
- Congestion will vary with generation patterns and transmission circuit outages



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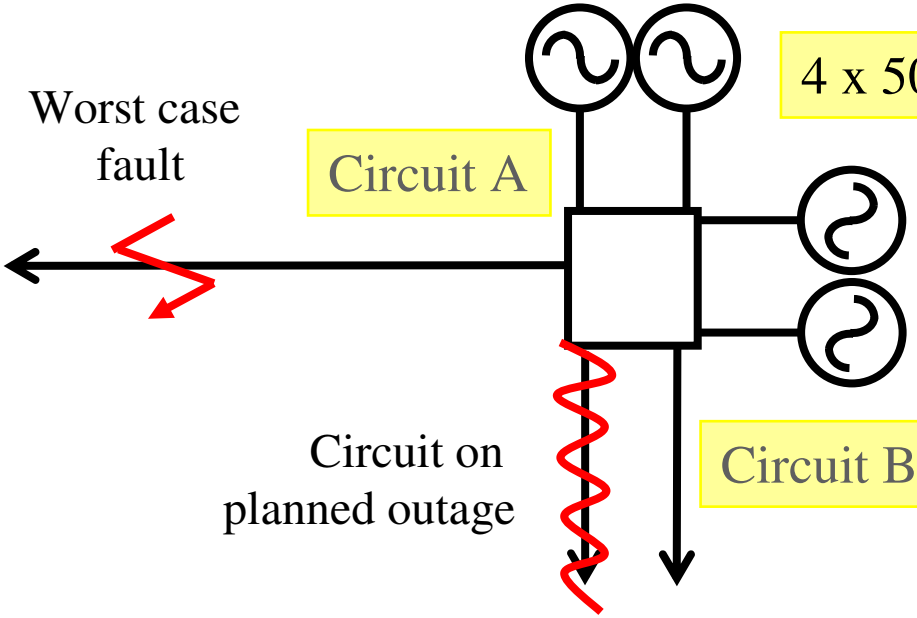
Example – a thermal constraint



- Exceed rating and take post fault drops
- Intertrip generation
- Pre-fault generation restrictions

	Rating	Pre-fault flow	Post fault flow
Circuit A	2200	1100	0
Circuit B	1500	900	2000

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Outage Risk Management – 1
- how we manage costs

- Integral part of the planning process
  - Multiple scenarios are considered
- Forecast generation patterns and prices are derived from
    - historic generation patterns
    - forward prices
    - market intelligence
  - Engineers perform analysis to
    - determine requirement for use of Balancing Services
    - evaluate potential costs and cost risk of alternatives
    - determine innovative ways of mitigating constraint costs
    - evaluate possible commercial options or system options
    - ensures that cost risks are balanced against the importance of the work that the outages allow to be carried out

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Outage Risk Management - 2
- how we mitigate risk to customers

- Carry out regular line patrols
- Arrange cable section/circuit patrols as necessary
- Ensure 3 monthly site/bay defect checks are completed
- Review known defects and technical limitations
- Ensure successful trip and autoreclose test completed annually
- For demand at risk
  - Consider the Emergency Return to Service strategy
  - Consider if extended working hours are viable
  - Arrange strategic manning of sites when appropriate
  - Monitor weather conditions before and during work
  - Consider any contingency actions necessary

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Constraint Management Solutions - in the field

- Outage Acceleration
- Emergency return to service strategy
- Short-term Rating Enhancement
- Hotwire
- Condition Monitoring
- Outage Postponement

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Constraint Management solutions - in the office

- Contract / Trade
- Balancing Services
- Intertrips
- Demand Transfers
- Special Actions
- System Reconfiguration
- Weather/condition monitoring

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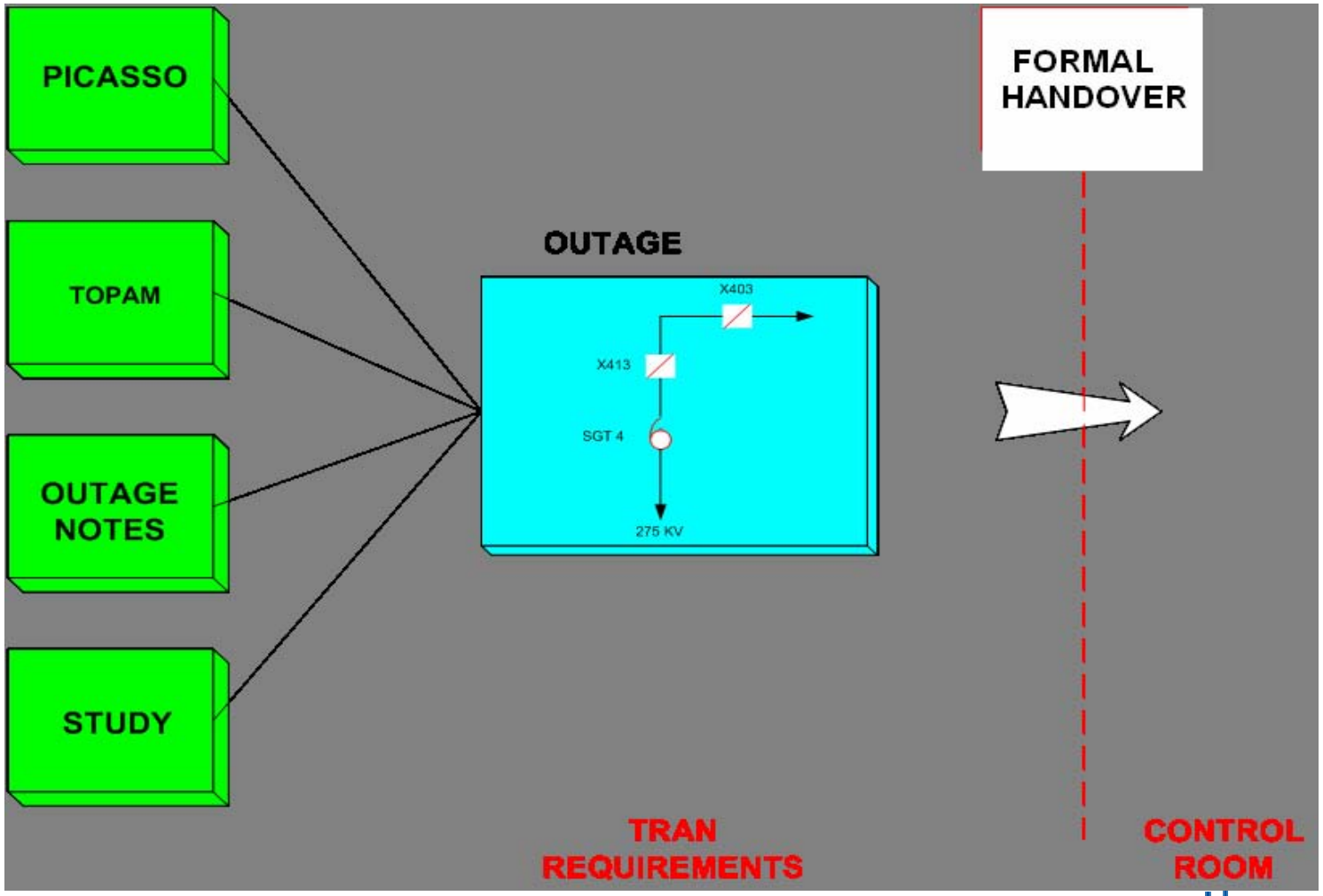
Life of an Outage 1 - Handover



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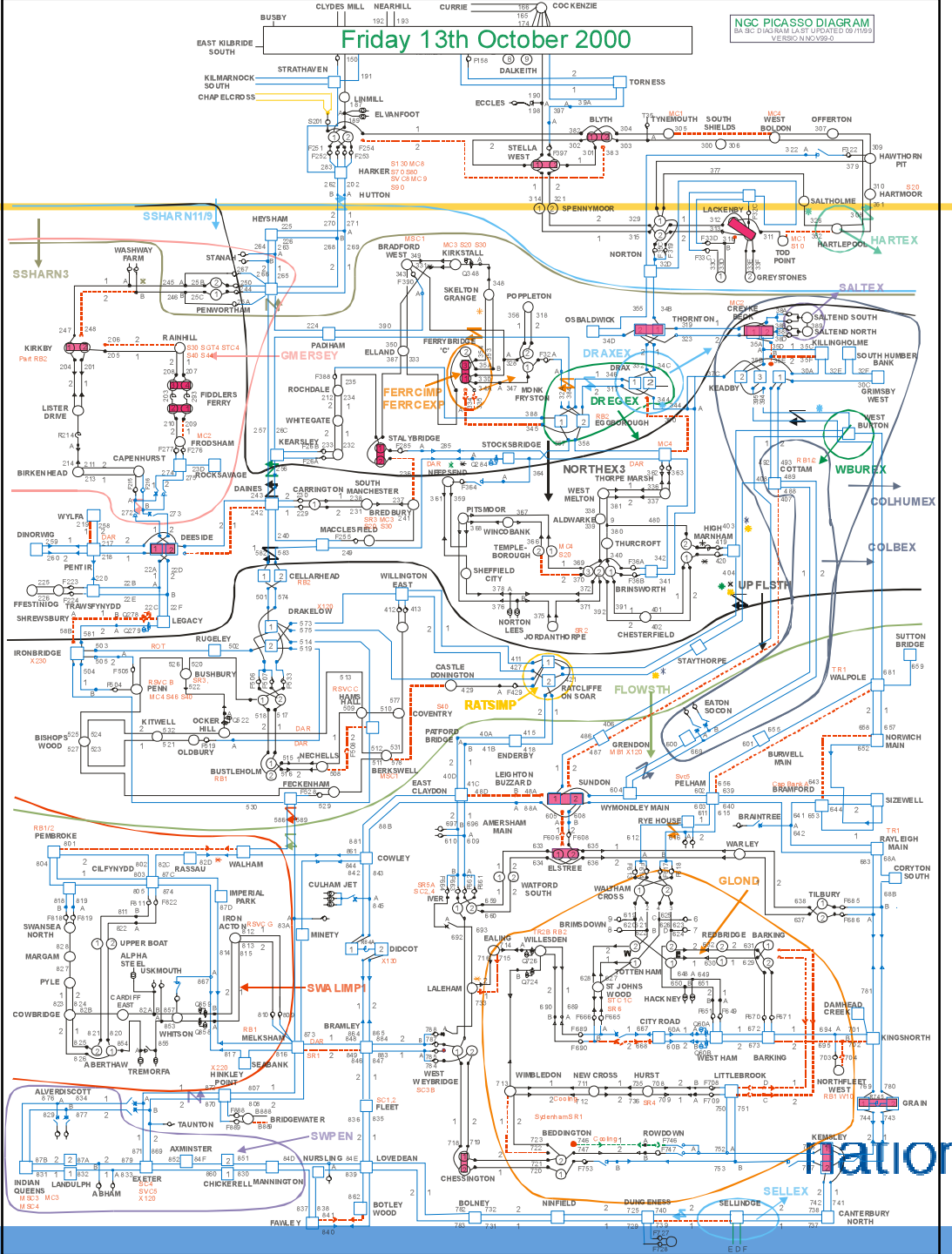
The Picasso



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Picasso detail

Constraint			Outage Circuits					Complimentary Limits				
WESTEX4 (Thermal Export)			None					WESTEX8				
DAYAHEAD LIMIT			CONTROL LIMIT		TAE INITIAL			INC	DEC	% Eff	Assumed Contraint Plant In study	
TIME	MAX	FL	MAX	FL								
05:00	10000					T R I P	1) Kingsnorth - Northfleet East SC					
07:30	5500						2) Kemsley - Littlebrook / Kemsley - Beddington DC	SABA41	BEDW41	18	(2A)	(DP)
2100	10000							DUNC41	FINO41	28	ALL BEDW	ALL BEDW
								MARK41	KOSO41	16	2 FINO	2 FINO
								SABA41	SILB21	14	1 SILB	2 SILB
								SABA41	SILB22	12	500 SELL	1500 SELL
						O L	1) Northfleet East - Singlewell	DUNC41	TELL41	14		
							2) New Cross - Hurst 1	Q724	UP	25		
								Q60A/B	UP	15		
With explected plant all overloads within 6hr ratings												

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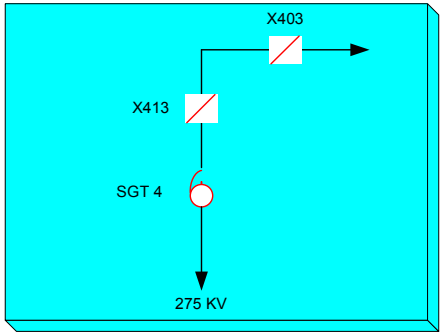
Outage Lifecycle in Control



T- 18hrs

T- 3hrs

T= 0hrs

OPTIMISATION

STRATEGY

REAL TIME

POST EVENT

Server

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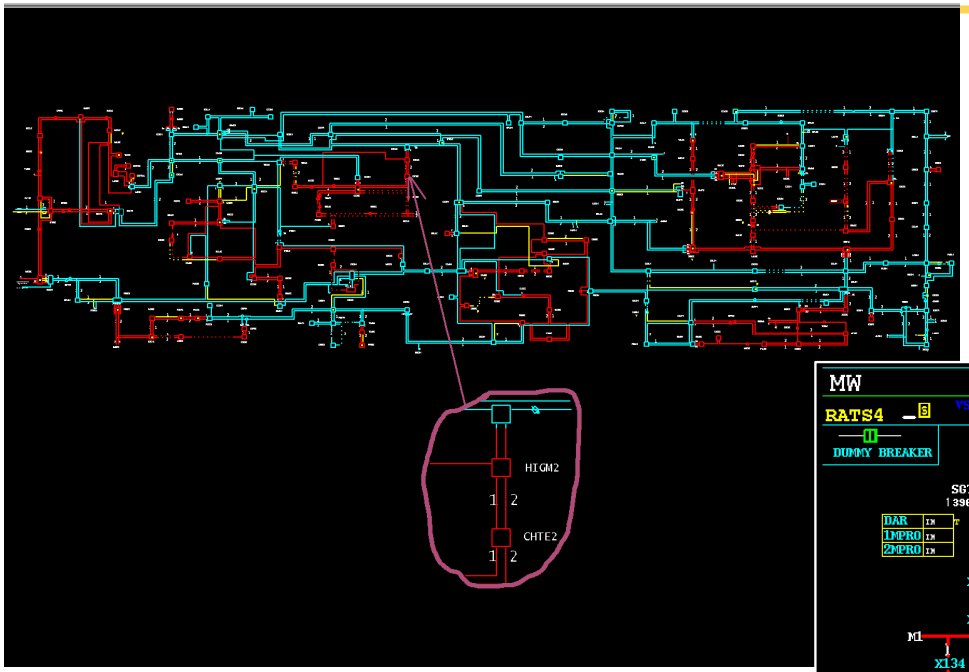
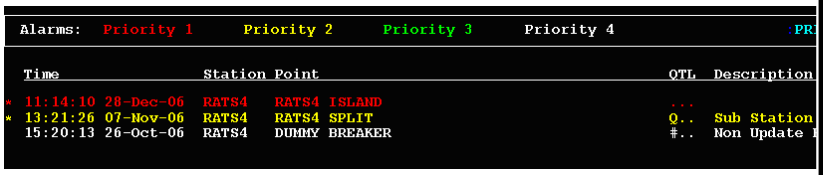
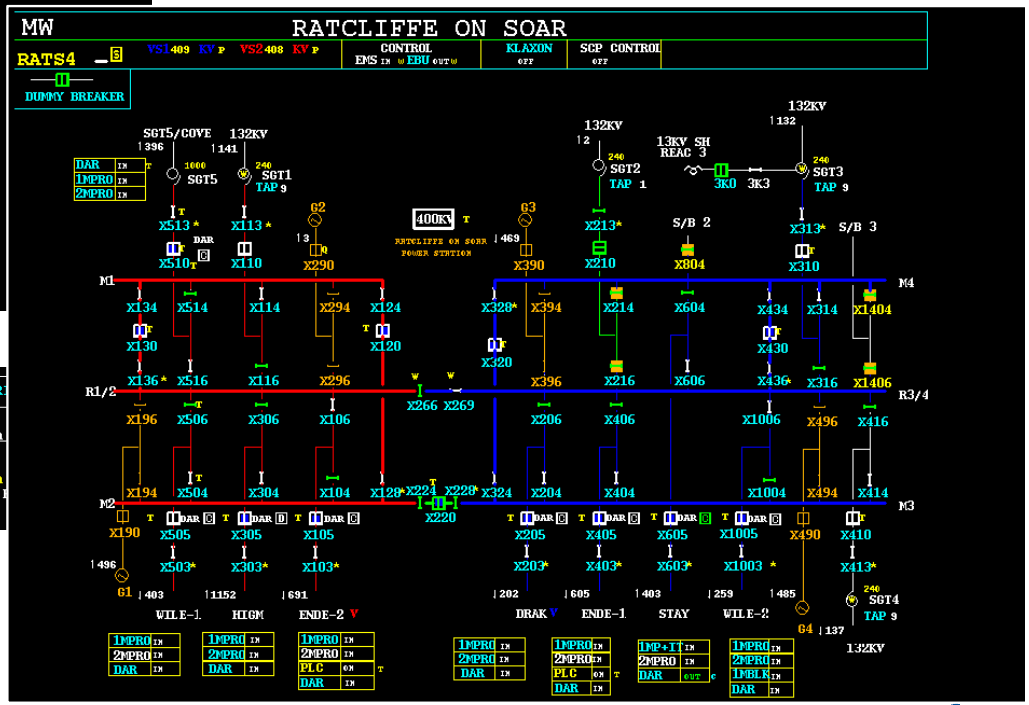
Real time monitoring
Integrated Energy Management System



- 273 outstations,
- 96 consoles,
- 25000 events per day,
- 8000 analogue changes/sec





- 700,000,000 Data points processed daily
- System built by GE in Florida
- Commissioned 2003

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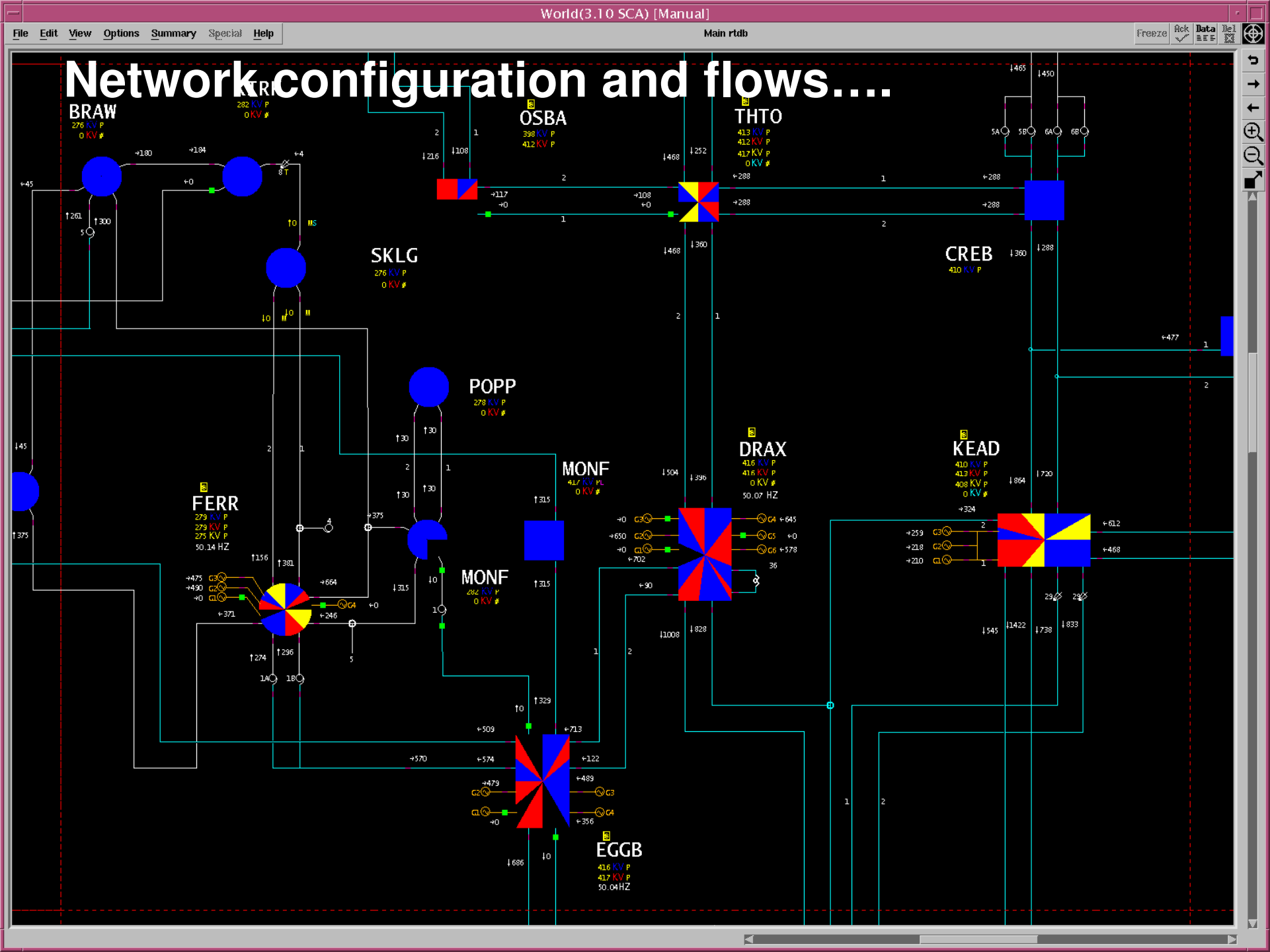
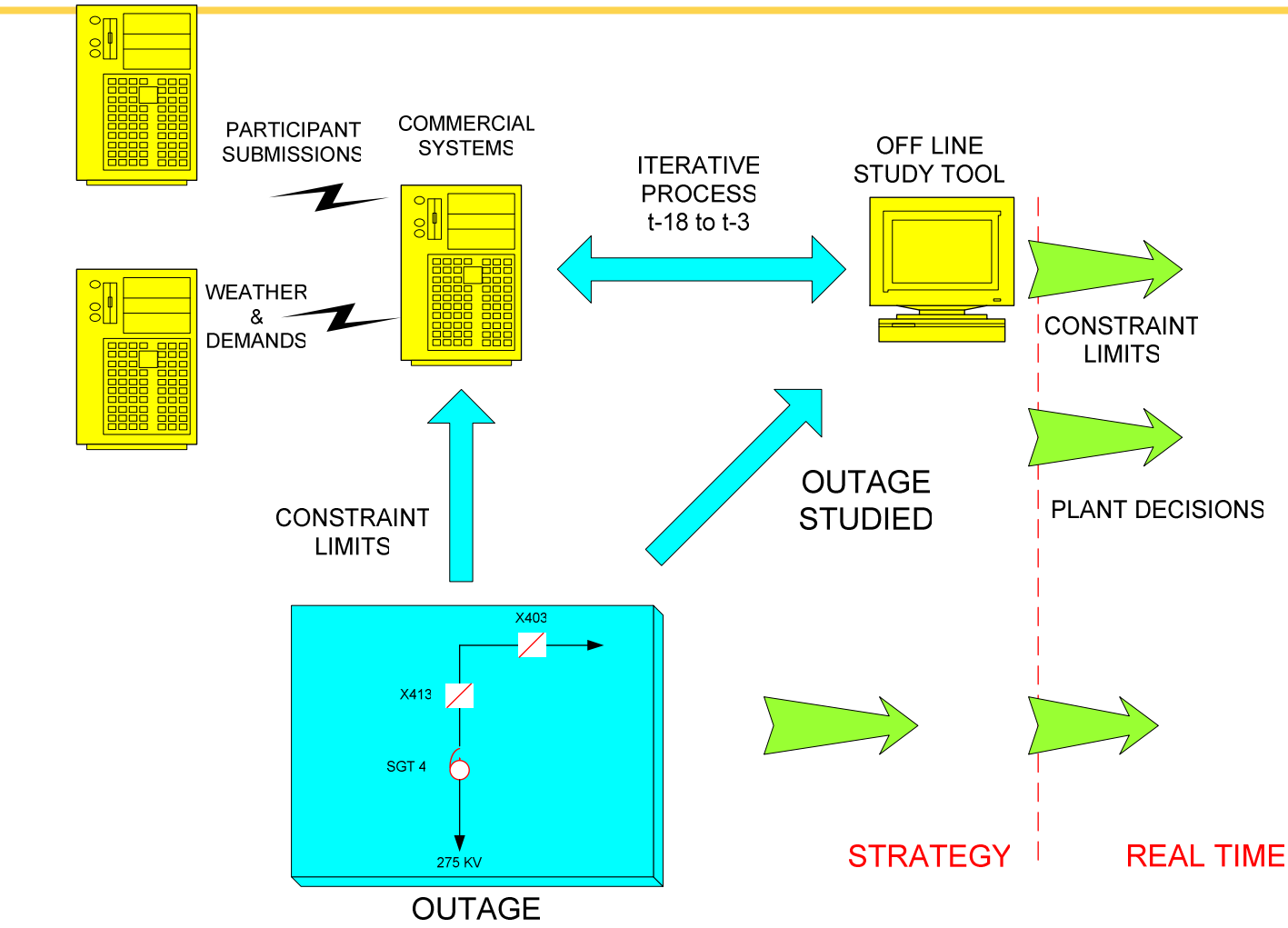

World(3.10 SCA) [Manual]
File Edit View Options Summary Special Help
Main rtdb
Freeze Ack Data Rel
Network configuration and flows....
BRAW
276 KV P
0 KV #
STRI
282 KV P
0 KV #
OSBA
398 KV P
412 KV P
THTO
413 KV P
412 KV P
417 KV P
0 KV #
SKLG
276 KV P
0 KV #
CREB
410 KV P
POPP
278 KV P
0 KV #
MONF
417 KV PL
0 KV #
MONF
282 KV P
0 KV #
DRAX
416 KV P
416 KV P
0 KV #
50.07 HZ
KEAD
410 KV P
413 KV P
408 KV P
0 KV #
FERR
279 KV P
279 KV P
275 KV P
50.14 HZ
EGGB
416 KV P
417 KV P
50.04 HZ

Life of an Outage 2 - Strategy



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Generation uncertainty

- Generation losses, short notice replacement
- Variability of generation due to self despatch under NETA, as little as 60 minutes notice of plant synchronising / de-synchronising
- Interaction between gas and electricity markets
- Energy trading does lead to short notice changes in PN profile
- High volumes of interconnector trades can lead to volatile transfers.

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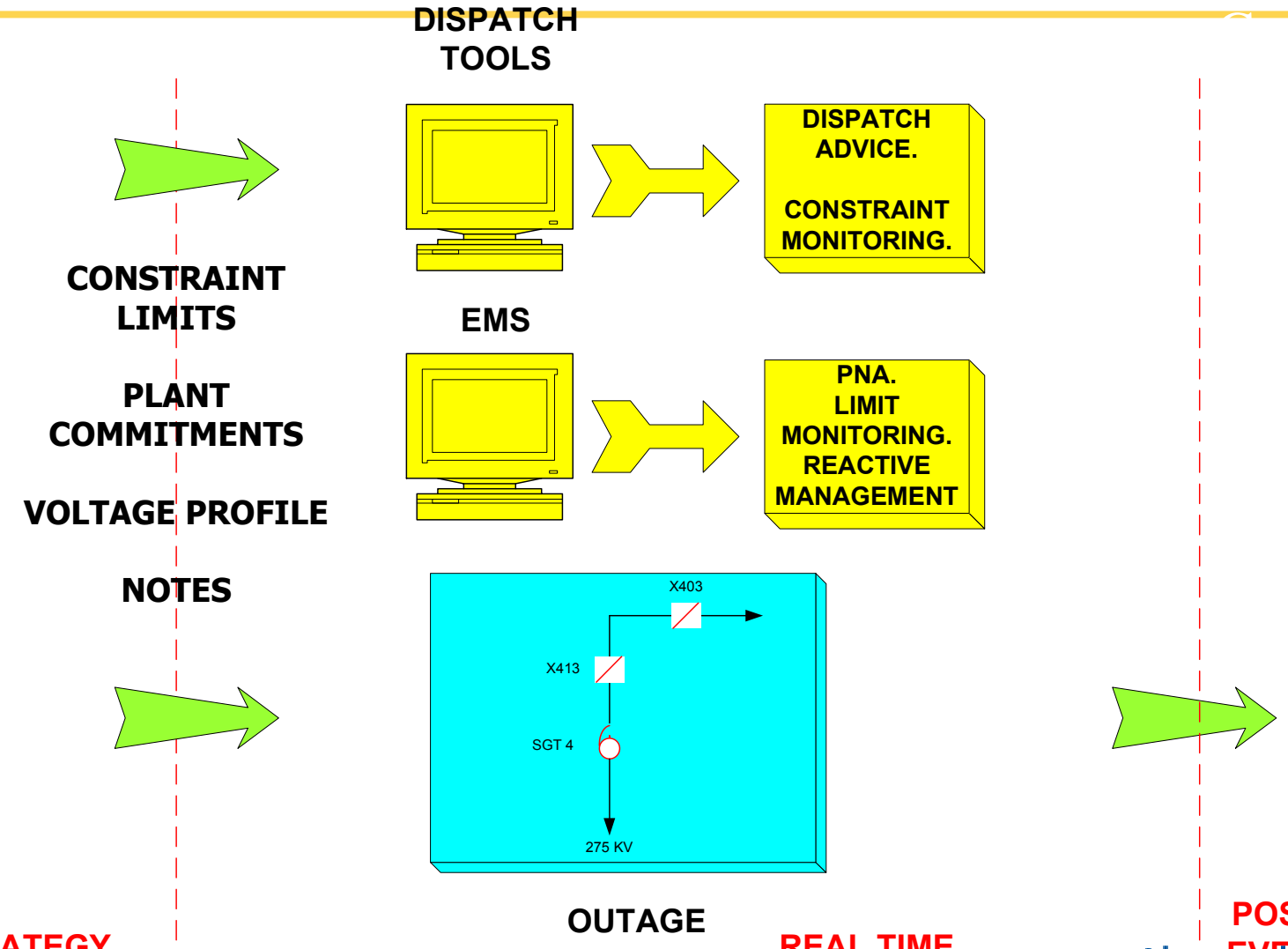
Life of an Outage 3 - Real Time



Real time constraint issues

- Complexity of highly interconnected network
- Variability of circuit ratings
- Geographical distribution of generation and demand
- Network configuration (pre-fault)
- Interaction between Limits
- Pre fault or post fault actions
- Increasing embedded/intermittent generation

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