transition

Moving to a smart future

High Level Design Documentation: Power Systems Analysist (PSA) Tool

October 2022

Scottish & Southern Electricity Networks

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1 INTRODUCTION

1.1 Document Purpose

The purpose of this functional design document is three fold:

- Provide business users with a solution overview
- Provide the build team with adequate information for low level design preparation
- Provide IT support teams with a system overview

1.2 Key Terms

Term	Description
PSA	Power systems analysis
S&D Tool	Select and dispatch tool (S&D)
BAU	Business as usual
OT	Operational technology
RTC	Requirements traceability catalogue
UAT	User acceptance testing

1.3 Management Overview

This section is a high-level management and technical overview of the requirement and the solution, it should be read in conjunction with the other referenced documents if more functional and technical detail is required.

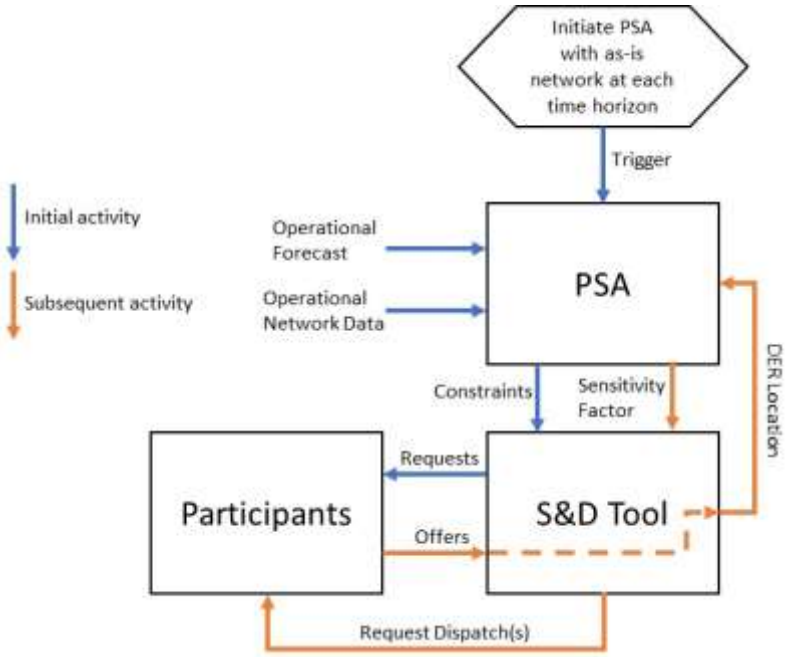
The Power Systems Analysis (PSA) software is part of the solution for the NIC TRANSITION Project Technical Trials which are to take place Q1/Q2 2023. The PSA solution is based around the DigSILENT PowerFactory software product chosen by SSEN as the ongoing Power Flow analysis tool. As an NIC project it will not impact BAU or OT.

The overall solution includes the S&D Tool (Select and Dispatch Tool) combined together to form an alternative solution to the current system being used for trials. The S&D Tool bespoke design and development is being delivered, under contract, by TNEI.

The requirements for PSA are defined in the Requirements Traceability Catalogue and the Context Diagram both referenced earlier in this document.

The goal of the technical trials is to test the end-to-end process/workflow of PSA-driven flexibility procurement, selection and dispatch with PowerFactory as the core PSA software.

Scope and context of PSA in the overall solution



The objectives of the Technical Trials are as follows:

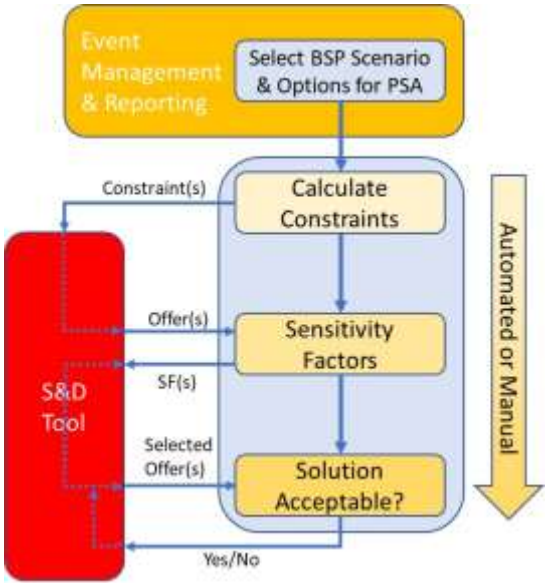
- Testing the end to end process for flexibility by:
    - Incorporating short term operational forecast & topological datasets (PSA)
    - Calculating constraints on the network (PSA)
    - Advertising for offers to resolve constraints (S&D Tool)
    - Receiving and validating offers (S&D Tool)
    - Calculating sensitivity factors (PSA)
    - Assessing offers based on costs and sensitivity factors (S&D Tool)
    - Determining if proposed dispatch(s) reduces overload to zero (PSA)
    - Requesting dispatch(s) (S&D Tool)
- Using these four services:
    - Sustain Peak Management SPM
    - Sustain Peak Export Management SPEM
    - Secure Constraint Management SCM
    - Dynamic (DYN)
- Across these time horizons:
    - Week and day ahead
- Not testing:

- Within day time horizon for procurement process
- MIC/MEC services
- Peer to Peer transactions
- Financial settlement process for Participants (doing but not testing)
- Baselining of measured utilisation data
- Edge cases (events that fall outside of the normal expected behaviour)

The high-level functions of PSA are to identify constraints on the network and translate to flexibility requirements; communicate these to S&D Tool; receive offers from S&D Tool; calculate network sensitivity factors associated with these offers and communicate these to S&D Tool; receive candidate offers from S&D Tool and determine if they resolve the constraint(s) and communicate this to S&D Tool.

These steps can be conducted in an automated process or step by step manual process to gain more insights and understanding.

High level functional processes of PSA and interactions with S&D Tool



PSA will be developed using Python scripts that manage the data inputs/outputs and processing of PowerFactory. There will be a separate graphical user interface (GUI) developed to enable data entry and management of the separate stages of the processes.

The PSA solution includes a Python API interface to retrieve data from NeRDA and SIA.

NeRDA will provide the near real-time status of circuit breakers on the network, SIA will provide the 10-day ahead demand and generation forecast of the network.

These technical areas have been significantly de-risked by already implementing test harnesses for NeRDA, SIA, and PowerFactory.

The scope of the Technical Trials, in terms of network area, has been agreed as:

- Simplified network model:
    - Single BSP (Cowley Local)
    - Single Primary (Rose Hill)
- Scenarios:
    - Base model (Normal running arrangement)
    - Maintenance (Planned outages)
    - Contingency, N-1(s) (Unplanned outages)

This will enable the trials to concentrate on maximising the learnings from the use of PowerFactory as the core power flow calculation engine in a standalone Power Systems Analysis.

2 REQUIREMENTS OVERVIEW

The full functional and non-functional requirements, and the associated context diagram can be found in the referenced documents:

RTC Power Systems Analysis (PF++) FR NFR v1.0.xlsx

SSEN Context Diagram Scope PSA tool v1.0.vsdx

2.1 Functional Requirements

The following requirements were identified through extensive interviews with members of the existing TRANSITION project team. The HLD ID (section ID) enables traceability of original requirements through the design documents.

2.1.1 Identify constraints

ID	Actual Requirement (I want)	Justification (So That)	HLD ID
1.1	To be able to run the process manually	Every process step can be manually triggered	5.2.3
1.2	To be able to run the process automatically	They can be calculated out of normal working hours if required	5.2.3
1.3	To select the BSP	Defines the BASE network model to be used	5.2.3
1.4	To select the service types	Specific services can be included/excluded,	5.2.3
1.5	To select the MAINT spreadsheet (if applicable)	Planned outages can be modelled	5.2.3
1.6	To select the Contingency (N-1) spreadsheet (if applicable)	Unplanned but predefined outages can be modelled	5.2.3
1.6.5	To select the Switch Configuration spreadsheet (if applicable)	Individual switches can be toggled on/off	5.2.3
1.7	To select the SIA forecast	There is a choice of forecast if required	Not Reqd
1.8	To select the time step	There is a choice of time step if required	5.2.3
1.9	To select the leading/lagging power factor	Default is 0.95. Nothing is hard coded in the system	5.2.3
1.10	To select the iteration step used to determine kW value to resolve a constraint	More precise kW values to resolve a constraint can be determined	5.2.3
1.11	To press the button manually to start the calculation	Constraints are identified	5.2.3
1.12	To be prompted when the calculation has finished	Users know when the calculation is finished	5.2.3
1.13	To view the constraints in a single line diagram in heatmap format as a time series (not a single snapshot)	Graphical visualisation of network topology and related % overload (heatmap) gives a better representation of the data, especially over a time series	5.2.3

1.14	To be able to view/edit the constraints data in Excel	Results can be viewed and manual entries made if required	5.2.3
1.15	All data and additional parameters saved	All subsequent calculations use the same data	5.9

2.1.2 Calculate sensitivity factors

ID	Actual Requirement (I want)	Justification (So That)	HLD ID
2.1	To be able to run the process manually	Every process step can be manually triggered	5.2.3
2.2	To be able to run the process automatically	They can be calculated out of normal working hours if required	5.2.3
2.3	To be able to view/edit the input offer data in Excel	Data can be checked and manual entries made if required	5.2.3
2.4	To select to use all time steps or just start and end time for processing	Processing time can be reduced if all time steps not selected	5.2.3
2.5	To select the % step in SF calculation	Processing time can be reduced if larger % step selected	5.2.3
2.6	To press the button manually to start the calculation	Sensitivity factors are calculated	5.2.3
2.7	To be prompted when the calculation has finished	Users know when the calculation is finished	5.2.3
2.8	To be able to view/edit the output sensitivity data in Excel	Results can be viewed	5.2.3
2.9	All data and additional parameters saved	All subsequent calculations use the same data	5.9

2.1.3 Overload reduced to zero

ID	Actual Requirement (I want)	Justification (So That)	HLD ID
3.1	To be able to run the process manually	Every process step can be manually triggered	5.2.3
3.2	To be able to run the process automatically	They can be calculated out of normal working hours if required	5.2.3
3.3	To be able to view/edit the input candidate offer data in Excel	Data can be checked and manual entries made if required	5.2.3
3.4	To press the button manually to start the calculation	Final check that the solution is acceptable	5.2.3
3.5	To be prompted when the calculation has finished	Users know when the calculation is finished	5.2.3
3.6	To be able to view/edit the output results data in Excel	Results can be viewed	5.2.3
3.7	All data and additional parameters saved	All subsequent calculations use the same data	5.9

2.1.4 Data management and reporting

ID	Actual Requirement (I want)	Justification (So That)	HLD ID
4.1	All data inputs to be saved at every stage of the process	Calculations can be repeated	5.9
4.2	All result outputs to be saved at every stage of the process	Outputs from different runs can be compared	5.9
4.3	All inputs and outputs to be stored in human readable form	To enable manual viewing/editing in Excel or similar apps	5.9
4.4	All inputs and outputs to be able to be extracted into CSV/Excel	To enable more detailed analysis/reporting	5.9
4.5	All data to be under configuration control	An audit trail can be provided	5.9

2.1.5 User interface

ID	Actual Requirement (I want)	Justification (So That)	HLD ID
5.1	To have default values for data entry fields	It's quick and easy to run the process	5.2
5.2	To have validation checks on data entry items	Valid data is used in calculations	5.2
5.3	To be able to view/edit input/outputs easily	Data can be checked and manual entries made if required	5.2
5.4	To be able to manually start processes	User can control when the processes start	5.2
5.5	To be informed when a process has completed successfully	User can perform the next steps	5.2
5.6	To be alerted when a process has encountered an error	User can work out what needs to be corrected	5.2

2.2 Non-Functional Requirements

The following non-functional requirements were identified through extensive interviews with members of the existing TRANSITION project team:

ID	NFR Area	NFR Description
NFR 1	**Accessibility**	There is no specific requirement to access the data stored in the database directly. Access through the export of data and subsequent processing in MS Excel is sufficient at this stage
NFR 2	**Usability**	The solution must be easy to use by SSEN staff
NFR 3	**Accuracy and Precision**	The solution should not truncate or round any data

NFR 4	**Data Retention**	The data should be kept after the end of the trials for a period in line with SSEN retention rules
NFR 5	**Security and Data Protection**	The solution must have the ability for SSEN to implement its IT security and data protection rules
NFR 6	**Infrastructure Supportability**	The solution must have the ability for SSE Infrastructure Support to support it.
NFR 7	**User Support**	The solution must have the function to enable user support on an on going basis
NFR8	**Development**	The solution must have the ability for SSEN to implement its development rules
NFR9	**Second Line Support Team**	The solution must have the ability for SSEN 2nd line support to support it.
NFR10	**Backup and Recovery**	The solution must have the ability for SSEN to implement its back up and recovery procedures,
NFR11	**Performance**	The Solution must enable SSEN employees to perform their roles without degradation
NFR12	**Audit Trail**	The solution must have the ability for SSEN to implement its audit requirements/rules
NFR13	**Interoperability**	The solution must have the ability to integrate with existing SSEN systems
NFR14	**Availability**	The Solution must available at all times when SSEN employee need to perform their duties
NFR15	**Scalability**	The solution must be architected in such a manner as to allow it to scale in response to increased usage, throughput, or functionality. Vertical scaling i.e. upgrading existing hardware (memory, CPU, storage, etc.)must first be possible. Furthermore it should be possible to scale horizontally by adding more application or database servers
NFR16	**Maintainability**	The ability of the system design to support phased delivery, and agile development in response to industry changes and developments

2.3 Unsatisfied Requirements

None identified.

2.4 CRICEFW Overview / Solution Inventory

Not applicable.

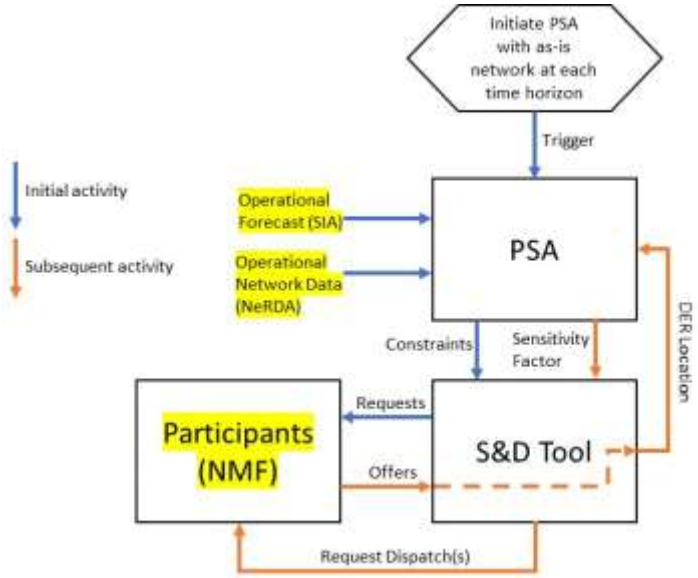
3 OVERALL DESIGN CONCEPT

The following sub-sections provide an overview of the entire design from an application viewpoint. Later sections will break it down by functional area.

3.1 Application Impact Diagram

No existing applications are impacted by this design. The only interfaces to external systems are highlighted in the diagram below:

External interfaces highlighted



The operational forecast is read from SIA using an API, the operational network data is read from NeRDA using an API. The APIs will be accessed using Python. There will be a data file exchange between the S&D Tool and the Participants (shown as the NMF) in this diagram.

3.2 Application Overview

Not applicable.

3.3 Non-Application Requirements

Not applicable.

4 APPLICATION MODEL AND BUSINESS IMPACT

4.1 Application Heat Map

Not applicable.

4.2 Functional Overview

Not applicable.

4.3 Business Impacts

Not applicable.

4.4 Design Decisions and Constraints

Not applicable.

5 APPLICATION FUNCTIONAL COMPONENT DESIGN

The PSA solution consists of five main elements:

- File detector and monitoring
- User interface
- Python scripts
- PowerFactory
- External data interfaces
- Calculate constraints
- Calculate sensitivity factors
- Determine overload reduced to zero
- Data management and reporting

The file detector and monitoring process is the heart of the interface between PSA and S&D, and also the automated background processing of the PSA detecting constraints every 30 minutes (time interval to be confirmed).

The user interface enables users to select network models, input files, enter additional processing parameters and decide if manual or automated processing is required.

The Python scripts provide a processing wrapper around PowerFactory and performs data input and output functions.

PowerFactory performs power flow calculations. In each run to identify constraints PowerFactory will be called a minimum of 336 times (7 days x 48 half hour steps).

Each run will be performed on the BASE scenario, and if selected MAINT and CONT (N-1) scenarios.

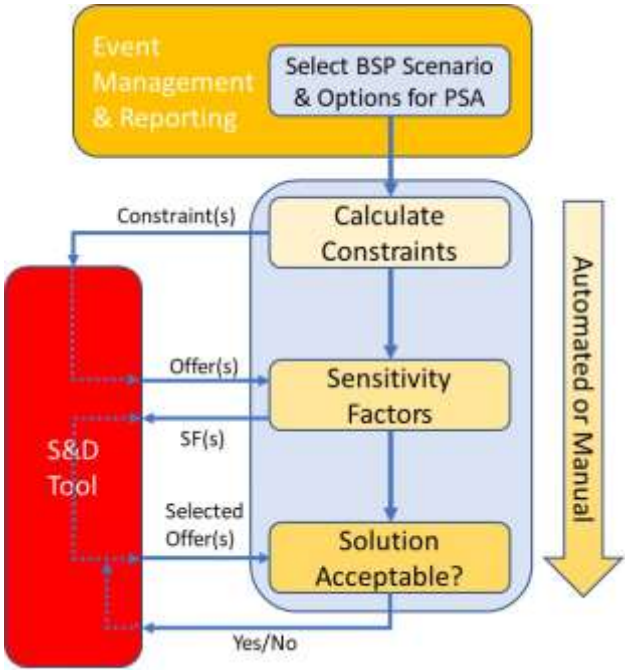
The external data interfaces include API calls to NeRDA (near real-time network status of assets) and SIA (10 day forecast for demand and generation)

The functional areas of the solution are:

- Detect files created by PSA and S&D and initiate appropriate action
- Identify constraints and subsequent flexibility requirements
- Calculate sensitivity factors for candidate offers/contracts received from S&D
- Overload reduced to zero (acceptable solution to resolve the constraint)
- User interface
- Data management and reporting

Where possible HLD IDs have been highlighted and cross referenced back to the RTC requirements ID to aid traceability.

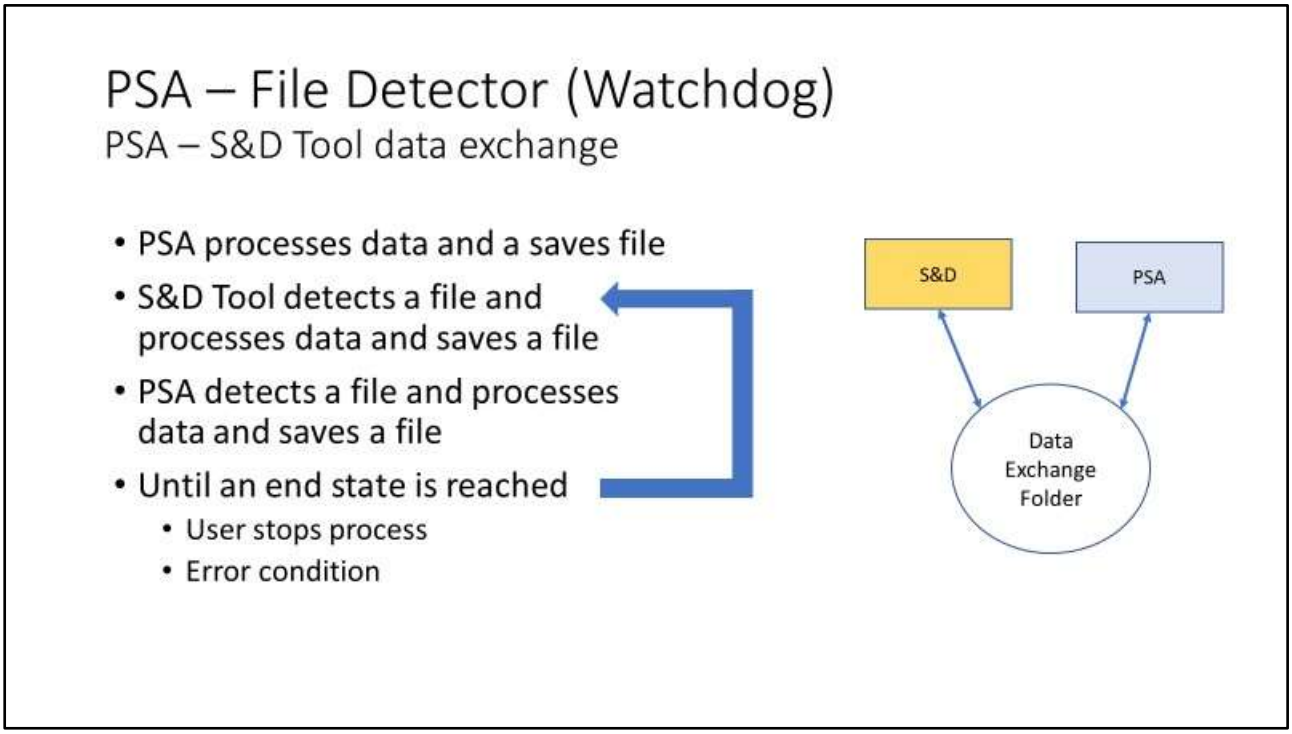
High-level functions of PSA



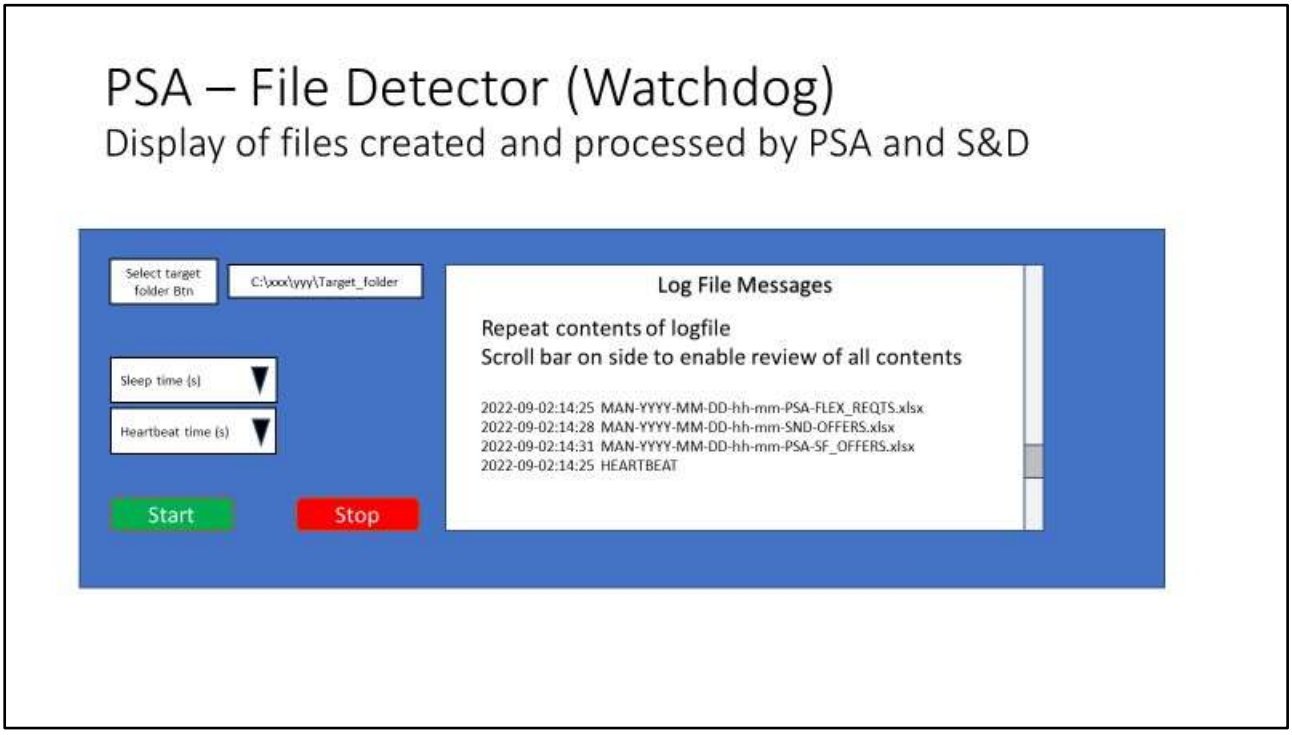
5.1 File Detector and Monitoring

The file detector and monitoring process manages and coordinates the file transfer mechanism between PSA and S&D.

PSA and S&D will share a folder for the outputs of each system for processing as inputs by the other system.



The monitoring process will display all files detected, a heartbeat indicating processing is continuing, and the latest run that has been completed. All outputs on the monitoring screen will include a timestamp.



5.1.1 Folder and file naming

PSA will create a folder based upon the run time and selection of manual or automatic processing, known as the PSArunID:

MAN-YYYY-MM-DD-hh-mm

AUT-YYYY-MM-DD-hh-mm

Files that are created by PSA and S&D will be prefixed by the appropriate PSArunID

Each individual file will be named specifically indicating the type of data it contains and hence the type of processing required by the next system.

Full details of this mechanism will be included in the LLD.

5.2 User Interface Design

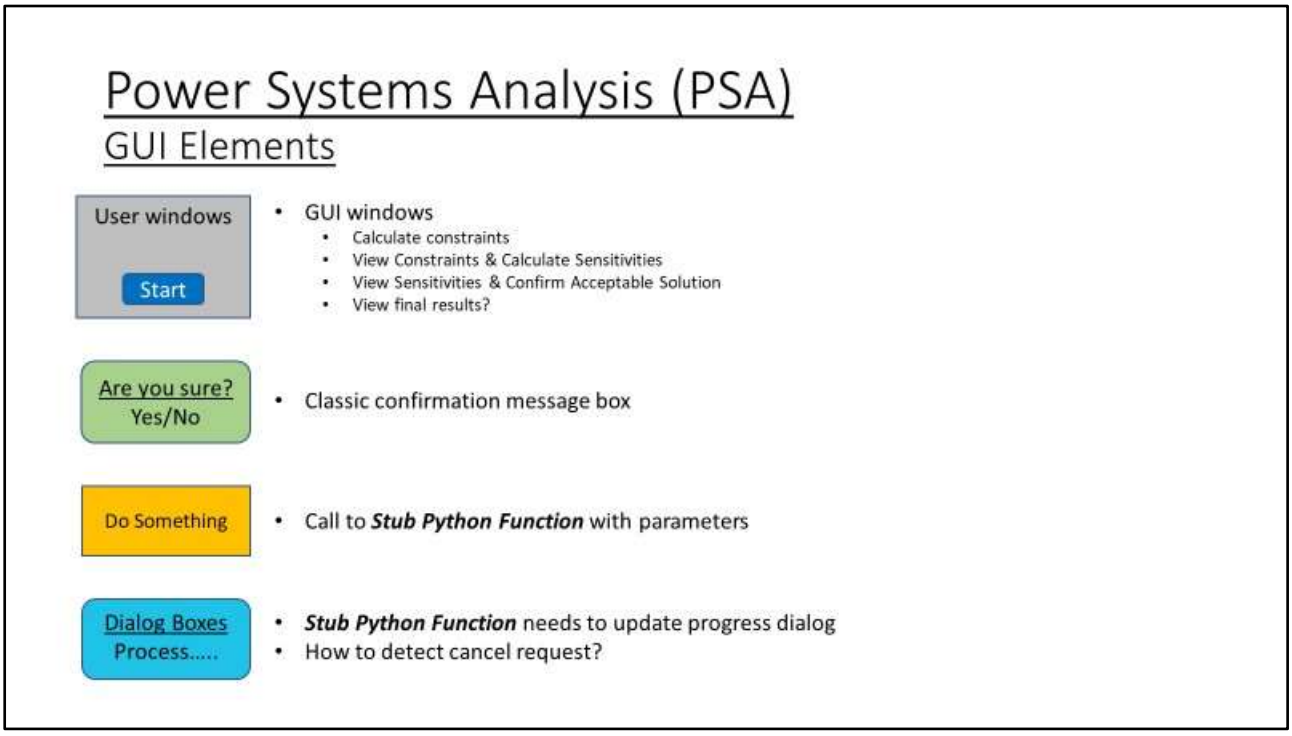
The user interface will be developed in a functional way, as outlined in previous requirements documents. More detail will be provided in the LLD.

The over-arching principles of the user interface are as follows:

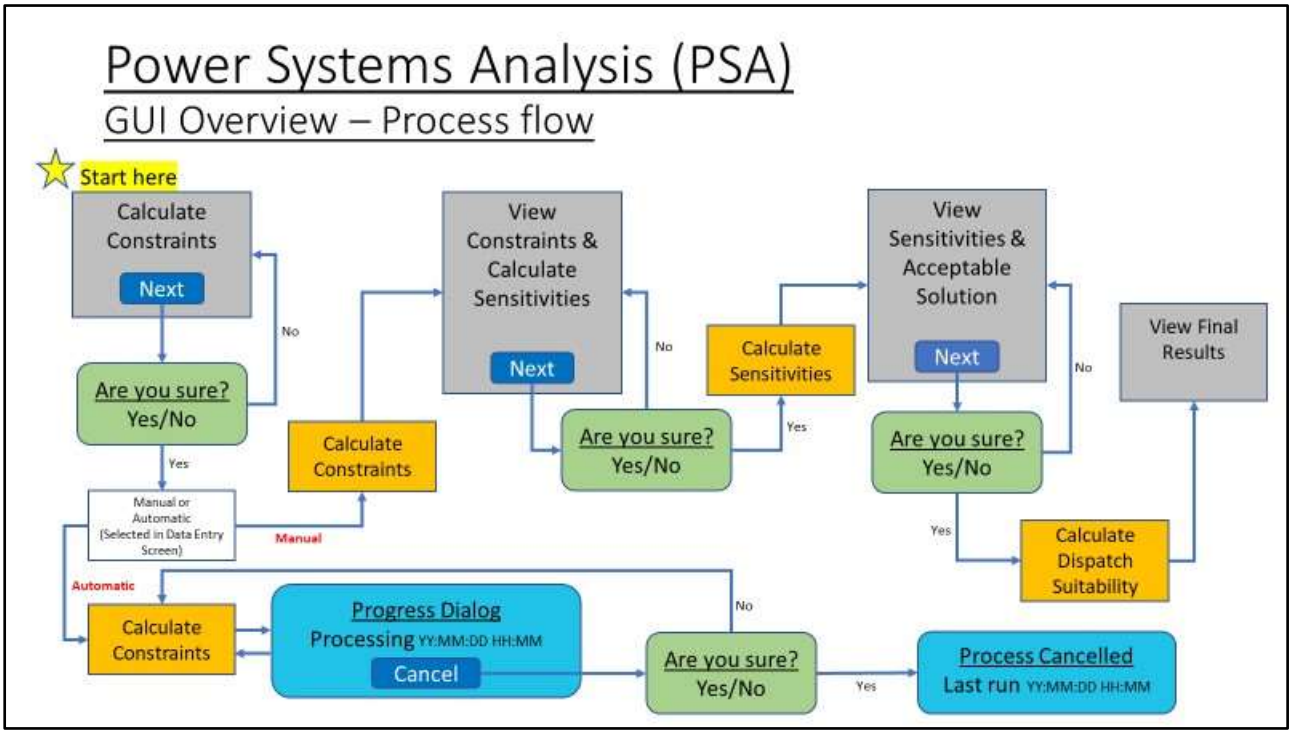
- Simple interface
  - Out of the box look and feel
  - No branding
  - No help files

- Main screens for data entry, subsequent screens and progress dialogs
  - Default values
  - Validation on free text data entry fields
  - Numeric min, max etc
  - Ability to view/edit input files using Excel
- Runs in two modes
  - Manual
    - Three screens for data entry and confirmation of further processing
  - Automatic
    - Runs without any user interaction
    - Progress updates displayed to user
    - Ability to cancel the process (after the current run has completed)

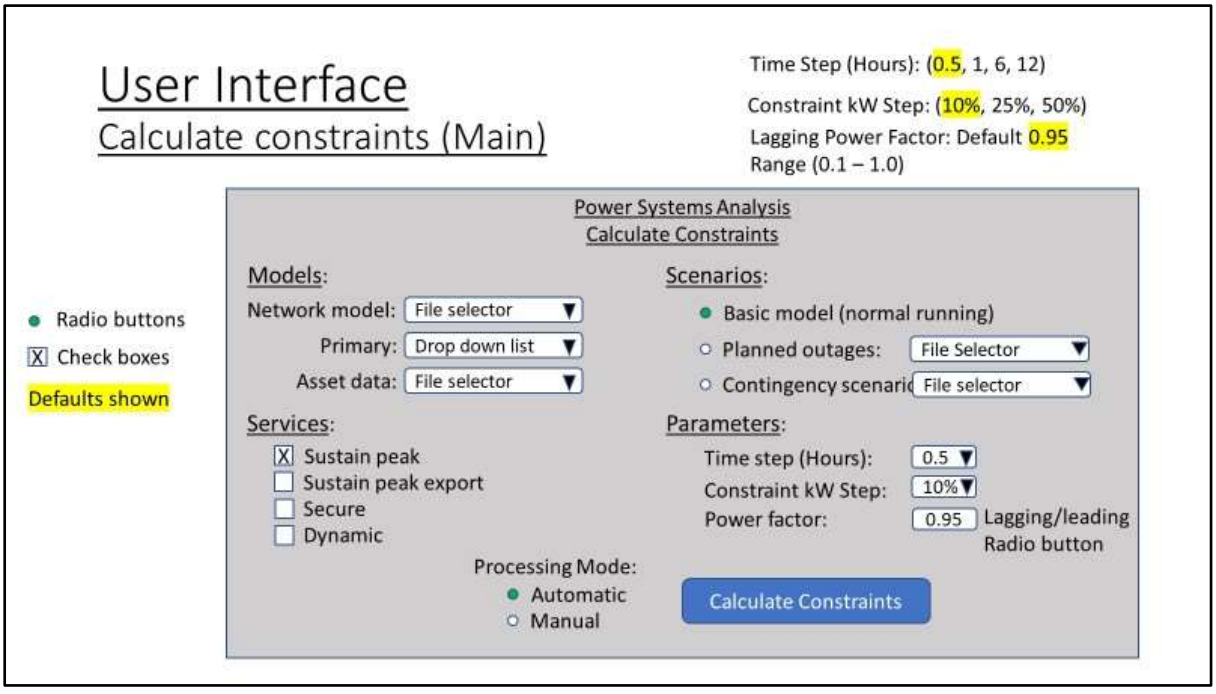
5.2.1 Design elements

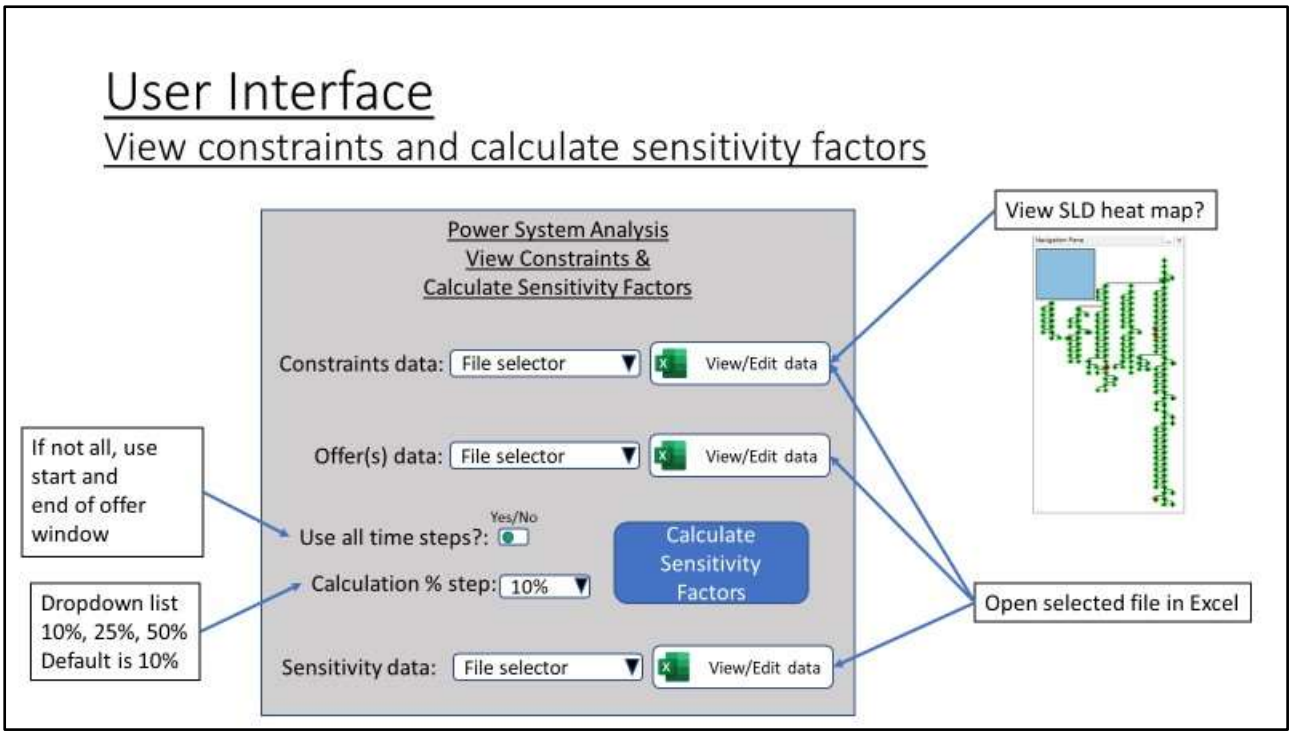


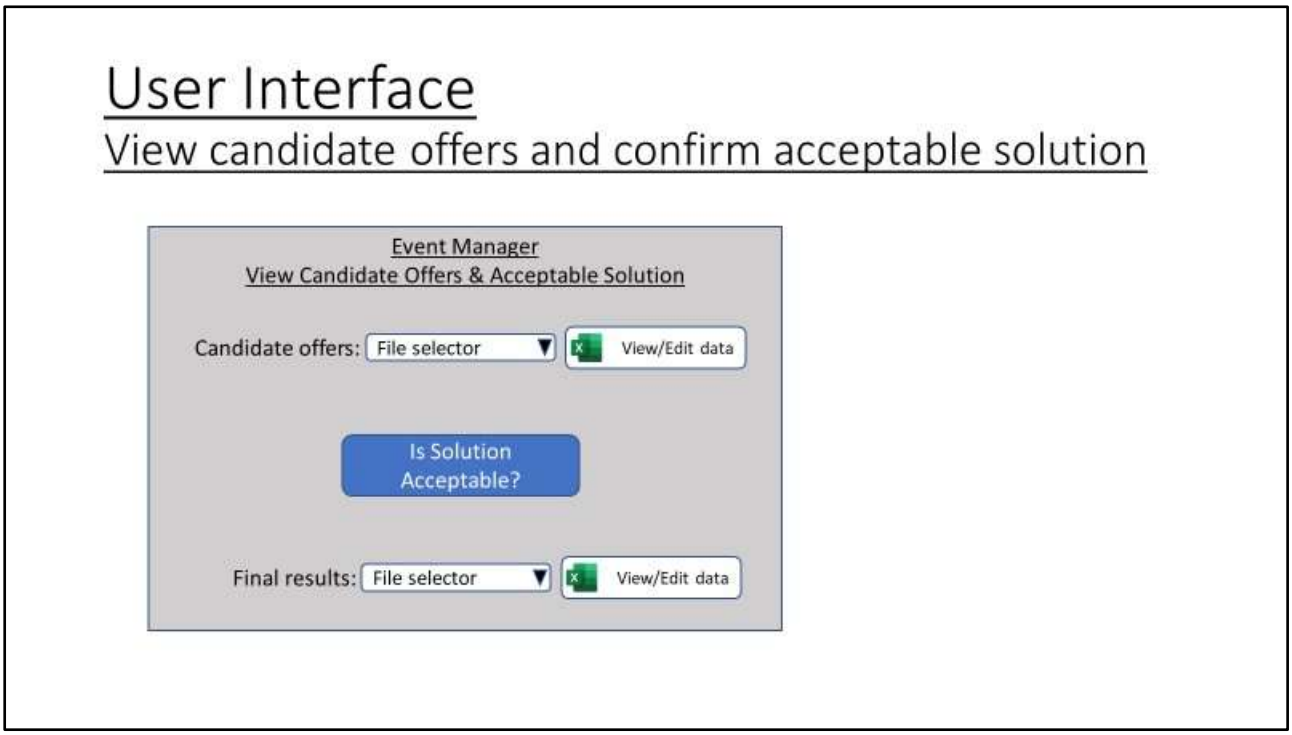
5.2.2 Process flow



5.2.3 Screens (Mock-ups)







5.3 Python Scripts

The script development should use Python 3.7.1 or greater. During development and testing the Anaconda and Jupyter notebook environment is proposed, although Visual Studio Code and a source code configuration control solution (GitBash) is recommended.

5.4 PowerFactory

PowerFactory by DigSilent is the software to be used for performing the power flow calculations. The current installed version in use is 2021 SP7.

5.5 External Interfaces

SIA and NeRDA are the only external interfaces for PSA. Not withstanding S&D as previously stated.

SIA provides a 10 day ahead forecast of generation and demand for assets on the network. PSA will always load the latest data on every processing run.

NeRDA (Near Real-time Data Access) provides the status of assets on the network. PSA will only require the status of switches/circuit breakers.

Both SIA and NeRDA data are accessed via an API from the Python scripts.

SIA and NeRDA user accounts (and passwords) specific to the TRANSITION Technical Trials project will need to be created to enable API access.

5.6 Identify/Calculate Constraints/Flexibility Requirements

SIA provides the 10 day ahead forecast for asset generation and demand, which includes previous actual measurements and temporal effects such as the weather.

NeRDA provides near real-time data on the assets in the network. However, PSA only needs the current circuit breaker status (open, closed, indeterminate).

Planned outages (maintenance) can be modelled by manually creating an outage file in Excel and selecting it via the user interface

Unplanned outages (N-1, contingency scenarios) can be modelled by manually creating an outage file in Excel and selecting it via the user interface.

A %loading value is calculated for each asset, for every time step (default 0.5 hours 30 minutes), for the next 7 days. Each %loading value is stored and output in an Excel file, which can be viewed separately if required.

The results data is checked for each asset, and if that asset has a %loading factor greater or equal to its individual %loading maximum parameter then it indicates a constraint for that day and time period.

Intermediate outputs as an Excel workbook containing the %loading values can be created if required.

The constraints are then converted into a flexibility requirement that determines how much power is required to be injected at a point on the network at a specific time and for a specific duration to resolve the constraint to an acceptable level.

The final output is a single Excel spreadsheet containing each individual flexibility requirement PSA-FLEX_REQTS

If no constraints are detected, and hence no flexibility requirements, then a PSA-NO_FLEX_REQTS file is created to signify that that run has completed and no flexibility requirements were detected.

5.7 Calculate Sensitivity Factors (SFs)

S&D processes the FLEX_REQTS output from PSA and requests offers from participants.

S&D receives offers from participants, these offers are initially checked by S&D and "valid" offers are passed to PSA to have SFs calculated. The detailed calculation of the SFs and the specific data passed back to S&D will be defined in the LLD.

In addition, just prior to dispatch, S&D will pass "CANDIDATE" contracts to PSA for final calculation of SFs as part of the final confirmation process to confirm the solution is acceptable.

5.8 Overload Reduced to Zero

This is the process to determine if a set of "CANDIDATE" offers/contracts are able to resolve any constraints on the network. The detailed determination of the constraint resolution and the specific data passed back to S&D will be defined in the LLD.

If the set of "CANDIDATE" offers/contracts are not acceptable then they are returned as "FAILED", otherwise "APPROVED".

5.9 Data Management & Reporting

All data files used by PSA will be stored in the folder defined by the PSArunID, this includes those created as outputs by PSA for inputs to S&D and those created by S&D as inputs for PSA.

A number of intermediary output files will also be created to provide visibility to the users of the data used and results created in PF load flow calculations. These will include the SIA and NeRDA data extracts.

Reports will be able to be generated from the outputs from PSA and S&D. Details of these will be included in the LLD.

6 DESIGN RAIDs

6.1 Risks

Describe here any risks which might prevent the successful delivery of the proposed solution or have an adverse impact on existing IT or business operations. Include a note of the Project Risk number if the risk has also been raised against the project.

The description of the risk should begin "There is a risk that……" to ensure that the actual risk is clearly identified.

Risk ID	Area	Description of Risk	Mitigation
?	PowerFactory	Single PF instance not able to cope with the level of processing required	Purchase multiple concurrent licences
?	PowerFactory	Install of PF is less than optimal and incurs unforeseen issues in a networked environment	Lesson learned from BAU project and consultancy days from DigSilent to assist
?	Scope creep	New or enhanced requirements requested after completion of the LLD and code development well established	Will be assessed on a case by case basis. However, default response will be NO, unless it seriously impacts the running of the trials.
?	PSA/S&D interface	Disconnect between PSA and S&D on the syntax and/or semantics of the data exchange	Well defined and documented interface specs with example file formats and meanings of the data

6.2 Assumptions

This section should show any assumptions that were made, but could not be verified, during the design phase. Include a note of the Project Assumption number if the assumption has also been raised against the project.

Assumption ID	Area	Description of Assumption
?	PowerFactory	PF allows parallel running to assist in performance issues

6.3 Issues

Include any unresolved issues which may impact the successful delivery of the solution. Include a note of the Project Issue number if the issue has also been raised against the project.

Issue ID	Area	Description of Issue
	None	

6.4 Dependencies

Describe here any dependencies which may impact the successful delivery of the proposed solution on time, with details of any containment plan. List anything on which the success of this development depends. This might include:

- *Dependencies on other projects being implemented*
- *Dependency on the availability of source data*
- *Dependencies on critical development skills*

Include a note of the Project Dependency number if the dependency has also been raised against the project.

Dependency ID	Area	Description of Dependency
?	Infrastructure and software availability	HCL timescales for standing up suitable hardware and software environment.

*** End of Document ***