Contingency Analysis – Future (advanced)

1 Descriptions of Function

All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work should be so noted.

1.1 Function Name

Contingency Analysis – Future (advanced)

1.2 Function ID

IECSA identification number of the function

G-4.4,G-4.5,G-4.6,G-5.9.2,G-5.9.3,G-5.9.4

1.3 Brief Description

Describe briefly the scope, objectives, and rationale of the Function.

In layman's terms, Contingency Analysis (CA) is a "what if" scenario simulator that evaluates, provides and prioritizes the impacts on an electric power system when problems occur. A contingency is the loss or failure of a small part of the power system (e.g. a transmission line), or the loss/failure of individual equipment such as a generator or transformer. This is also called an unplanned "outage". Contingency analysis is a computer application that uses a simulated model of the power system, to:

- evaluate the effects, and
- calculate any overloads,

resulting from each outage event.

Contingency Analysis is essentially a "preview" analysis tool. It simulates and quantifies the results of problems that could occur in the power system in the immediate future.

CA is used as a study tool for the off-line analysis of contingency events, and as an on-line tool to show operators what would be the effects of future outages. This allows operators to be better prepared to react to outages by using pre-planned recovery scenarios.

Future CA as described in this use case template is an enhanced application that takes advantage of the improved communications architecture being defined by IECSA for the future. It will use wide area data and other data to improve its reliability, and to analyze power system security (safe and stable operation) for a wide operating region. Future CA will also incorporate intelligence features to resolve execution problems by using its knowledge base of previous experience in solving difficult situations.

1.4 Narrative

A complete narrative of the Function from a Domain Expert's point of view, describing what occurs when, why, how, and under what conditions. This will be a separate document, but will act as the basis for identifying the Steps in Section 2.

Note: This narrative assumes that the reader has already reviewed the use case template for Contingency Analysis – Baseline (current usage), and is therefore familiar with the terminology and the functions of this application for power system security analysis.

1.4.1 Introduction

Contingency analysis (CA) is an Energy Management System (EMS) application that analyzes the security (i.e. the safe and stable operation) of a power system. It calculates, identifies and prioritizes the:

- current and power flow overloads in equipment,
- voltage violations at buses, and
- some system stability problems

that would occur if contingency events (i.e. equipment failures or outages) happen in the future. Contingency analysis simulates the effects of removing equipment, one by one, and calculates the results using a model of the power system. CA is essentially a "what if" problem identification tool that is used for off-line studies by system planners and outage schedulers, and for on-line support by system operators.

This narrative describes an advanced contingency analysis application ("Future CA") that can be achieved in the near future, possibly before 2010. This application will have features and performance that together address some of the CA shortcomings that are reviewed in the narrative for today's CA of 2004. For details of these deficiencies, refer to the use case template for Contingency Analysis – Baseline.

Some of these CA shortcomings (and therefore its requirements) can be addressed with an improved communications architecture, which will support the use of more, more frequent, higher quality, and wider-area data. This will enhance CA to form one of the tools necessary for the future "self-healing grid" that the IECSA project is helping to define.

In the list below, the CA shortcomings that are candidates for significant or partial improvement due to an advanced communications architecture are marked with an asterisk (*).

Problems that exist in many current implementations of Contingency Analysis include:

(a) Lack of Reliability and Robustness in the CA solution "engine" (* partial)

(b) Usability – difficult to set up and use CA (* partial)

(c) Difficult for users to interpret the avalanche of numeric CA results

(d) Restricted visibility - not always a "wide area" or regional solution, and does not always "see" accurate topology (*)

(e) Few or no remedial action suggestions for operators (* partial)

(f) Slow performance

(g) No intelligence or learning from previous cases (* partial)

(h) Relatively isolated application, no links with Equipment Condition Monitoring or Phase Angle telemetry (*)

(i) Rarely coupled with the SystemOperator Training Simulator (* partial)

This use case template for Future CA will focus on the CA improvements that will come from using a communications architecture that is being defined in the IECSA project. This advanced architecture is a prerequisite for building the integrated tools that are needed to achieve a self-healing grid.

1.4.2 Future CA improvements

<u>1.4.2.1 Wide area CA and requirements</u>

The Future CA will be improved by the use of an advanced communications architecture that supports the considerably increased acquisition, sharing and exchange of information and data among utilities, ISOs, and RTOs. This will allow the exchange of the extensive data needed for input to a "wide area network model" which can essentially be common to all participants.

Each utility can then have a "view" of a wide area that extends beyond its service area into a larger control area, or a complete operating region. The contingency analysis will therefore be able to show and quantify the effects of contingency events that may occur outside each utility's immediate service area, but that can affect the local operating conditions.

The size of this network model, and the corresponding data and contingency events requirements for wide area CA, will be typically 10 times those of the current baseline CA. Targets include a model size of 20,000 buses, supported by 50,000 data points, and screening 10,000 contingencies.

The communications architecture must also provide very fast acquisition of this extensive data from its many widespread sources (collection target within 10 seconds) while ensuring the time coherency of the data ("skew" target within 5 seconds). The referential integrity of data with its source, quality, time and other attributes must be preserved during its acquisition and possibly afterwards for storage.

Wide area CA will require much higher performance than baseline CA so that contingency analysis runs essentially in real time, even with the wide area network model. The target will be to provide CA results for the most severe contingencies every 20 seconds, which is necessary for its effective on-line use by operators.

A wide area CA will make possible (and essential) the coordination of regional remedial actions by each utility, for mutual security benefits. Studies can be performed on the most likely and most serious contingencies over a wide area, to identify and test the best recovery scenarios. Then remedial action "scripts" can be prepared and used in a coordinated mode by each utility, based on the wide area simulation. In some conditions coordinated remedial actions over a wide area may be more effective than local actions, to maintain overall power system security and stability.

Regional authorities such as ISOs already employ a basic form of wide area CA. The Midwest ISO (MISO) uses a very large network model (over 30,000 buses), based on wide area data (over 80,000 data points) obtained through several Inter Control Center Protocol (ICCP) data links. This MISO CA performs reasonably fast studies of wide area power system security, for operations support. It executes less frequently than the State Estimator, which typically runs every 5 minutes, according to the Interim Report on the August 2003 Blackout. However it is a significant step toward the wide area CA of the future, because it allows the CA to "see" and evaluate contingency effects over a very large operating region.

Wide area CA will therefore require significant improvements in data gathering capability from many sources, and in data exchange among all the utilities in a region. Additional needs include fast performance, tight time coherency and data integrity. These requirements can be met with an advanced communications architecture.

Wide area CA will be an improvement over the current baseline CA that has restricted visibility of power system contingency effects throughout an operating region. This is one of the operational problems described in the Interim Report on the August 2003 Blackout.

1.4.2.2 CA with improved topology data ("deeper CA")

The CA algorithm works best (i.e. does not have problems solving) when:

- the network model is correct (i.e. the model represents the real connectivity or topology of power system equipment), and

- it uses accurate base case data for that model (for a current "now" CA study, usually the State Estimator results are the most dependable).

Problems occur when the network model is different from the real-world power system. This can be caused by incorrect topology being reported (due to transducer wiring errors, or incorrect status is manually entered or reported by phone from the field) or being deduced from SCADA data. In this case the network model and the initial base case data do not match properly, and CA may encounter problems such as failing to solve. Experts can usually fix the problem by adjusting the model or its data, but this takes time - often many minutes, and sometimes hours. Then CA loses its relevance as an on-line tool for operators.

But better topology data is often available, which could be used by CA. In many power utilities that use hierarchical control centers, the Energy Management System (EMS) where the CA executes does not "see" all the sub-transmission and distribution SCADA data that the regional or distribution control centers have available from the substations and field. Only a subset of the field data (from the higher voltage part of the system) is sent to the EMS, either reported from its own RTUs, or more typically sent using separate "EMS" scan maps within multi-purpose RTUs. The majority of the field data is sent to other lower level monitoring and control systems such as regional and distribution SCADA.

However this lower level field data contains valuable information that can be used by the EMS to correctly deduce or confirm the connectivity and status of substation and other field equipment, essentially by a "local estimation" or by using a simple set of rules.

When more of the sub-transmission and distribution SCADA data is available for use in a topology estimator or connectivity validation tool, then the "deeper" CA will benefit from using a valid network model, and will be more reliable. An advanced communications architecture will provide this additional data for improved topology. This addresses another of the operational problems that are described in the Interim Report on the August 2003 Blackout.

1.4.2.3 CA with access to alternate and wide area data

The CA algorithm sometimes fails to solve, because of faulty or missing data, or an incorrect network model. Typical problems include:

- Use of manually-entered data (sometimes obtained by phone from a neighboring utility) that is incorrect or incorrectly entered,
- Use of telemetered data that is inaccurate or invalid, or
- Incorrect assumptions about the operating status of equipment (such as transmission lines or generators) at the boundary of a utility's service area.

The improved communications architecture can be used to provide a wider range of data from other utilities, which the Future CA will use to become more robust and accurate. With a wider range of data available, some of it being obtained from alternate sources outside the local operating area, the CA application and user have access to the data that "best fits" the situation under study. The CA user will choose the best data for the situation, and can either select it or manually enter it for use during the set up procedure.

With an advanced communications architecture providing additional and redundant "checkpoint" data to CA, the application can be enhanced to automatically choose the correct data for dependable solutions (see the next section for "intelligent CA").

The availability of alternate and a wider range of data (from the boundary of a utility and from other utilities in the region) will therefore improve the ability of CA to work reliably, to provide solutions in unusual cases.

1.4.2.4 CA using special data (condition monitoring and phase angle measurements)

Although utilities are increasing their use of equipment condition monitoring data for asset management and maintenance planning, this data is rarely used in system operations or security assessment. Future CA will use equipment condition data to:

- Provide condition-based operating limits for major power system equipment (such as transformers, transmission lines, series compensators, and inductors);
- Initiate contingency analysis studies as part of the equipment outage planning and scheduling process;
- Integrate equipment condition data and contingency analysis in the reliability based maintenance process.

With improved transducers and very tight time synchronization (approaching a few milliseconds in current utility tests at Bonneville Power and SRP), transmission line phase angle measurements within utilities and over wide areas are starting to be used to show pending power system stability problems. Future CA will use these phase angle measurements to initiate contingency analysis in its on-line mode, so that operators can see potential problems as they are developing.

When phase angle indicators of potential problems (power angle "twist" approaching stability limits) are combined with the Future CA capabilities, remedial actions will be suggested for operators, or in some cases they will be automatically executed, similar to load and generation shedding schemes.

1.4.2.5 CA with remedial action

Future CA will make use of the advanced communications architecture to become more of a "closed loop" application. In addition to:

- acquiring and using data from wider, deeper, alternate and special sources, and
- providing warnings and alarms for potential problem situations for future contingency events,

it will provide remedial action plans as part of the CA results. Operators will use these to "move" the power system away from exposure to insecure (due to overloads and violations) or unstable conditions, which the contingency analysis shows for possible outages in the system.

SystemOperator can perform these remedial actions, but in some cases they will be executed automatically using the control capabilities of the data acquisition and control (DAC) application. The advanced communications architecture will provide access to the field equipment and control devices; however in most situations remedial actions will be routed through DAC to avoid conflicts.

For wide area and regional operations, remedial actions will need to be coordinated among the participating utilities and reliability organizations. With proper coordination and planning, Future CA can send remedial action control outputs directly to field equipment and automatic systems, similar to the load shedding and generation dumping schemes used currently.

1.4.2.6 Additional "intelligence" features for CA

The Future CA can be enhanced with the ability to "look for the best source" data that will allow it to resolve problem situations. The application can use the communications architecture to interrogate alternate sources and actively find better data from the wider range available, both inside and outside the utility.

Future CA will also be able to check a stored library of previous studies and solutions, to identify similar situations to the current study being performed. This "knowledge base" library will include previous "fixes" applied by specialists for problem cases that did not solve without adjustments.

Future CA will use its knowledge base to assist the user (using prompts or assumptions) with the set up procedures and definition of the input data, network model adjustments, contingency lists and execution parameters.

In case of problems with the network model, or if the input data does not match the model, Future CA can exercise its "intelligence" by:

- finding and suggesting the best data to use from alternate sources, or
- checking its knowledge base and suggesting changes to the model or input data.

These changes or fixes can be quickly tried in a user-prompted or "self-healing" mode, so that CA guides itself toward a solution while alerting the user about the decisions it has made. An audit trail with the decision logic and choices will be maintained as part of the solution mechanism. As CA gains experience in resolving problem situations, it will be able to provide to users a confidence factor for its solutions. In this way raw data (from alternate sources and about the guided solution process) is transformed into useful information, and becomes part of the knowledge base.

These "intelligent" features of CA - the ability to find better data, and to learn from and use its previous solution experience - will improve its reliability and usability as an on-line operations tool. The intelligence features of Future CA form a significant enhancement to current baseline CA, and make it a key component of the self-healing grid of the future.

1.4.2.7 CA coupled with the SystemOperator Training Simulator

In most current implementations, contingency analysis works separately (and often remotely) from the SystemOperator Training Simulator. When operating situations and contingency analysis cases/solutions are encountered that would be useful as training scenarios for operators, there are often no tools (or cumbersome tools) to transfer these cases to the Training Simulator.

The advanced communications architecture will include the capability for quick and easy transfer of cases from Future CA to SystemOperator Training Simulators. Tools for standardizing the case descriptions, data formats and input requirements will be needed for "feeding" Training Simulator applications from various suppliers.

Future CA will therefore be a source of challenging cases to be used for improved training for operators. This is another step toward the self-healing grid.

1.4.2.8 Future CA – prerequisites and outstanding issues

There are several prerequisites and issues that should be examined in more detail and resolved for the successful implementation of Future CA, considering its wide area capability and other improvements. These include:

- Apply and benefit from the experience with the basic wide area CA as already implemented at ISOs and RTOs in their function as area and regional reliability coordinators;
- Significant work and tools will be needed to develop and support the wide area network model, its frequent changes, and its parameters;
- Methods must be developed to collect the necessary data from many sources (participating utilities and regional authorities), and "feed" a wide area CA, fast enough (collection target within 10 seconds) to support its on-line use by operators;

- Significant work and tools will be needed to acquire and exchange data in common formats, requiring data conversion and re-mapping among different EnergyManagementSystems, data sources and applications;
- Uniform data access methods will be needed for all types of data, for ease of use;
- High performance needs - wide area CA should execute fast enough (solution target every 20 seconds) to be used for on-line operations support as well as for off-line studies;
- Performance may need to be enhanced by using a reduced wide area network model, that still contains enough detail to provide useful information;
- Data coherence and time synchronization needs (time skew) – the wide area data should be time synchronized (target within 5 seconds) so that the network model uses coherent data;
- Time synchronization needs for special data - phase angle measurements across an operating region must be very tightly synchronized (within a few milliseconds) to be useful;
- Data integrity – the CA input data and its attributes (source, quality, time stamp, etc.) must be preserved throughout the process, and (perhaps) afterward for storage
- Older RTU technology, field devices and communications technology currently used by utilities are limitations that will slow down data gathering to the "lowest common denominator" until they are upgraded;
- Several types of data must be gathered and shared among utilities, including the network model and parameters, initial base case set up data, real-time measurements, State Estimator solutions, special data, manually entered data, and the Future CA results including remedial action plans;
- Storage and archiving – the requirements for short-term storage and historical archiving of Future CA cases, including large data files, should be considered within the communications architecture;
- Work will be needed to develop coordinated remedial action plans for the most serious contingencies, for joint execution by utilities in the region;
- It may be possible to implement automatic triggering and automatic execution of remedial actions, similar to load shedding and generation shedding routines that are largely automatic today;
- For technical support and data flow optimization, it may be more feasible for all participating utilities to use a single regional wide area CA running on a central server (i.e. an extension of the current ISO type of CA), with real-time access and displays provided to all utilities for executing individual studies and obtaining CA results;

- For accuracy of its solutions, the Future CA should include in its network model the operations of Special Protection Systems (such as automatic load shedding and generation dumping), as well as the operating status of these systems;
- Future CA could be extended to provide useful results if the power system breaks into islands, for use in system restoration;
- Common training will be needed for users, including use of the operator training simulator for scenarios in the wide area context;
- For effective use by multiple utilities in an operating region, Future CA will require a common and intuitive User Interface, user procedures, and maintenance tools;
- Improved presentation methods (probably using graphics) will be needed to show the wide area CA results, to ensure easier and quicker understanding by all users, especially the busy power system operators;
- There may be some restrictions on sharing of certain data among utilities due to deregulation (e.g. knowledge of planned outages by one utility might provide a "market power" advantage to another utility).

1.4.2.9 Future CA improvements summary

In summary, the combination of the contingency analysis improvements reviewed above will constitute a Future CA that takes advantage of an advanced communications architecture to address many of the current CA shortcomings. Future CA will feature:

- Acquisition and use of data from wider, deeper, alternate and special sources
- Improved reliability and robustness (i.e. solving without problems and the need for expert assistance) due to the use of wide area, deeper and alternate data
- Improved usability (i.e. easier setup) with the uniform access to, and automatic use of, many sources of data
- Improved usability with a standard and intuitive User Interface
- Increased visibility of the interconnected power system, using the wide area data for regional solutions that are more valuable for on-line operations
- Remedial action plans that CA provides to operators, or automatically executes in some situations using DAC or direct control outputs
- Intelligence to learn from experience and guide itself toward correct solutions, for increased reliability in problem situations
- Use of special data such as equipment condition monitoring and phase angle measurements

- Easy transfer of unusual cases to the training simulator for building scenarios

These CA improvements can be implemented using an advanced communications architecture that is being defined by the IECSA project. Future contingency analysis will provide increased value to system operators, as a dependable on-line decision support tool. Actual implementation of the Future CA by suppliers will likely be done in stages, and is achievable by 2010, to form a major component of a self-healing grid.

1.4.3 Future CA usage

Future CA will be used for off-line studies as follows:

- A request to evaluate a power system change or a planned equipment outage initiates the contingency analysis study
- The CA user sets up the study, using input data from wide area and other sources, now available through the advanced communications architecture (and stored for use in "future" study cases)
- The intelligence features of CA assist the user to define the study case, including the input data, network model adjustments, contingency lists, and the execution parameters
- In case of execution problems, the intelligence features help to find a solution using alternate data or model adjustments, based on previous learned experience
- CA presents its wide area results (severity-ranked lists of overloads and violations, for the utility and the operating region) to the CA user for evaluation (probably with graphic displays for easier interpretation of the results)
- If necessary, the CA user easily transfers the study case and parameters to the Training Simulator for use in building operator training scenarios

Future CA will be used for on-line operations support as follows:

- Experts perform the set up of CA for on-line use, including the network model, definition of input data and the contingency list to be used, etc.
- An execution control program in the EMS for the security analysis sequence initiates CA to execute continuously, typically every 20 seconds
- CA uses for its solutions the wide area and other source data for the current operating conditions, continuously updated through the advanced communications architecture

- In case of execution problems, the intelligence features automatically find a solution using alternate data or model adjustments, based on previous learned experience
- CA presents its wide area results (severity-ranked lists of overloads and violations, plus warnings and alarms to notify of potential problems) to the system operators for decision support
- CA also provides lists of remedial actions for each severe contingency, for manual implementation by operators, or for automatic execution using the DAC application and the advanced communications network
- If necessary, the operators can easily transfer interesting CA cases and remedial action lists to the Training Simulator

As shown above, to the casual observer Future CA will work in a similar way to current baseline CA. However with its improvements the application will be more reliable, the results will show the wide area effects of contingencies, and operators will have an on-line tool that assists with remedial actions.

1.4.4 Future CA incremental data inputs and outputs

In addition to the data inputs that already are used in current baseline contingency analysis, Future CA will exploit the advanced communications architecture to use the following "new" data:

- Wide area data such as SCADA, network models and parameters, State Estimator solutions, telemetry and manual entries obtained from a large operating region, beyond each utility's boundaries
- Deeper data and accurate topology information from SCADA, distribution systems, telemetry and manual entries within each utility
- Alternate and substitute data, that Future CA actively seeks for use in solving execution problem situations
- Special data such as equipment condition monitoring and phase angle measurements

In addition to the results that already are provided by current baseline contingency analysis, Future CA will use its improvements and exploit the advanced communications architecture to provide the following "new" outputs:

- Remedial action lists, for operators to implement, or for automatic execution
- Control outputs (remedial action commands) to the DAC application, or in some cases directly to field devices and special protection systems

- Storage of cases and model or data adjustments by experts, for use in the knowledge base library
- Transfer of cases and associated parameters to the SystemOperator Training Simulator

These incremental inputs and outputs will be supported by the advanced communications architecture, to enhance the Future contingency analysis application.

1.4.5 Additional communications impacts for "central server" CA

If Future CA were implemented in a central server, to serve many remote users at utilities throughout an operating region, there would be communications impacts due to:

- Users sending requests and data for off-line contingency analysis studies to be executed at the central CA facility
- The return of CA results and displays to regional users
- The continuous "broadcast" of on-line CA results to operators and other users at participating utilities

In this use case template, it is assumed that each participating utility will have its own Future CA application working in its EnergyManagementSystem. The analysis and communications impacts reflect this "individual Future CA" model.

1.5 Actor (Stakeholder) Roles

Describe all the people (their job), systems, databases, organizations, and devices involved in or affected by the Function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTO, RTU, IED, power system). Typically, these actors are logically grouped by organization or functional boundaries or just for collaboration purpose of this use case. We need to identify these groupings and their relevant roles and understand the constituency. The same actor could play different roles in different Functions, but only one role in one Function. If the same actor (e.g. the same person) does play multiple roles in one Function, list these different actor-roles as separate rows.

Grouping (Community) '		Group Description
Users of Future Contingency Analysis (CA) for off-line power system security studies, and related actors. *Note that "security" means the safe (equipment will not be damaged) and stable (the power system will remain up and running) operation of the electric power system.*		*Users of Future Contingency Analysis in an off-line (non real-time) "study" mode or environment for (a) power system planning (changes or expansion), or for (b) equipment outage planning and scheduling.*
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
SystemPlanner	Person	Prime actor and off-line CA user. Engineer who studies the power system to ensure overall system security, with the ability to withstand at least the first major contingency (failure event). Assists with planning and evaluating changes to the power system, such as the addition of substations and transmission lines.
EquipmentOutagePlanner and Scheduler	Person	Prime actor and off-line CA user. Engineer who responds to outage requests from field maintenance personnel ("can I take this equipment out of service from XX to YY date?" by evaluating the impact on power system security if the equipment is withdrawn. Schedules equipment outages for minimum risk (to avoid same-time outages of key equipment), approves outage requests for execution by operators, and assists with the preparation of the annual maintenance schedule for the complete power system.
Future CA User (SM)	Person	Generic "stand-in" user actor for the SM = study mode, representing either of the main off-line CA users – the power system planner or the equipment outage planner/Scheduler. For simplicity, this generic actor is used in the sequence steps for the Future CA off-line study mode.
EnergyManagementSystem	Computer system (single machine or distributed	The computer system that supports computation through various applications (including Contingency Analysis), the user interface

Grouping (Community) '		Group Description
Users of Future Contingency Analysis (CA) for off-line power system security studies, and related actors. ***Note that "security" means the safe (equipment will not be damaged) and stable (the power system will remain up and running) operation of the electric power system.***		***Users of Future Contingency Analysis in an off-line (non real-time) "study" mode or environment for (a) power system planning (changes or expansion), or for (b) equipment outage planning and scheduling.***
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
	network based)	(displays), data input and output, communications (internal and external), storage in its databases, and other functions. The EnergyManagementSystem is an actor in the sense that it is responsible for the control and execution of these many functions, including CA.
EMSDatabase	Stored information in computer memory or on media	Main repository of the real-time and static information used by Contingency Analysis and its human actors, and by other EMS applications. Responsible for: • finding, organizing, storing and providing the data requested by CA and other applications, and needed by the user displays, and • storage of CA results. The EMS databases provide the power system data (collected by the DAC application) including real-time information, wide area and other input data used by Future CA, and the State Estimator solutions for initializing CA studies that are based on the current operating conditions.
Future Contingency Analysis application	Computer program(s) and displays	The solution engine within the Future CA application that solves the network model for each contingency event, and calculates the CA results. Includes Future CA internal application improvements such as

Grouping (Community) '		Group Description
Users of Future Contingency Analysis (CA) for off-line power system security studies, and related actors. *Note that "security" means the safe (equipment will not be damaged) and stable (the power system will remain up and running) operation of the electric power system.*		*Users of Future Contingency Analysis in an off-line (non real-time) "study" mode or environment for (a) power system planning (changes or expansion), or for (b) equipment outage planning and scheduling.*
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
		intelligence, knowledge base, use of wide area & alternate & special data, output of remedial actions, etc. For simplicity these functional improvements will not be modeled with separate actors, although some improvements will have associated communications requirements that are significant. Also includes user interface (UI) displays provided by the EMS and the CA application for data input and information output.
SystemPlanner	Person(s)	Note: This description is included for background information only; this secondary actor does not need to be "modeled". Engineers and technicians who are responsible for power system planning. They provide change study requests to the power system planner (a CA user) in the form of planned modifications to the electric power system, using drawings and written specifications.
FieldEquipmentMaintenanceMgmtSystem	Person(s)	Note: This description is included for background information only; this secondary actor does not need to be "modeled". Engineers and technicians who are responsible for power equipment maintenance (for generators, power lines, transformers, etc.) and preparation of the annual maintenance and outage plan. They request outage approvals from the outage planner and Scheduler (a CA user), in order to withdraw equipment from

Grouping (Community) '		*Group Description*
Users of Future Contingency Analysis (CA) for off-line power system security studies, and related actors. ***Note that "security" means the safe (equipment will not be damaged) and stable (the power system will remain up and running) operation of the electric power system.***		***Users of Future Contingency Analysis in an off-line (non real-time) "study" mode or environment for (a) power system planning (changes or expansion), or for (b) equipment outage planning and scheduling.***
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
		service for maintenance.
PowerNetworkModelEngineer	Person	Note: This description is included for background information only; this secondary actor does not need to be "modeled". NetworkEngineer specialist, who maintains the model of the power system (used by CA and other control center applications) to keep it current, and consistent with the utility's and the neighboring utilities' configurations.
DatabaseAdministrator	Person(s)	Note: This description is included for background information only; this secondary actor does not need to be "modeled". Database analyst who performs changes to, and resolves problems with, the various databases in the EMS that CA uses.
ExternalComputerSystem	Devices	Sources of utility, wide area and other data used by Future CA for its solutions. These include: • other computer systems within the utility (e.g. power equipment parameters are stored in a different computer system), and • computer systems and other data sources at other power utilities which provide necessary data about neighboring power systems, using data links and other communications methods. Note: for modeling purposes, these external systems could be

Grouping (Community) '		Group Description
Users of Future Contingency Analysis (CA) for off-line power system security studies, and related actors. *Note that "security" means the safe (equipment will not be damaged) and stable (the power system will remain up and running) operation of the electric power system.*		*Users of Future Contingency Analysis in an off-line (non real-time) "study" mode or environment for (a) power system planning (changes or expansion), or for (b) equipment outage planning and scheduling.*
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
		divided into "local" and "wide area remote" sources of data. The communications requirements for each source will be specific to that source. Practically all external data is provided through the EMS databases. Therefore the model will be simplified by using a single actor (external computer systems) as the source for all "other data" used by CA.
Special systems	Devices	Sources of special data used by Future CA for its solutions. Includes equipment condition monitoring data and phase angle measurements from the utility and the wider operating region. This actor can be shown in the model simply to highlight a different data source used by Future CA. However this data would still route through the EMSDatabase actor.
DAC	Subsystem and application in the EMS or SCADA system	Collects most of the real-time and wide area data for the EMS databases. Also, for on-line CA, DAC is the receiver and processor of control commands to field devices in the power system. (a) Operators can use DAC to perform remedial actions as suggested by Future CA results (i.e open breakers, increase

Grouping (Community) '		*Group Description*
Users of Future Contingency Analysis (CA) for off-line power system security studies, and related actors. ***Note that "security" means the safe (equipment will not be damaged) and stable (the power system will remain up and running) operation of the electric power system.***		***Users of Future Contingency Analysis in an off-line (non real-time) "study" mode or environment for (a) power system planning (changes or expansion), or for (b) equipment outage planning and scheduling.***
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
		generation, etc.), or in some cases (b) Future CA may send commands directly to DAC to perform remedial actions as automatic procedures, without operator assistance.
SystemPlanners		
SystemOperator		
NERC		

Replicate this table for each logic group.

Grouping (Community) '		*Group Description*
Users of Future Contingency Analysis (CA) for on-line power system security studies and operations decision support, with related actors. ***Note that "security" means the safe (equipment will not be damaged) and stable (the power system will remain up and running) operation of the electric power system.***		***Users of Contingency Analysis in an on-line (essentially real-time) environment, to support power system operations. Typically they use the Energy Management System in the control room. Group includes related actors for these users.*** ***Note - only the ADDITIONAL actors for on-line Future CA use are identified here. The other actors are the same as for the Grouping for off-line study use.***
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
SystemOperator	Person	Primary user of on-line CA. Also called a "Dispatcher". Person who "operates" the power system using the DAC (data acquisition and control) application in the EMS and/or SCADA system, to manage the operating conditions of the power system in real-time. In a wide area context there will be several operators at the utilities in an operating region, all using Future CA and its results including remedial action suggestions.
OutageCoordinator	Person	User of on-line CA. The outage coordinator manages the short-term weekly and daily equipment outage schedule, approves each scheduled outage before it is implemented by operators, and advises operators during the equipment withdrawal procedures.
NetworkEngineer	Person	User of on-line CA. The network engineer is an expert in the power system who advises operators (usually upon request) before and during their execution of complex or unusual procedures. He also monitors the current operating conditions and the CA results.
Future CA User (OM)	Person	Generic "stand-in" user actor for the OM = on-line mode, representing any of the main on-line Future CA users – the operator, outage coordinator, or network engineer.

Grouping (Community) '		*Group Description*
Users of Future Contingency Analysis (CA) for on-line power system security studies and operations decision support, with related actors. *Note that "security" means the safe (equipment will not be damaged) and stable (the power system will remain up and running) operation of the electric power system.*		*Users of Contingency Analysis in an on-line (essentially real-time) environment, to support power system operations. Typically they use the Energy Management System in the control room. Group includes related actors for these users.* *Note - only the ADDITIONAL actors for on-line Future CA use are identified here. The other actors are the same as for the Grouping for off-line study use.*
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
		For simplicity, this generic actor is used in the sequence steps for the Future CA on-line mode.

1.6 Information exchanged

Describe any information exchanged in this template.

Information Object Name	*Information Object Description*
Outage request	Document form, electronic and paper The outage request is a form submitted by field maintenance personnel to the equipment outage planner and Scheduler. It requests approval to take equipment out of service for a defined period of time, for a specific reason.
Outage approval	Document form, electronic and paper Approval form issued by the outage planner and Scheduler, to approve the equipment outage and schedule it for a specified date/time/duration. Operations and maintenance personnel would then perform the equipment outage procedures.

Information Object Name	*Information Object Description*
Change study request (study of a power system modification)	Document drawing and description, electronic and paper Notice of a planned change to the power system (e.g. the addition of a substation) to be studied. The system planner reviews this change using CA, to evaluate the impacts on the modified configuration in case of contingency events (equipment failures).
Change study report	Document drawing and description, electronic and paper Report prepared by the system planner from the results of the CA study, which accepts, accepts with modifications, or requests further study about the planned change.
Annual maintenance and outage plan (or similar names)	Document, electronic and paper Plan used to schedule the un-availabilities for power system equipment. Consulted to determine future planned configurations of the power system. Used for studies of new outage requests and for risk assessment by operations. Is refined into monthly and weekly outage schedules throughout the year, to reflect current operating conditions of the power system.
Network model (wide area)	Stored files on computer media Static simulated model of the wide area power system, used by Future CA. This model uses the parameters and characteristics of the real-world power system and "behaves" like the real system for the purposes of studies. Can be a model of the current power system, or of a future configuration of the power system.
Base case initial data	Stored files on computer media + Manually entered data Data that CA obtains from the EMS databases in order to set up the network model before executing the analysis. Includes data that is entered manually by users. Sometimes the base case is for a study of a future operating condition of the power system, requiring a future "picture" of the network and its parameters. Future CA will assist the definition of the base case initial data, with automated choices based on previous similar situations, and "prompts" to the user.
CA study model	Temporary or stored file

Information Object Name	*Information Object Description*
	Network model that has been adjusted by the CA user, by removing or adding equipment until it represents the desired starting point for the CA study. Future CA will assist the definition of the study model, with automated choices based on previous similar situations, and "prompts" to the user.
Contingency list	Document, electronic and paper and Temporary or stored file List of contingency events (equipment outages) that is prepared by the CA user, and input to CA as the list of events to evaluate. Typically a base contingency list is retrieved from the EMS database and manually enabled and modified by the user (on displays) before it is ready for CA to use. These lists can range from a few selected items of power system equipment, to thousands of elements of the power system. They are the "test scripts" for CA execution. Future CA will assist the definition of the contingency list, with automated choices based on previous similar situations, and "prompts" to the user.
Execution parameters	Stored files on computer media + Manually entered data Control parameters (enable or disable certain features of the application, and enter values) that the CA user selects from menus or enters manually, to set up the behavior and functionality of the application.
Screened contingency list	Document, electronic and paper and Temporary or stored file List of the most serious equipment outages that are selected by the CA screening process (or manually selected by the CA user) to undergo a complete analysis to determine the severity of violations and overloads.
CA results	Document forms and graphic pictures, electronic and paper Lists of bus voltage violations and branch overloads for the wide area operating region, shown in displays and on printouts. Typically these results consist of long lists of numbers sorted by priority – worst case violations/overloads are shown at the top of the list. Future CA will have improved visualization technology and incorporate graphic pictures for easier interpretation of results. CA users also provide written reports to summarize these results for other departments.

Information Object Name	*Information Object Description*
Stored CA results	Data files CA study results are stored in the EMS databases for review by system planning, outage scheduling, and operations personnel. They can also be accessed by or transferred to the Training Simulator, for use in building training scenarios for operations personnel.
CA error messages	Temporary or stored file The CA application issues notification to the users of any problems with its execution, so that the user can adjust the model or provide additional data inputs to correct the problem. Future CA will use its intelligence features to resolve solution problems based on previous experience and the use of better or alternate data.
CA warnings and alarms	Temporary or stored file For on-line users Future CA will issue warning messages and even audible alarms, to notify operators about overloads or violations that WOULD occur IF certain contingency events happen in future. These are essentially "preview" warnings or alarms about the effects of possible future events.
Remedial action suggestions	Temporary or stored file Future CA will provide suggestions for operators to correct potential overloads and violations. These would typically consist of suggestions to adjust or add generation, reduce load, adjust power system voltage levels, add reactive VAR resources, isolate a problem area, etc.
Remedial action commands	Temporary or stored files Future CA may send commands directly to DAC to perform remedial actions as automatic procedures, without operator assistance. Operators will also issue remedial action commands to DAC.
Saved cases for the knowledge base library	Data files Future CA will save useful and unusual study cases (network models, base case data, and adjustments by experts to allow solutions) in its knowledge library. The intelligence features will use this library

Information Object Name	*Information Object Description*
	to assist in providing solutions when execution problems occur.
Saved cases for the SystemOperator Training Simulator	Data files Future CA will transfer interesting study cases (network models, base case data and results) to the SystemOperator Training Simulator using easy procedures, if a CA user initiates this type of "saved case".

1.7 Activities/Services

Describe or list the activities and services involved in this Function (in the context of this Function). An activity or service can be provided by a computer system, a set of applications, or manual procedures. These activities/services should be described at an appropriate level, with the understanding that sub-activities and services should be described if they are important for operational issues, automation needs, and implementation reasons. Other sub-activities/services could be left for later analysis.

Activity/Service Name	*Activities/Services Provided*
Acquire and use extensive data	Future contingency analysis (CA) will use extensive data to be more robust, and to provide wide area analysis and visibility of the regional power system.
Use intelligent features to solve execution problems	Future CA will incorporate intelligent features to solve difficult cases, with minimal assistance needed from users and experts.
Identify the most serious contingencies for detailed analysis	CA performs a quick screening of the hundreds or even thousands of possible equipment outages (contingencies), and identifies the few (typically 10-50) that would have the worst effects on the power system.
Analyze the most serious contingencies and quantify the effects of each	CA performs a complete analysis of the most serious contingencies, to calculate the magnitude of branch overloads and voltage violations for individual elements of the power system. These "what if" simulations are the main tool for ensuring secure power system operation in case of equipment failures or planned equipment outages.
Organize the analysis results (by severity) and display them to users	CA presents the overloads and violations in order of their severity, in tabular lists. These are displayed

Activity/Service Name	*Activities/Services Provided*
(both on-line and off-line use)	and can be stored for reference. Future CA will use graphic displays for presentation of wide area results. For on-line use by operators, summary displays show highlights of the CA results, such as the names of contingency events that would result in severe overloads, and the number of these overloads.
Issue warnings and alarms to operators (on-line use)	CA issues warning and alarm messages to power system operators, to alert them about the effects of **future** contingency events (i.e. a preview) that would result in branch overloads and voltage violations.
Provide remedial actions (on-line use)	Future CA will provide remedial action suggestions for operators to perform, and will issue remedial action commands for automatic execution.
Save results and cases for reference, in the CA database and knowledge base	CA users can save results and the study cases (power system conditions), for future review. This includes Future CA saving in its knowledge base difficult cases and fixes applied by experts, for intelligent use in future situations. Note: this "save case to knowledge base" activity is NOT included in the step-by-step analysis, because it is an internal (background) activity of Future CA, with no external communications impact.
Transfer study cases to the operator training simulator for use in training	Future CA users can easily transfer interesting study cases to the operator training simulator, for use in training scenarios.

1.8 Contracts/Regulations

Identify any overall (human-initiated) contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues that affect the design and requirements of the Function.

Contract/Regulation	*Impact of Contract/Regulation on Function*
Deregulation and competition (FERC Orders 888 and 889, etc,)	May restrict the sharing of power system data (especially equipment unavailabilities) among competing utilities (and related companies), which could limit the Contingency Analysis solutions to the "observable" network, instead of a wider area solution.

Policy	From Actor	May	Shall Not	Shall	Description (verb)	To Actor
NERC Operating Policy 2.A – Transmission Operations	NERC			X	Operate the power system in a secure and reliable manner, using security analysis tools to recognize and avoid problem conditions. "All control areas shall operate so that instability, uncontrolled separation, or cascading outages will not occur as a result of the most severe single contingency." (voluntary reliability guidelines and standards for utilities)	SystemPlanners and SystemOperator

Constraint	Type	Description	Applies to
Thermal limits of power system equipment	Engineering	Flow limits (maximum current and MW) to be respected in order to avoid damage to, or premature aging of, power system equipment (such as generators, transmission lines, transformers, breakers, etc.). Used by CA to calculate overloads.	Future Contingency Analysis application
Stability limits for transmission lines and corridors	Engineering	Flow limits (maximum MW and MVA) for transmission lines and corridors, to be respected in order to maintain power system stability. Used by CA to calculate overloads.	Future Contingency Analysis application
Voltage limits	Engineering	Voltage limits on buses (high and low) to be respected in order to maintain secure and stable operation of the power system. Used by CA to calculate violations.	Future Contingency Analysis application

Wide area and other data	Communications	Future CA will need an advanced communications architecture to provide wide area and other types of data for the calculations.	DAC
Need for fast solutions (a)	Performance of the application (computer resources)	For on-line use by power system operators (decision support), CA must provide fast solutions, within seconds of an event. Current (2004) computer resources can already meet this constraint, so there is no problem for Future CA resources.	EnergyManagementSystem
Need for fast solutions (b)	Performance of the application (application design)	For on-line use by power system operators (decision support), CA must provide fast solutions, within seconds of an event. Future CA will have improvements to meet this constraint, even for wide area solutions.	Future Contingency Analysis application
Need for robust application	Reliability of the application (application design and features)	For both off-line and on-line use, CA must be reliable – it must provide solutions even in difficult situations with limited input data. Future CA will have intelligent features to assist with solutions.	Future Contingency Analysis application
Need for ease-of-use of the application	Usability of the application (application design and user interface)	In order to be useful for on-line analysis and decision support, the CA application must be easy to use, without requiring a programmer's skills.	Future Contingency Analysis application
Need for fast analysis of the results	Usability of the application (application design and results presentation)	The CA application must present its voluminous numeric results in a manner that can be quickly understood by users, especially for on-line use. This requires summary displays and graphical displays that are designed for easier interpretation.	Future Contingency Analysis application

2 Step by Step Analysis of Function

Describe steps that implement the function. If there is more than one set of steps that are relevant, make a copy of the following section grouping (Preconditions and Assumptions, Steps normal sequence, and Steps alternate or exceptional sequence, Post conditions)

2.1 Steps to implement function

Name of this sequence.

Future Contingency Analysis Off-line Study Mode Sequence (SM)

2.1.1 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities

Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place

Identify any initial states of information exchanged in the steps in the next section. For example, if a purchase order is exchanged in an activity, its precondition to the activity might be 'filled in but unapproved'.

Actor/System/Information/Contract	***Preconditions or Assumptions***
EMSDatabase	The EMS databases must contain current power system data for the wide area operating region and other data needed by Future CA, including the State Estimator solutions for initial data.
Network model	The network model must reflect the current or other situation of the regional power system that will be studied.

2.1.2 Future Contingency Analysis Off-line Study Mode Sequence = FCA-SM steps

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new “sub” function, then referring to that “subroutine” in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between “entities”, e.g. people, systems, applications, data bases, etc. There should be a direct link between the narrative and these steps.

The numbering of the sequence steps conveys the order and concurrency and iteration of the steps occur. Using a Dewey Decimal scheme, each level of nested procedure call is separated by a dot ‘.’. Within a level, the sequence number comprises an optional letter and an integer number. The letter specifies a concurrent sequence within the next higher level; all letter sequences are concurrent with other letter sequences. The number specifies the sequencing of messages in a given letter sequence. The absence of a letter is treated as a default 'main sequence' in parallel with the lettered sequences.

Sequence 1:

```
1.1 - Do step 1
1.2A.1 - In parallel to activity 2 B do step 1
1.2A.2 - In parallel to activity 2 B do step 2
1.2B.1 - In parallel to activity 2 A do step 1
1.2B.2 - In parallel to activity 2 A do step 2
1.3 - Do step 3
1.3.1 - nested step 3.1
1.3.2 - nested step 3.2
```

Sequence 2:

```
2.1 - Do step 1
2.2 – Do step 2
```

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[1]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.6*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
1.1	Outage request Or Change study request (can split these later into separate sequences if necessary, but each request initiates the same steps)	FieldEquipmentMaintenanceMgmtSystem Or SystemPlanner	Initiate CA study	Initiates the Contingency Analysis study, by: • a request for off-line analysis of an equipment outage request or • a change (to the power system) request		Future CA User (SM) (a generic user to represent the EquipmentOutagePlanner and Scheduler, or the SystemPlanner)	Outage request Or Change study request		Intra-Control Center

[1] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
1.2		Future CA User (SM)	Set up CA study	CA user sets up the CA study, by using CA displays to feed/input/acquire the necessary network model and data from the EMS databases, and by using manual entries. Notes: • the intelligent features of Future CA will prompt and assist the set up procedures; • several elements of data are required to "set up" a CA study; • these elements can be acquired from many wide area and other sources, however all necessary data is available through the EMS databases; • this process becomes more complex for a future study case	EMS databases ExternalComputerSystem Special systems DAC	Future ContingencyAnalysis application	Network model Base case initial data	Communications issues: interfaces and data exchange and performance	Intra-Control Center

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
1.3		Future CA User (SM)	Adjust the network model	CA user adjusts the network model to represent the power system configuration to be studied. The user performs this by manually removing equipment from a base configuration, or possibly by adding equipment.		Future ContingencyAnalysis application	CA study model	Communications issues: may need access to stored future data and historical data	Intra-Control Center
1.4		Future CA User (SM)	Define contingency list to be used	CA user defines the list of contingency events to be used in the study. Includes making manual adjustments to stored lists retrieved from the EMS database. This list could range from a few outages to be evaluated, to thousands of outages to be simulated.	EMS databases	Future ContingencyAnalysis application	Contingency list		Intra-Control Center
1.5		Future CA User (SM)	Set CA execution parameters	CA user sets the CA execution control parameters, to define constraints and outputs.		Future ContingencyAnalysis application	Execution parameters		Intra-Control Center

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
1.6	CA user starts contingency screening process ("start" button)	Future ContingencyAnalysis application	Screen for worst contingencies	CA application performs a quick check to screen (identify) the worst contingencies, and displays these to the user. Note: users may choose to skip this step and instruct the application to proceed directly to the "complete analysis" step CA-SM.7.		Future CA User (SM)	Screened contingency list		Intra-Control Center
1.6.1	CA solution fails or has solution problems	Future ContingencyAnalysis application	Future CA resolves solution problems	Future CA alerts the CA user when it encounters solution problems; then will use its intelligent features and ability to find better or alternate data, to automatically resolve problems of incorrect models or mismatched data	Future Contingency Analysis application	Future CA User (SM)	CA error messages	Communications issues: interfaces and data exchange and performance	Intra-Control Center
1.7	CA user starts complete analysis for the worst contingencies	Future ContingencyAnalysis application	Perform complete analysis of the worst contingencies	Future CA application performs a complete analysis of the worst contingencies, to calculate and display the branch overloads and voltage violations for each outage, for the wide area operating region.		Future CA User (SM)	CA results	Performance and visualization issues	Intra-Control Center

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
1.8		Future CA User (SM)	Reviews and interprets CA results	CA user reviews and interprets the CA results. Typically results are presented in summary tabular displays, however Future CA will use graphic display techniques to assist interpretation of voluminous results.				Presentation and visualization issues	Intra-Control Center
1.9		Future CA User (SM)	Saves results	CA user initiates the printing and "save" of CA results in the EMS databases. User may transfer the CA study model and results to the Training Simulator (an external system).		EMS databases ExternalComputerSystem	CA results	Communications issues: interfaces and data exchange	Intra-Control Center
1.10		Future CA User (SM)	Issues report	CA user issues report based on the CA results: an outage approval, or a report on the effects of the proposed change to the power system. Report templates and forms are typically available from the CA application and EMS. May also affect the annual maintenance and outage plan.		FieldEquipmentMaintenanceMgmtSystem Or SystemPlanner	Outage approval Change study report		Intra-Control Center

2.1.3 Steps – Alternative / Exception Sequences

Describe any alternative or exception sequences that may be required that deviate from the normal course of activities. Note instructions are found in previous table.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments

2.1.4 Post-conditions and Significant Results

Describe conditions that must exist at the conclusion of the Function. Identify significant items similar to that in the preconditions section.

Describe any significant results from the Function

Actor/Activity	***Post-conditions Description and Results***
	See FCA-SM. 10 above – immediate results of off-line Future CA are in the form of an outage approval, or a study report on the proposed change to a power system configuration.
	Overall result of contingency analysis: a secure and stable power system, even after contingency events occur.

START A SECOND SEQUENCE:

2.1.5 Steps to implement function

Name of this sequence.

Future Contingency Analysis On-line Operations Mode Sequence (OM)

Note: This mode of use of Future Contingency Analysis is very similar to the off-line study mode, except that:

- the users are the power system operators in the control center, outage coordinators who manage the planned withdrawal of equipment from the power system, and network engineers who provide advisory support to the operators
- the application runs continuously in the background, providing its results (a preview of contingency effects) to operators with updates at every execution cycle (target every 20 seconds)
- the application looks at contingencies starting with the current operating situation (not future situations), and uses the current power system data and State Estimator data from the wide area to initiate its network model for the operating region
- operators typically do not interact with the application or initiate their own studies; it is more of a "look only" advisory tool
- the on-line Future CA provides visual warnings and even audible alarms to operators, to notify them of overloads and violations that would occur if certain contingency events happen in future (i.e. a "what if" preview of the effects of future outages)
- on-line Future CA provides lists of remedial action suggestions, which will be performed by operators to correct potential problems
- on-line Future CA may send commands directly to DAC to perform remedial actions as automatic procedures, without operator assistance

2.1.6 Preconditions and Assumptions

Same as 2.1.1 above.

2.1.7 Future Contingency Analysis On-line Operations Mode Sequence = FCA-OM steps

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[2]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.6*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
2.1	Periodic "start CA" command from the execution control program	EnergyManagementSystem	Initiate on-line Future CA execution	Initiates the Future Contingency Analysis in periodic cycles (target every 20 seconds) using the application execution control program (security analysis sequence).				Communications issues: gather wide area and other data fast enough to support on-line use of Future CA	Intra-Control Center
2.2	CA results presented to users	Future ContingencyAnalysis application	Present on-line Future CA results	Presents the on-line Future CA results in displays for the users to consult and monitor; revised results are presented after every CA execution cycle, target every 20 seconds		Future CA User (OM)	CA results CA warnings and alarms Remedial action suggestions	Presentation and visualization issues	Intra-Control Center

[2] Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
2.3	Future CA user action	Future CA User (OM)	Action by users of on-line CA	Future CA on-line users may react to the CA results and remedial action suggestions by: • SystemOperator: Planning remedial actions, to be ready if a contingency event occurs • OutageCoordinator and NetworkEngineer: Implementing or postponing a scheduled outage • SystemOperator: Making remedial action changes to the power system to reduce exposure to problems in case of a contingency event		DAC FieldEquipmentMaintenanceMgmtSystem	Remedial action commands	Communications issues: output commands to DAC and field devices	Intra-Control Center
2.4	Future CA action	Future ContingencyAnalysis application	Future CA direct remedial action	Future CA may issue direct remedial action commands to DAC, to correct undesirable operating situations in the power system.		DAC	Remedial action commands	Communications issues: output commands to DAC and field devices	High security DAC

2.1.8 Steps – Alternative / Exception Sequences

N/A

2.1.9 Post-conditions and Significant Results

Describe conditions that must exist at the conclusion of the Function. Identify significant items similar to that in the preconditions section.

Describe any significant results from the Function

Actor/Activity	***Post-conditions Description and Results***
	See FCA-OM.2 and FCA-OM.4 above – immediate results of on-line Future CA are in the form of CA results (summaries of overloads and violations), CA warnings and alarms for operators, remedial action suggestions for operators, and direct remedial action commands issued by Future CA.
	Overall result of Future Contingency Analysis: a secure and stable power system, even after contingency events occur.

2.2 Architectural Issues in Interactions

Elaborate on all architectural issues in each of the steps outlined in each of the sequences above. Reference the Step by number.

Microsoft Excel
Worksheet

2.3 Diagram

For clarification, draw (by hand, by Power Point, by UML diagram) the interactions, identifying the Steps where possible.

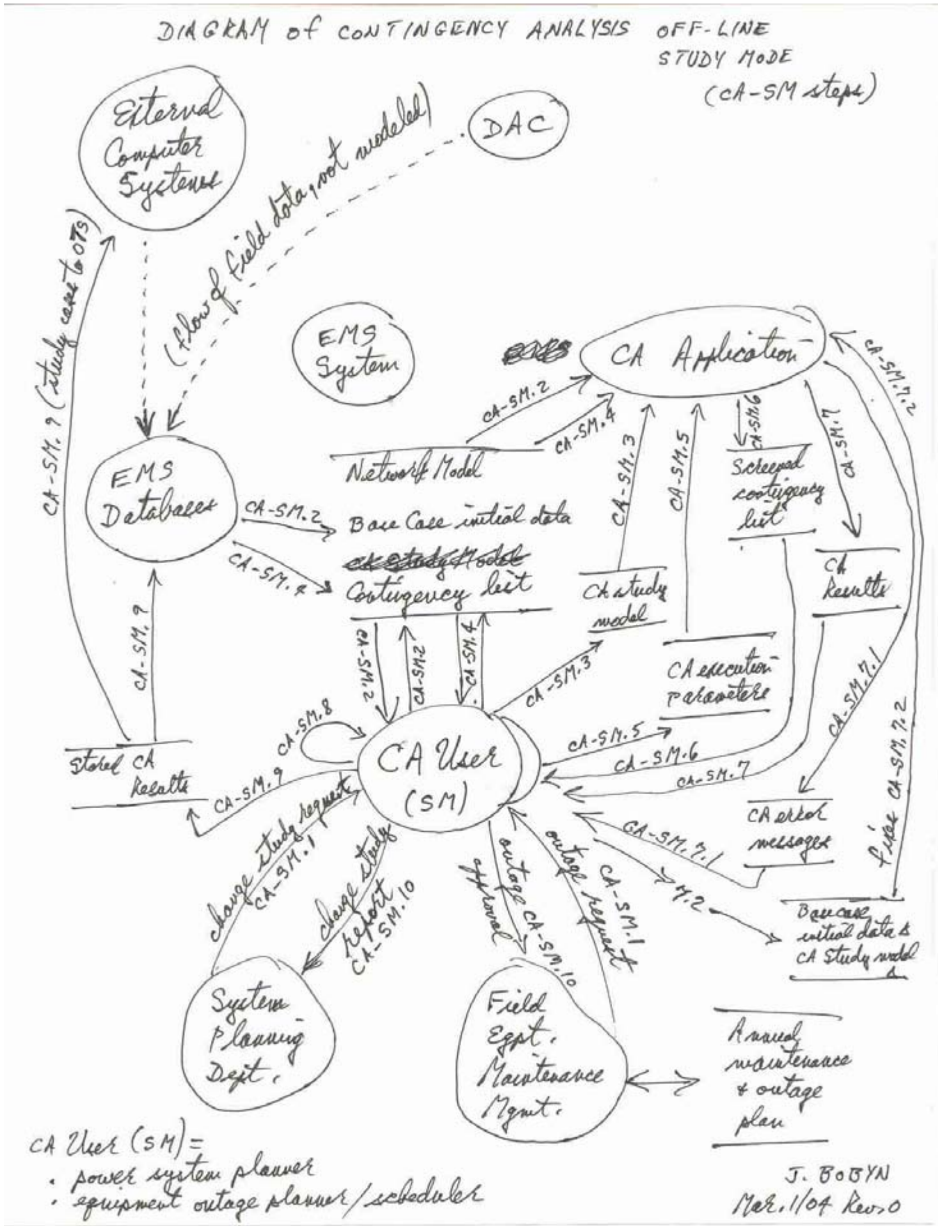
DIAGRAM of CONTINGENCY ANALYSIS OFF-LINE STUDY MODE (CA-SM steps)
External Computer Systems
DAC
(flow of field data, not modeled)
EMS System
CA Application
EMS Databases
Network Model
Base Case initial data
Contingency list
CA study model
CA execution parameters
Screened contingency list
CA Results
stored CA Results
CA User (SM)
CA error messages
Base case initial data & CA Study model
System Planning Dept.
Field Eqpt. Maintenance Mgmt.
Annual maintenance & outage plan
change study request
change study report
outage approval
outage request
CA User (SM) =
· power system planner
· equipment outage planner/scheduler
J. BOBYN
Mar. 1/04 Rev. 0

3 Auxiliary Issues

3.1 References and contacts

Documents and individuals or organizations used as background to the function described; other functions referenced by this function, or acting as "sub" functions; or other documentation that clarifies the requirements or activities described. All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work must be so noted.

ID	Title or contact	Reference or contact information
[1]		
[2]		

3.2 Action Item List

As the function is developed, identify issues that still need clarification, resolution, or other notice taken of them. This can act as an Action Item list.

ID	Description	Status
[1]		
[2]		

3.3 Revision History

For reference and tracking purposes, indicate who worked on describing this function, and what aspect they undertook.

No	Date	Author	Description
0.95	February 29, 2004	J. Bobyn	Completed Rev. 0.95 for posting to project site. • Performed additions, edits and changes according to reviews with Jamshid Sharif-Askary and Mark Adamiak

No	Date	Author	Description
			• Still needs a process/data flow diagram for section 2.3 to be complete Rev. 1.0