Contingency Analysis - Baseline

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 – Baseline (current usage)

1.2 Function ID

IECSA identification number of the function TBD

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.

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.

1.4.1 Notes and definitions

This narrative is intended to provide an overview of the ContigencyAnalysisSystem, including its major components, methodology, use, users, and a summary of its data inputs and outputs. This narrative is not intended to be a course in power engineering, and so will deal with everything at a high level.

1. The term "security" refers to the secure and stable operation of the electric power system in case of one or more equipment failures. It does not refer to the protection of digital information from computer "hackers" in the data communications world.

2. An "element" of a power system usually refers to its electrical equipment (e.g. generator, transformer, transmission line, circuit breaker, etc.). An "outage" is the removal of equipment from service. It can be intentional and planned (i.e. for maintenance), or unplanned (i.e. due to failure). Element can also refer to the wider context of a group of devices that together constitute an outage, such as a busbar which effectively goes out of service if one or more breakers do not operate correctly.

3. This narrative provides a high level and generic view of the Contingency Analysis software application. Each utility's use of this application will vary, ranging from off-line use in study and planning mode only, to its on-line use by system operators and network engineers for decision support.

4. The fine points and variations of what exactly constitutes a "contingency" or failure of some part of the power system are not covered in this narrative.

5. Related applications for security analysis of the power system, and supporting applications in SCADA and Energy Management Systems, are simply referenced, not described.

6. A high level and generic explanation is provided of the power flow algorithm, which is the basis of the contingency analysis. More detailed coverage is not necessary to understand the functionality of CA.

1.4.2 Overview of Contingency Analysis

Evaluation of power system security is necessary in order to develop ways to maintain system operation when one or more elements fail. A power system is "secure" when it can withstand the loss of one or more elements and still continue operation without major problems.

Contingency Analysis (CA) is one of the "security analysis" applications in a power utility control center that differentiates an Energy Management System (EMS) from a less complex SCADA system. Its purpose is to analyze the power system in order to identify the overloads and problems that can occur due to a "contingency". A contingency is the failure or loss of an element (e.g. generator, transformer, transmission line, etc.), or a change of state of a device (e.g. the unplanned opening of a circuit breaker in a transformer substation) in the power system. Therefore contingency analysis is an application that uses a computer simulation to evaluate the effects of removing individual elements from a power system.

After a contingency event, power system problems can range from:

- none - when the power system can be re-balanced after a contingency, without overloads to any element, to
- severe - when several elements such as lines and transformers become overloaded and risk damage, to
- critical - when the power system becomes unstable and will quickly collapse.

Current electric utility operating policies (such as NERC's) require that each utility's power system must be able to withstand and recover from any "first contingency" or any single failure. Future policies may extend this to withstanding a "second contingency" or any subsequent single failure. Therefore contingency analysis is one of the tools used primarily by power system planners and engineers to "test" the power system (using a software model) for its strengths and weaknesses, and for compliance with the operating policies. CA has always been an important part of electric utility system planning and operations, even before there were computers to assist the analysis, when manual calculations were used.

By analyzing the effects of contingency events in advance, problems and unstable situations can be identified, critical configurations can be recognized, operating constraints and limits can be applied, and corrective actions can be planned.

In the planning mode, apart from analysis of the complete power system for overall security, CA is also used for scheduling the withdrawal of power system equipment for periodic or restorative maintenance. The effects of equipment outages are evaluated using future operating conditions of the power system. The schedule for planned outages is arranged for minimal risk of problems by using these CA studies, to avoid scheduling concurrent outages of critical system elements.

CA is therefore a primary tool used for preparation of the annual maintenance plan and the corresponding outage schedule for the power system. This outage schedule requires modification to reflect changes in the operating conditions over time, and so CA is used repeatedly to refine the schedule of planned outages, for long term and short term planning. If there are no problems revealed by a final check using CA just before an outage is scheduled to take place, the planned outage is approved by the outage coordinator or network engineer, and it is implemented by the system operator or dispatcher in the control center. Operators perform the outage by using the DAC (data acquisition and control) applications to open breakers and switches, to isolate equipment from the power system.

1.4.2 Methodology and the contingency analysis process

The CA application is based on a detailed electrical model of the power system, called the "network model". This is a simulated model of the real power system that is prepared by each utility's system planners and network engineer specialists. They translate the real world equipment and connections of a power system (typically shown in a schematic representation, called a one-line diagram) into a mathematical model of the power network that is suitable for solution by computer algorithms. This network model contains the connection information (called the topology and connectivity), and the electrical characteristics of the equipment (such as the impedance of transmission lines). The algorithm in contingency analysis uses this network information (often called network "parameters") and the network model to simulate, and calculate the effects of, removing equipment from the power system.

The network model is usually the same model used in other security analysis applications, so it must be accurate and must reflect the real world power system in order to provide realistic and useful results. For many utilities, in order to be accurate the size of the network model will be several hundred or even a few thousand "buses" (connection points for electrical components of the model) and "branches" (connected components of the model, between the buses). The network model may be reduced or simplified from its real world configuration, containing fewer buses and fewer electrical components than are shown on the detailed one-line diagram of the system. However network engineers prepare the model with enough detail to provide a good simulation of the operation of the real power system, with accurate results.

The network model is simply a static set of parameters and equations, but it cannot be "solved" (i.e. used to calculate results) until it is "initialized" by entering "starting" values for the simulated power system. These starting values are the real world starting point for the algorithm, so that it works with real data that reflects the current operating conditions in the power system. Initialized values are the real world reference for the network model.

Initialized values include bus voltages, production levels for each generator, loads, and power interchanges with neighboring utilities. Initial values are sometimes taken from the current SCADA database (measurements from field transducers) at the control center. Preferably the initial values are taken from the State Estimator database (if this application exists and is reliable), because these values are estimated and are more accurate representations of the actual state of the power system. Other parameters such as operating and equipment limits, and generation participation factors are also taken from the SCADA database to be used as references for calculating overloads and violations.

The multiple sets of limits that may be used for power system operations and for security analysis is a complex subject that is beyond the scope of this narrative about CA.

With an initialized power network model, contingency analysis can now be executed with a series of contingency events that is prepared by the CA user. A "contingency list" contains each of the elements that will be removed from the network model, one by one, to test the effects for possible overloads of the remaining elements. The criteria for selection of elements for the contingency events are further described below.

In its basic form, CA executes a "power flow" analysis for each potential problem that is defined on a contingency list. The power flow (sometimes called a load flow) is the name of the algorithm used by contingency analysis to solve for the currents, voltages, and real and reactive power flows (MW and MVA) in each part of the power system. A "network solution" consists of these calculated results for every bus and branch in the power network model.

The failure or outage of each element in the contingency list (e.g. a loss of a generator or a transmission line) is simulated in the network model by removing that element. The resulting network model is solved (i.e. computer programs solve the complex matrix equations that make up the power flow algorithm) to calculate the resulting power flows, voltages, and currents for the remaining elements of the model.

Results of each contingency test – the network solution – are compared with the limits for every element in the power system. For example, a transmission line that was loaded at 85% of its MVA rating before the contingency event, might now be loaded at 120% of its rating after the event. Similarly a load bus voltage may fall to 90% of its nominal value, due to the same contingency. If limit violations occur, these are arranged in a tabular list according to how serious the overloads or violations are. The list of violations is saved in the CA database. The CA process continues - the network model is reset to its initial operating conditions, and the next contingency (element outage) is applied and analyzed. This process continues one after another, until all the contingency events on the test list are examined. All the violations resulting from each contingency, one list per contingency, are saved in the CA database for review by users.

Typically the power system model is tested for many hundreds of possible problems, including the failure of each generator and line, as well as other elements. These events are placed on the contingency list by experienced planning and operations engineers because of their importance - the severity of their effects, and their likelihood (probability) of occurrence. Establishing the contingency lists is a result of planning studies that use power flows to identify the sensitive areas of a power network, under various loading conditions. In practice these sensitivity studies can reduce the number of contingencies that need to be evaluated by CA, to study only the most serious and likely events.

Large computer resources are needed to process a power flow solution for each contingency in a large power system composed of many hundreds of elements, especially when these studies are conducted for several operating states and loading levels of the system. If voltage violations and reactive power flows are of most concern in a particular system or operating state, then a complete AC power flow is required for each contingency.

Execution times for testing hundreds of contingencies have of course been reduced significantly over the past 30 years, and it is now possible to execute the CA in a few seconds with current control center computers. Other methods are used in practice to further improve CA execution times, such as the use of simpler DC power flow analysis when approximate MW power flows are more important than voltage limits on buses. Therefore CA can be used not only as a system planning tool, but is "fast enough" to be used as an on-line analysis tool by power system dispatchers and network engineers, to support preventive and corrective operator actions in case of problems.

1.4.3 Results and use

The results of the CA are compared against safe operating and stability limits for each element of the power system being studied. Violations for each overloaded element are shown in lists (e.g. "For contingency #1 outage of generating unit G001, line L123 exceeds normal MVA limit by 50%"). The results of the contingency analysis are organized by ranking of their severity –the most overloaded elements of the power system appear at the top of the list. Lists can contain hundreds of entries, but typically the most important violations are in the top 50, and these indicate the major problem areas.

In practice there can be more than one operating limit for many elements of the power system, such as short-term and long-term thermal limits (e.g. ambient temperature and the duration of an overload affect the safe operating limits for transformers and transmission lines). There can also be several stability limits for lines and interconnections, depending on the configuration and the operating state of the power system (light, medium, or heavy loading). All of these limits are checked by CA, upon selection by the user.

In the real power network, if limits are exceeded after the first contingency event happens, protection equipment will react and remove overloaded equipment from the power system. This can create further overloads, resulting in cascading outages, which could eventually collapse the power system in a complete blackout.

Therefore the results of CA are used initially by system planners, to study the effects of outages and to establish secure operating limits and constraints for the power system under different conditions. NetworkEngineers use CA as a study tool to develop corrective actions in predefined "cookbooks" for system operators, to improve their ability to resolve problems. In addition CA is used as an on-line decision support tool to assist the operators' understanding and correction of unusual situations, by looking at the effects of possible outage events.

1.4.4 Current CA implementation

In current Energy Management Systems and planning departments, CA is no longer a separate application, and is often an extension of the power flow or optimal power flow applications. This allows the related applications to work from common network models and base cases, and provides a single point of editing and maintenance.

Since the results of contingency analysis are used to define operating limits and constraints for the power system, combined applications have evolved such as Security Constrained Economic Dispatch, Security Constrained Unit Commitment, and Security Constrained Optimal Power Flow. These advanced applications use the CA results to directly provide operating limits and constraints as part of their results, to streamline the process instead of using separate applications to come up with the same results.

1.4.5 CA evolution, users and future

Contingency analysis was originally (in the 1960s) such a computer intensive application that its use was limited to power system planners, for evaluating the design of the power system and to develop operating constraints and corrective measures for the dispatchers. Analysis was performed in off-line computers, often in large mainframes or specialized engineering minicomputers. Results were typically available only after many hours of computation, with huge stacks of paper printouts (remember those?) needing days of line-by-line analysis by power system experts.

Due to vastly increased computer power and the use of special selection techniques to minimize the contingency events that need to be examined, in 2004 the CA application has become very fast. Results are available in seconds and graphical display tools allow quick visual analysis. CA can therefore be used as an on-line operations support tool, by dispatchers and network engineers.

However CA is still a complex application, and like many of the security analysis applications, its acceptance for on-line use by system dispatchers has been limited. Procedures that are acceptable for backroom analysts are not adequate for busy operations staff. The workload of executing regular power dispatch and switching tasks, reacting to problem situations, and entering data for reports, does not leave much time for the dispatcher's use of advanced security analysis applications. Relatively complex initialization, data entry requirements, and infrequent use also mean a re-learning curve that further affects its acceptance. Future improvements in the human interface and set up procedures may increase the use of CA as an on-line tool.

CA is used in a wider arena, for analyzing huge power pool and wide area networks for operating regions such as the Midwest ISO (Independent System Operator). Power marketing and trading entities, as well as the ISOs and TSOs (Transmission System Operator), have driven some of these requirements. For these very large network models, further improvements in execution time, user tools and results presentation will be needed in order for the application to be effective.

1.4.6 Data Inputs and Outputs

The CA application requires data inputs from many sources, including:

- equipment lists for the power systems to be studied
- contingency lists of the selected elements to be studied
- sets of limits for power system elements (lines, generators, transformers, etc.)
- base case "starting" data to initialize the network model (often this is the current network solution taken from the state estimator application)
- other base cases for studies of other power system operating states (saved cases from the study power flow application)
- power system loading models (these may be part of the base cases)
- "triggers" to start the application, such as automatic execution upon loss of a power system element, periodic execution as part of the security analysis sequence, or manual execution "on demand" by a user

In addition, CA users enter or select data such as:

- definition and selection of contingencies (list of outages to be analyzed, activate or deactivate violation checking, etc.)
- selection of base cases (initial conditions for the power network model)
- execution control parameters (groups of contingencies, participation of units in generation loss, number of highest priority contingencies to be processed)
- enable automatic grouping of switching devices to define an element outage
- enable generation of warnings and alarms (usually for on-line users)
- severity ranking of contingencies (various factors can be used and weighted to rank and display the limit violations, such as branch current or MVA flow, bus voltage, reactive power generation, bus voltage shifts, reactive power shifts, etc.)
- adjustments to the weighting factors
- stop the CA execution at certain points in its sequence

The CA application provides several outputs, such as:

- displays for users to set up and control the application

- execution status and problem displays, showing progress and non-convergence situations
- results – in the form of many types of contingency violation lists, according to severity, type of equipment, loss of generation or load, equipment affected by multiple contingencies, creation of islands, etc.
- results – in the form of many types of graphical displays, showing the overloads on one-line diagrams with color codes for severity, flags for types of problems, graphs, and even 3D representations of groups of analyses, etc.
- visible warnings and audible alarms for operations staff and dispatchers, and sometimes for study users, to alert them about potential problems if certain contingencies should occur in the future

1.4.7 Shortcomings in Current Contingency Analysis

As mentioned previously in section 1.4.5, the CA application has some shortcomings in current practice. Some of these result in CA being more useful as an off-line planning tool than as an on-line tool for operators. Other shortcomings restrict its capability in identifying problems outside the immediate control area that could impact the control area, or limit the effective conversion of its voluminous numerical results into meaningful information and intelligence for operations use.

Some of the CA shortcomings could be addressed with an improved communications architecture, which would support the use of more, more frequent, higher quality, and wider-area data. This would 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 improvement with an advanced communications architecture are marked with an asterisk (*).

The list of CA shortcomings includes:

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

- "touchy"
- "sensitive"
- breaks easily
- sometimes needs assistance by a programmer-analyst and a network engineer to resolve problems

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

- Complex application
- Sometimes needs programmer-level entries in "code"
- Sometimes minimal use of dialogue boxes and menus for users
- Access to various data sources is not consistent
- Access to alternate and wider area data (to resolve situations of faulty, incomplete or missing data, needed for dependable solutions) is rarely provided (*)
- Definition and selection of contingencies can be lengthy

- Poor user guides
- Poor or no scripts to follow
- Lack of default entries, "prompts" and "help" features

Summary - CA can be flexible and capable, but is rarely an "elegant" application; it needs an intuitive interface and better user features.

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

- Summaries of overloads and violations are usually tabular displays, without being integrated in one-line diagrams for easier association with the power network
- Few or no graphic tools to assist interpretation of hundreds of numbers
- Comprehension of CA results can be relatively slow for new users

Summary - not an intuitive output style.

(d) Restricted visibility - not always a "wide area" or regional solution (*)

- May not show the problems at boundaries of the power system (*)
- Without a large area model, CA can not show problems that start in remote locations, beyond the local control area (*)
- Does not always "see" accurate topology, even in the local control area

(e) Few or no remedial action suggestions for operators

- rarely provides operator "action lists", especially for unusual situations
- does not suggest remedial actions for wide area implementation, using coordinated multi-utility operations (*)

(f) Slow performance

- Can sometimes be too slow for operators to use effectively for decision support, although modern computers can handle most requirements

(g) No intelligence or learning from previous cases

CA can be initiated from previous base cases, but the application is not equipped with intelligence to learn from previous cases:

- How to assist the set up procedure, using self-start procedures
- How to resolve difficult situations (for example by trying or suggesting fixes to problems, such as interrogating and using alternate data sources) (*)

(h) Relatively isolated application, no links with Equipment Condition Monitoring (for revised limits and integration with outage scheduling for maintenance) or Phase Angle telemetry (operating conditions could trigger the CA analysis) (*)

- CA shows its "study function" roots, since it is not usually linked with real-time triggers or telemetry
- Closer coupling with equipment condition and state measurement telemetry would enhance the value of CA (*)

(i) Rarely coupled with the Training Simulator

- CA study cases should be easily transferable to the Training Simulator for use in building scenarios

These and other CA shortcomings combine to make it less effective than its potential as a refined and usable decision support and guidance tool for operations.

The interim report on the August 14, 2003 blackout ("U.S. – Canada Power System Outage Task Force, Interim Report: Causes of the August 14th Blackout … November 2003") refers to some of these CA shortcomings, such as restricted visibility of the regional power system, and the need for correct topology data.

The "future" Contingency Analysis will be defined (in another template) to improve many of these current shortcomings, and to make CA a key component of the "self healing grid" of the future.

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 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 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. Typically they use the Energy Management System (EMS) workstations outside the control room, or sometimes they use separate computer facilities. This Group includes related actors for these users.***
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,

Grouping (Community) '		*Group Description*
Users of 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 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. Typically they use the Energy Management System (EMS) workstations outside the control room, or sometimes they use separate computer facilities. This Group includes related actors for these users.***
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
		and assists with the preparation of the annual maintenance schedule for the complete power system.
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 CA off-line study mode.
EnergyManagementSystem	Computer system (single machine or distributed network based)	The computer system that supports computation through various applications (including Contingency Analysis), the user interface (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

Grouping (Community) ’		*Group Description*
Users of 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 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. Typically they use the Energy Management System (EMS) workstations outside the control room, or sometimes they use separate computer facilities. This Group includes related actors for these users.*
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
		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, and the State Estimator solutions for initializing CA studies that are based on the current operating conditions.
ContigencyAnalysisSystem	Computer program(s) and displays	The solution engine within the CA application that solves the network model for each contingency event, and calculates the CA results. Also includes user interface (UI) displays provided by the EMS and the CA application for data input and information output. Displays are used to set up and control the application, enter and modify input data, view results, and save/transfer results. Typically these are tabular/character displays, but advanced graphical presentations are sometimes used to assist the interpretation of results.

Grouping (Community) '		Group Description
Secondary actors who are involved with the use of Contingency Analysis (CA) for off-line and/or on-line power system security studies.		*These secondary actors are probably less important for the model of high level communications and data exchanges. This is because they work in the background to interact with the primary actors, perform system support work, or represent "busy work" tasks (e.g. Input/Output among data sources) that are supported within the EMS architecture.* *Note: If this distinction between primary and secondary actors is not important for the model, then this group can be merged with the first group of "Users of CA … and related actors".*
Actor Name	**Actor Type (person, device, system etc.)**	**Actor Description**
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. These include changes such as system expansion and equipment upgrades due to load growth, reliability and security improvements, replacement of outdated equipment, and the addition of new transmission lines and generation facilities.
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

Grouping (Community) '		Group Description
Secondary actors who are involved with the use of Contingency Analysis (CA) for off-line and/or on-line power system security studies.		*These secondary actors are probably less important for the model of high level communications and data exchanges. This is because they work in the background to interact with the primary actors, perform system support work, or represent "busy work" tasks (e.g. Input/Output among data sources) that are supported within the EMS architecture.* *Note: If this distinction between primary and secondary actors is not important for the model, then this group can be merged with the first group of "Users of CA … and related actors".*
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
		maintenance and outage plan. They request outage approvals from the outage planner and Scheduler (a CA user), in order to withdraw equipment from service for maintenance. These outages can range from a few hours to many months in duration.
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. Uses the future configurations of the power system (according to the annual maintenance plan) to define power network models for future studies.
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.

<table>
<tr><th colspan="2">Grouping (Community) ’</th><th>Group Description</th></tr>
<tr><td colspan="2">Secondary actors who are involved with the use of Contingency Analysis (CA) for off-line and/or on-line power system security studies.</td><td>These secondary actors are probably less important for the model of high level communications and data exchanges. This is because they work in the background to interact with the primary actors, perform system support work, or represent "busy work" tasks (e.g. Input/Output among data sources) that are supported within the EMS architecture.

Note: If this distinction between primary and secondary actors is not important for the model, then this group can be merged with the first group of "Users of CA … and related actors".</td></tr>
<tr><th>Actor Name</th><th>Actor Type (person, device, system etc.)</th><th>Actor Description</th></tr>
<tr><td>ExternalComputerSystem</td><td>Devices</td><td>Note: this may be a primary actor (grouped as a single actor for simplicity), and could be divided into systems that are within and outside the utility. However practically all external data is provided through the EMS databases.

Sources of other data used by 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 at other power utilities which provide necessary data about neighboring power systems, using data links and other communications methods.</td></tr>
<tr><td>DAC</td><td>Subsystem and application in the EMS or SCADA system</td><td>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.

Operators can use DAC to perform remedial actions, if these suggestions are part of the CA results (i.e open breakers, increase generation, etc.).</td></tr>
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Replicate this table for each logic group.

Grouping (Community) '		Group Description
Users of 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 (almost 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 CA use are identified here. The other actors are the same as for the Groupings for off-line study use, and the secondary actors.*
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. Typical operations include monitoring power flows and voltage levels, switching equipment in and out of service (opening and closing breakers and switches by remote control), adding and adjusting generation sources (by remote control or using voice communications to field operators) to match the loads, and managing the operating conditions of the power system in real-time. In many utilities operators use CA as a source of "preview" alarms (or warnings) to show the violations that **could occur** (or are imminent) as a result of a future equipment failure (contingency). CA runs periodically to "look ahead" at potential future problems. An equipment failure event can also trigger CA to execute in a real-time advisory mode for operations support, to provide these "preview" alarms or warnings in case of a next contingency event. A typical CA display is non-graphic and shows the operator a summary of violations with the name of each important contingency event. Details about specific violations and overloads are available in other tabular displays. In

Grouping (Community) '		*Group Description*
Users of 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 (almost 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 CA use are identified here. The other actors are the same as for the Groupings for off-line study use, and the secondary actors.***
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
		advanced EnergyManagementSystems, suggested remedial actions may be displayed as a list of procedures for operators to use to remedy overload situations.
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. The outage coordinator may use CA as a "quick check" in the on-line mode using the current operating conditions, to make sure that a planned equipment outage will not create problems (violations and overloads). For this mode, easy setup and fast results (i.e. high performance) are necessary.
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. The network engineer may use CA as a "quick check" in the on-line mode, to validate procedures and try "what if" scenarios. Again, easy setup and fast results

Grouping (Community) '		*Group Description*
Users of 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 (almost 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 CA use are identified here. The other actors are the same as for the Groupings for off-line study use, and the secondary actors.***
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
		(i.e. high performance) are necessary.
CA User (OM)	Person	Generic "stand-in" user actor for the OM = on-line mode, representing any of the main on-line CA users – the operator, outage coordinator, or network engineer. For simplicity, this generic actor is used in the sequence steps for the CA on-line mode.
SystemPlanners		
SystemOperator		
NERC		

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. Sometimes the outage request includes an estimated "return to service time" if it is a short outage on critical equipment that might be quickly needed back in service.
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.
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	Stored files on computer media

Information Object Name	*Information Object Description*
	Static simulated model of the power system, used by CA and other EMS applications such as the power flow analysis. 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.
CA study model	Temporary or stored file 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.
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.
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

Information Object Name	*Information Object Description*
	overloads.
CA results	Document forms and graphic pictures, electronic and paper Lists of bus voltage violations and branch overloads, 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. New visualization technology incorporates graphic pictures for easier interpretation of results. CA users also provide written reports to summarize these results for other departments.
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.
CA warnings and alarms	Temporary or stored file For on-line users the CA application can 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 In some advanced implementations of baseline current Contingency Analysis, the application can

Information Object Name	Information Object Description
	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.

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
Identify the most serious contingencies for detailed analysis	Contingency 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 (both on-line and off-line use)	CA presents the overloads and violations in order of their severity, in tabular lists. These are displayed and can be stored for reference. 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	CA issues warning and alarm messages to power system operators, to alert them about the effects of

Activity/Service Name	*Activities/Services Provided*
operators (on-line use)	**future** contingency events (i.e. a preview) that would result in branch overloads and voltage violations.
Save results and cases for reference	CA users can save results and the study cases (power system conditions), for future review.
Transfer study cases to the operator training simulator for use in training	CA users can send 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.	ContigencyAnalysisSystem
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.	ContigencyAnalysisSystem
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.	ContigencyAnalysisSystem

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 meet this constraint.	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. Current (2004) CA application barely meets this constraint.	ContigencyAnalysisSystem
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.	ContigencyAnalysisSystem
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.	ContigencyAnalysisSystem
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.	ContigencyAnalysisSystem

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.

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 and other data needed by CA, such as the State Estimator solutions for initial data.
Network model	The network model must reflect the current or other situation of the power system that will be studied.

2.1.2 Steps – Normal Sequence

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
```

Contingency Analysis Off-line Study Mode Sequence = CA-SM 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.*[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	FieldEquipmentMaintenanceMgmtSystem, SystemPlanner	CA User (SM)	Outage request, Change study request	CA User (SM) (a generic user to represent the EquipmentOutagePlanner and Scheduler, or the SystemPlanner)	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		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: • several elements of data are required to "set up" a CA study; • these elements can be acquired from many sources, however all necessary data is available through the EMS databases; • this process becomes more complex for a future study case	EMSDatabase, ExternalComputerSystem, DAC	ContigencyAnalysisSystem	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		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.	CA User (SM)	ContigencyAnalysisSystem	CA study model	Communications issues: may need access to stored future data and historical data	Intra-control center
1.4		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.	EMSDatabase	ContigencyAnalysisSystem	Contingency list		Intra-control center
1.5		CA User (SM)	Set CA execution parameters	CA user sets the CA execution control parameters, to define constraints and outputs.	CA User (SM)	ContigencyAnalysisSystem	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)	ContigencyAnalysisSystem	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 1.7.	ContigencyAnalysisSystem	CA User (SM)	Screened contingency list		Intra-control center
1.7	CA user starts complete analysis for the worst contingencies	ContigencyAnalysisSystem	Perform complete analysis of the worst contingencies	CA application performs a complete analysis of the worst contingencies, to calculate and display the branch overloads and voltage violations for each outage.	ContigencyAnalysisSystem	CA User (SM)	CA results	Performance and visualization issues	Intra-control center
1.8		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 graphic display techniques can assist interpretation of voluminous results.				Presentation 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
1.9		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).	CA User (SM)	EMSDatabase, ExternalComputerSystem	CA results	Communications issues: interfaces and data exchange	Intra-control center
1.10		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.	CA User (SM)	FieldEquipmentMaintenanceMgmtSystem, 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
1.7.1	CA solution fails	ContigencyAnalysisSystem	Alerts user of failure to solve	CA display alerts the CA user when it cannot solve the network model, usually because of incomplete or faulty data.	ContigencyAnalysisSystem	CA User (SM)	CA error messages	Application robustness and problem diagnostic issues	Intra-control center
1.7.2		CA User (SM)	Adjust CA input data	CA user (with help from network model engineer and/or database support analyst) adjusts CA input data and/or the network model to fix the problem. Usually involves manual entry of data corrections.	PowerNetworkModelEngineer, DatabaseAdministrator	ContigencyAnalysisSystem	Base case initial data, CA study model	Application robustness and problem diagnostic issues	Intra-control center
1.7.3	Return to regular CA-SM sequence			After problems are resolved, the regular CA-SM sequence continues. Go back to step 1.7					NA

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 CA-SM. 10 above – immediate results of off-line 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.

Contingency Analysis On-line Operations Mode Sequence (OM)

Note: This mode of use of 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 (usually every few minutes)
- 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 to initiate its network model
- 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 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)
- Baseline CA does not usually extend to providing suggested lists of remedial actions, which could be performed by operators to correct potential problems.

2.1.6 Preconditions and Assumptions

Same as 2.1.1 above.

2.1.7 Steps – Normal Sequence

Contingency Analysis On-line Operations Mode Sequence = CA-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 CA execution	Initiates the Contingency Analysis in periodic cycles (typically every few minutes) using the application execution control program (security analysis sequence).				Communications issues: gather data fast enough to support on-line use of CA	NA

[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
2.2	CA results presented to users	ContigencyAnalysisSystem	Present on-line CA results	Presents the on-line CA results in displays for the users to consult and monitor; revised results are presented after every CA execution cycle, typically every few minutes	ContigencyAnalysisSystem	CA User (OM)	CA results, CA warnings and alarms, Remedial action suggestions	Presentation and visualization issues	Intra-control center
2.3	User action	CA User (OM)	Action by users of on-line CA	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	CA User (OM)	DAC, FieldEquipmentMaintenanceMgmtSystem		Communications issues: output commands to DAC and field devices	Intra-control center

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 CA-OM.2 above – immediate results of on-line CA are in the form of CA results (summaries of overloads and violations), CA warnings and alarms for operators, and (possibly) remedial action suggestions for operators.
	Overall result of 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.

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.

<table>
<tr><th>No</th><th>Date</th><th>Author</th><th>Description</th></tr>
<tr><td>0.7</td><td>December 4, 2003</td><td>J. Bobyn</td><td>Incomplete draft of the V1.28 template for Contingency Analysis - Baseline, sections 1 through 1.8, and sections 2.1 through 2.1.3 for the first sequence (Contingency Analysis Off-line Study Mode).

Still to be done:
Revise the Narrative section 1.4 (was written earlier) to track more closely with the remainder
Complete section 2.1.4 for the first sequence
Complete the steps sections 2.1 through 2.1.4 for the second sequence (Contingency Analysis On-line Operations Mode) but showing only the differences from the first sequence
Complete sections 2.2, 2.3 and 3 (the table in 2.2 will require analysis before it can be filled in accurately; the diagram in 2.3 will have to be produced by others)
Re-iterate and edit all above sections as necessary for consistent terminology, closed loops for the steps model, and to reflect comments and discussion and validation by other team members
Re-do another template for "CA future usage", showing enhancements and new requirements
Dec. 5 review: Grant said to make some "paper" actors into data = information exchanged – this may cause adjustments to be needed elsewhere TBD, AND add a list of shortcomings in current CA at the end of the narrative section 1.4.7</td></tr>
<tr><td>0.8</td><td>December 10, 2003</td><td>J. Bobyn</td><td>Completed:
section 2.1.4 for the first sequence (Off-line mode)
sections 2.1.5 to 2.1.9 for second Sequence (On-line mode)
and reviewed the Tables in section 2.2 for orientation and study of reference material</td></tr>
<tr><td>0.9</td><td>December 17, 2003</td><td>J. Bobyn</td><td>Completed Rev. 0.9 for initial posting to project site and review/comments:
Added list of CA shortcomings in Narrative section 1.4.7
Added Tables (Architectural issues) in section 2.2 for the first sequence (off-line</td></tr>
</table>

No	Date	Author	Description
			mode) only • Changed paper and data actors (forms, reports, etc.) to make them "Information exchanged", and rewrote the steps accordingly, with other minor edits elsewhere where needed Still to be done: • Revise the Narrative section 1.4 (was written earlier) to track more closely with the other sections • Complete the Table in section 2.2 for the On-line mode • Provide a draft of a process/data flow diagram in section 2.3 • Re-iterate and edit all sections as necessary for consistent terminology, and to reflect comments and discussion and validation by other team members and utilities • Re-do another template for "CA future usage", showing enhancements and new requirements
0.95	February 27, 2004	J. Bobyn	Completed Rev. 0.95 for posting to project site. • Performed significant edits and changes according to reviews with Grant Gilchrist • Still needs a process/data flow diagram for section 2.3 to be complete Rev. 1.0

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