September 2011 10-Year Assessment
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Multiple Outage Analysis

Steady State Multiple Outage Analysis

This section only discusses the steady state multiple outage analysis. The dynamic analysis of multiple outage contingencies is covered in the Stability Analysis Section.

On a five year rolling schedule, ATC performs a comprehensive evaluation of each appropriate NERC Category C and D outage types. The comprehensive review of the each outage type is spread out over the five year schedule to levelize the resources needed for the analysis. For each outage type in the remaining four years, ATC carries forward the list of outages defined as severe. NERC has defined Category C as selected multiple element outages that the system should not have wide spread cascading or go unstable. NERC has defined Category D as several types of more severe outage combinations. The following subsections summarize ATC's Category C and D multiple outage process and results.

NERC Category C

There are 9 Category C outage types. In 2010 ATC reviewed its process for analyzing Category C outage types and enhanced it for 2011. See Figure MO-1 for 2011 and succeeding 4 years schedule ATC expects to follow to analyze appropriate Category C outages.

For years prior to 2011, ATC Category C process is identified below.

As part of ATC's continuing effort to comply with NERC standards for multiple outage impacts on ATC's transmission system, an initial system wide screening was performed by Commonwealth Associates (CAI) in 2004. ATC enhanced its Category C contingency Analysis in succeeding years. For succeeding years,the Category C analysis includes the assessment of the selected potentially severe multiple outages identified from previous multiple outage studies. In addition, ATC performs a comprehensive multiple outage analysis for at least one of our five planning zones with an objective of revisiting each zone at least once every five years. Also for each of these prior years ATC performed a comprehensive Category C screening of the entire ATC 345-kV system plus all 100-kV and above tie lines to the neighboring transmission networks. More details about recent past years of analysis are provided below.

In 2008, we analyzed the potentially severe multiple outage lists from prior study years. Additional Category C events were evaluated by a comprehensive screening of Zone 5 facilities(100-kV and above) and a combination of all ATC 345-kV facilities (including ATC 345/138-kV transformers) and generators (100 MW and above).

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In 2009, we analyzed the potentially severe multiple outage lists from prior study years. Additional Category C events were evaluated by a comprehensive screening of Zone 1 facilities that included all 100-kV and above branches within Zone 1 and all 100-kV and above ties to Zone 1. This analysis also included a comprehensive screening of the entire ATC 345-kV system (including transformers with a 345 kV high-side), all 100-kV and above connected generators within the ATC transmission system and all 100-kV and above tie lines to our neighboring transmission networks. In addition, a comprehensive screening of NERC Category C.1 (bus section) and C.2 (breaker failure) events across the entire ATC transmission system were evaluated for all facilities 100-kV and above.

In 2010, we analyzed the potentially severe multiple outage lists from prior study years. Additional Category C events were evaluated by a comprehensive screening of Zone 2 and Zone 4 facilities that included all 100-kV and above branches within Zone 2 and Zone 4, all 100-kV and above ties to Zone 2 and Zone 4 and all 100-kV and above connected generators within Zone 2 and Zone 4. This analysis also included a comprehensive screening of the entire ATC 345-kV system (including transformers with a 345 kV high-side), all 100-kV and above connected generators within the ATC transmission system and all 100-kV and above tie lines to our neighboring transmission networks. In last half of 2010, we performed a comprehensive C.9 analysis.

For 2011, we analyzed the potentially severe multiple outage lists from prior study years. Additional Category C events were evaluated by a comprehensive screening of Zone 3 facilities that included all 100-kV and above branches within Zone 3, all 100-kV and above ties to Zone 3 and all 100-kV and above connected generators within Zone 3. This analysis also included a comprehensive screening of the entire ATC 345-kV system (including transformers with a 345 kV high-side), all 100-kV and above connected generators within the ATC transmission system and all 100-kV and above tie lines to our neighboring transmission networks.

In the 2011 analysis, ATC used the 2016 and 2021 all projects summer peak (100% of peak load) and off peak (70% of peak load) models with all ATC generators reactive power capability reduced to 95% of the maximum capability. Models with generators at 95% reactive power were used because of the ATC multiple outage planning criteria which states that the post contingency voltage thresholds should be met with the net generator reactive power limited to 95% of the applicable reactive power capability. Physical Operational Margin (POM) – Optimal Mitigation Measures (OPM) software was used to identify potential, large load shed or generation re-dispatch requirements. Table 1-1 below contains a summary of the NERC Category C types of outages that were performed for the 2011 TYA.

Table 1-1: Summary of the NERC Category C Outages Types

ATC System Studies	2016 & 2021 Summer Peak				2016 & 2021 70% Summer Peak			
	C1 & C2	C3	C5	C6 - C9	C1 & C2	C3	C5	C6 - C9
Zone 1	Severe List	Severe List	Severe List	See Notes 1 & 2	Severe List	Severe List	Not Analyzed (See note 3)	See Notes 1 & 2
Zone 2								
Zone 3		All	All			All		
Zone 4		Severe List	Severe List			Severe List		
Zone 5								
ATC 230-kV and above		All	All			All		

Note 1: For the ATC transmission system - C6 covered by B1, C1 & C2. C7 covered by C1, C2 & C3 without manual system adjustments. C8 covered by C1 and C2.

Note 2: For the ATC transmission system – C9 stuck breaker covered by C2. For the C9 with protection system failure not covered by C1 and C2, they were simulated using 2010 Assessment summer peak models for 2015 and 2020 only.

Note 3: C5 outages were not analyzed for off peak models because off peak models studies were intended to identify constraints under system maintenance conditions (N-1-1). Additionally, the impacts produced by C5 outages at peak load would be more severe than the impacts produced at off peak period.

ATC enhanced multiple outage screening in 2011 TYA by analyzing all ATC 230-kV and above system elements as compared to 345-kV and above system elements in the previous analyses.

The following contingencies were analyzed for this assessment:

- For the 2016 and 2021 analyses, from the 2010 study, the set of 84 selected severe Category C contingencies.
- All 230-kV branches (including 345/138-kV transformers) and generators connected to ATC Bulk Electric System, including all 100-kV and above ties to the 230-kV and above system.
- ATC's planning Zone 3 100-kV and above, including all 100-kV and above ties to Zone 3 and Zone 3 generators connected to the bulk electric system.

In 2016 summer peak, out of the 133 valid contingencies that caused system constraints, 16 contingencies required 100 MW or greater of load shedding to mitigate in addition to other remedial actions. In 2021 summer peak, out of the 167 valid contingencies that caused system constraints, seven contingencies required 100 MW or greater of load-shedding to mitigate in addition to other remedial actions. For the summer peak studies, ATC estimates that cascading could be ruled out on our modeled 2016 and 2021 summer peak systems through the use of specific load shedding and/or generation redispatch.

Further review will be done by System Planning and System Operations to develop or confirm appropriate and more specific mitigation solutions.

The 2016 and 2021 summer off peak study results show that there are potentially no Category C severe multiple outages in 2016 and 2021 summer off peak periods since none of the outages potentially require 100 MW or greater of load shedding to mitigate.

Considering the summer off peak studies as maintenance outage scenarios (Category B outages under system maintenance), the screening results show that in 2016, out of a total of 62 valid outages that caused system constraints, 11 outages could potentially require load shedding to mitigate. The 2021 off peak model studies show that out of the 43 outages that caused system constraints, 13 outages could potentially require load shedding to mitigate. These outages will be investigated further to confirm the needs and the appropriate mitigation measures. In general, the maintenance outage situation seems to be degrading as time passes. ATC's future studies will identify whether additional mitigation, beyond the 2011 TYA projects, is needed to maintain appropriate maintenance outage conditions.

NERC Category D

ATC assessed its transmission system for the conditions of Category D in Table 1 of the NERC TPL-004-0 Reliability Standard in 2011 for the near-term (2012 to 2016) horizon. ATC has performed Category D assessments annually since its inception in 2001 using a variety of current year and past year studies and simulations to address Category D outage types in Table 1. The most recent steady state studies and simulations are no more than five years old. On a rolling five year cycle, the Category D studies and simulations covers some aspect of every year in the near-term planning horizon. To meet the requirements regarding Critical Energy Infrastructure Information (CEII) the detailed results of these analyses are only available to signatories of CEII agreements.

We performed steady state Category D analyses for a range of conditions and study years. Over the past 5 years, we performed multiple generation interconnection studies using various models for the planned in-service years for Category D1 through D5 contingencies. Also in the past, MISO has performed studies for shoulder model conditions for selected Category D2, D3, and D4 contingencies [MTEP08, MTEP09, & MTEP10] using the five year future model. In 2010, we performed analyses that used the summer peak, all-project models for the study years of 2015 and 2020 for Category D6 through D10 contingencies.

For Category D11, ATC understands "a large load or major load center" to be either a single 100 kV and above end-use customer interconnected at one substation with 300 MW or more load (i.e. "a large load") or a 100 kV and above interconnected distribution

substation serving 300 MW or more of load (i.e. “major load center”), which is consistent with the load at risk threshold of CIP-002 requirement 1.2.5. ATC does not have any single end-use customers or interconnected distribution substations that meet these thresholds. Therefore, no Category D11 analysis is required.

For SPS studies (Category D12 and D13) in accordance with the MRO and RFC procedures for implementing PRC-012 and PRC-014, ATC performs an assessment of each Special Protection System for review by the applicable Regional Entity. These reviews include an assessment of the BES performance without the Special Protection System installed, which replicates a D12 contingency. These reviews also include an assessment of the BES performance for the inadvertent operation of the Special Protection System, which replicates a D13 contingency.

For Category D14, both MRO and RFC have performed analysis of severe power system disturbances for actual system events (e.g., August 2003 initiating event in RFC and September 2008 initiating event in MRO). These analyses have not identified a significant impact on the ATC system under these severe disturbances. Therefore, severe power swings or oscillations in another Regional Entity beyond the MRO and RFC will have an even less significant impact on the ATC system.

The Category D analyses are performed using system models that were drawn from the latest MMWG series of power system models that are available in the year prior to the year that the analyses were performed. Each of the MMWG models has all of the projected firm transfers for the applicable years described in the Methodology and Assumptions Section.

The Category D analyses were performed using the latest all-projects models, which include all of the existing and planned projects for the applicable power system model year as described in the All Projects Model Analysis Section.

The Category D analyses included Reactive Power resources to ensure that adequate reactive resources are available to meet system performance. We considered the static and dynamic reactive resources that were expected to be available in the years that were studied. In general, some margin of reactive resource capability was considered by modeling generator var output at reduced levels. We screened for voltage stability in the Category D contingencies, as noted in the Voltage Stability Section.

We included the effects of existing and planned protection systems in the Category D analyses by simulating event based outages. The Methodology and Assumptions Section discusses the inclusion of all existing and planned protection systems that would be applicable to the assessments. Previous year assessments can also be viewed to see that these assumptions were used to build models that have been used in ATC Category D

analysis. Dynamic studies in particular simulate protection scheme operating times, associated breaker clearing times, and back up device tripping functionality.

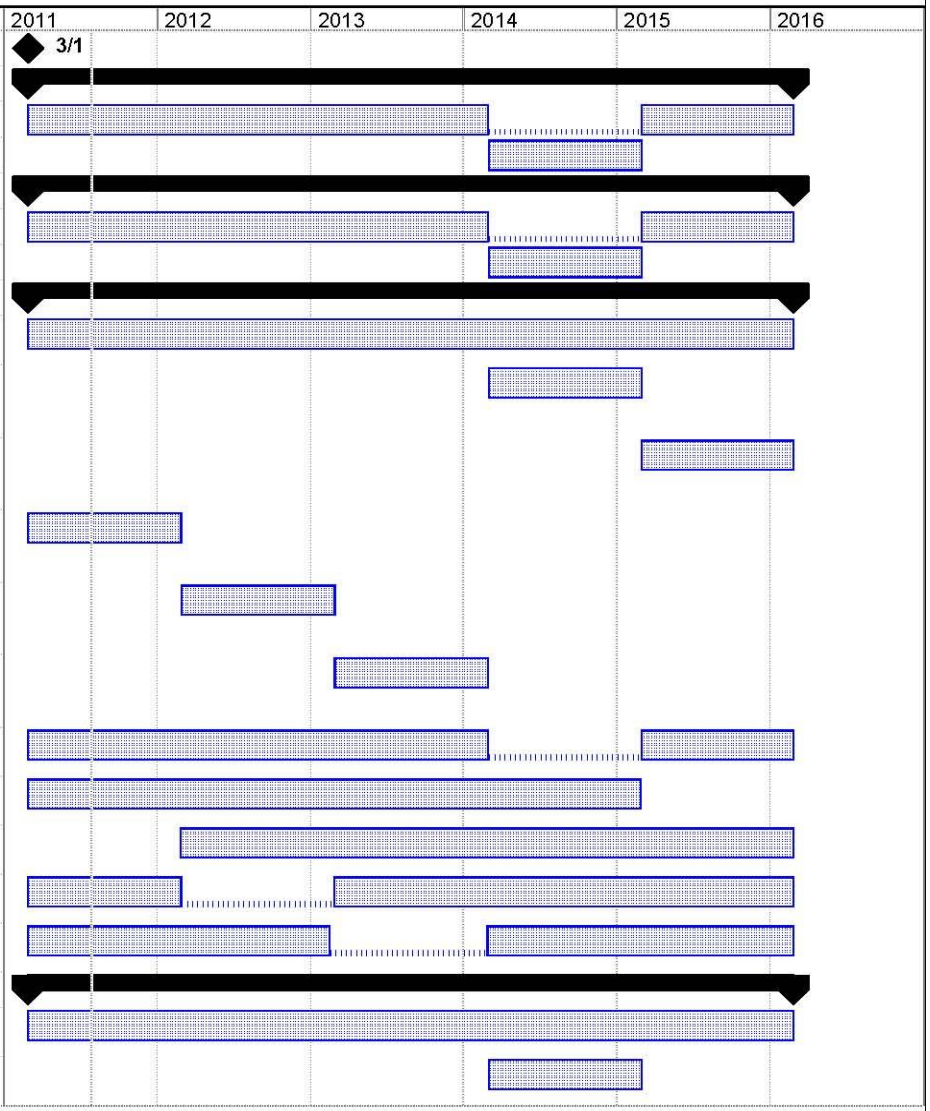
We included all existing and planned transmission control devices in our current and past studies and simulations. As in prior 10-Year Assessments, the Methodology and Assumptions Section explains the inclusion of all control devices that would be applicable to this assessment. These control devices included, but are not limited to: transformer automatic tap changers, phase shifters, automatic reactive compensation devices, and DVAR units.

We considered any planned facility outages in our current and past studies and simulations. A planned facility outage is a scheduled facility outage that ATC knows of soon enough to include in its planning horizon models. ATC was not aware of any specific facility outages scheduled for the planning horizon at the demand levels that were studied. As the future unfolds and facility outages are scheduled, they are scheduled for conditions that provide acceptable reliability. For short term (next 6 months) outage planning, ATC performs planned outage analysis for the appropriate demand levels.

Table MO-1: TPL-003-004 Steady State Analysis Schedule

TPL-003 and TPL-004 Steady State Analysis Schedule
(Final July 28, 2011)

ID	Task Name	Duration
1	No analysis needed for C.4, C.6, C.7, C.8, D.1-D.5, D.11-D.14	0 days
2	**C.1 Analysis**	**1304 days**
3	More severe C.1 list (100+ MW load shed)	1044 days
4	Comprehensive C.1 contingency list (100+kV, All ATC)	261 days
5	**C.2 Analysis**	**1304 days**
6	More severe C.2 list (100+ MW load shed)	1044 days
7	Comprehensive C.2 contingency list (100+kV, All ATC)	261 days
8	**C.3 Analysis**	**1304 days**
9	All two element combinations of the set of ATC 345-kV lines, 345-kV tie lines, 345kV transformers and 100+kV connected	1304 days
10	Zone 1x1, 1x2 and 1x3: All two element combinations of Zone 1 single contingencies with Zone 1, 2 and 3 single contingencies	261 days
11	Zone 2x2, 2x3 and 2x4: All two element combinations of Zone 2 single contingencies with Zone 2, 3 and 4 single contingencies	260 days
12	Zone 3x3, 3x4 and 3x5: All two element combinations of Zone 3 single contingencies with Zone 3, 4 and 5 single contingencies	261 days
13	Zone 4x4, 4x5 and 4x1: All two element combinations of Zone 4 single contingencies with Zone 4, 5 and 1 single contingencies	261 days
14	Zone 5x5, 5x1 and 5x2: All two element combinations of Zone 5 single contingencies with Zone 5, 1 and 2 single contingencies	261 days
15	Zone 1x1, 1x2 and 1x3: More severe C.3 list for these zone combinations (100+ MW load shed)	1044 days
16	Zone 2x2, 2x3 and 2x4: More severe C.3 list for these zone combinations (100+ MW load shed)	1044 days
17	Zone 3x3, 3x4 and 3x5: More severe C.3 list for these zone combinations (100+ MW load shed)	1044 days
18	Zone 4x4, 4x5 and 4x1: More severe C.3 list for these zone combinations (100+ MW load shed)	1043 days
19	Zone 5x5, 5x1 and 5x2: More severe C.3 list for these zone combinations (100+ MW load shed)	1035 days
20	**C.5 Analysis**	**1304 days**
21	All double circuits in the set of ATC 345-kV lines and 345-kV tie lines	1304 days
22	Zone 1: All double circuits in the set of ATC 100-kV lines and 100-kV tie lines for Zone 1	261 days

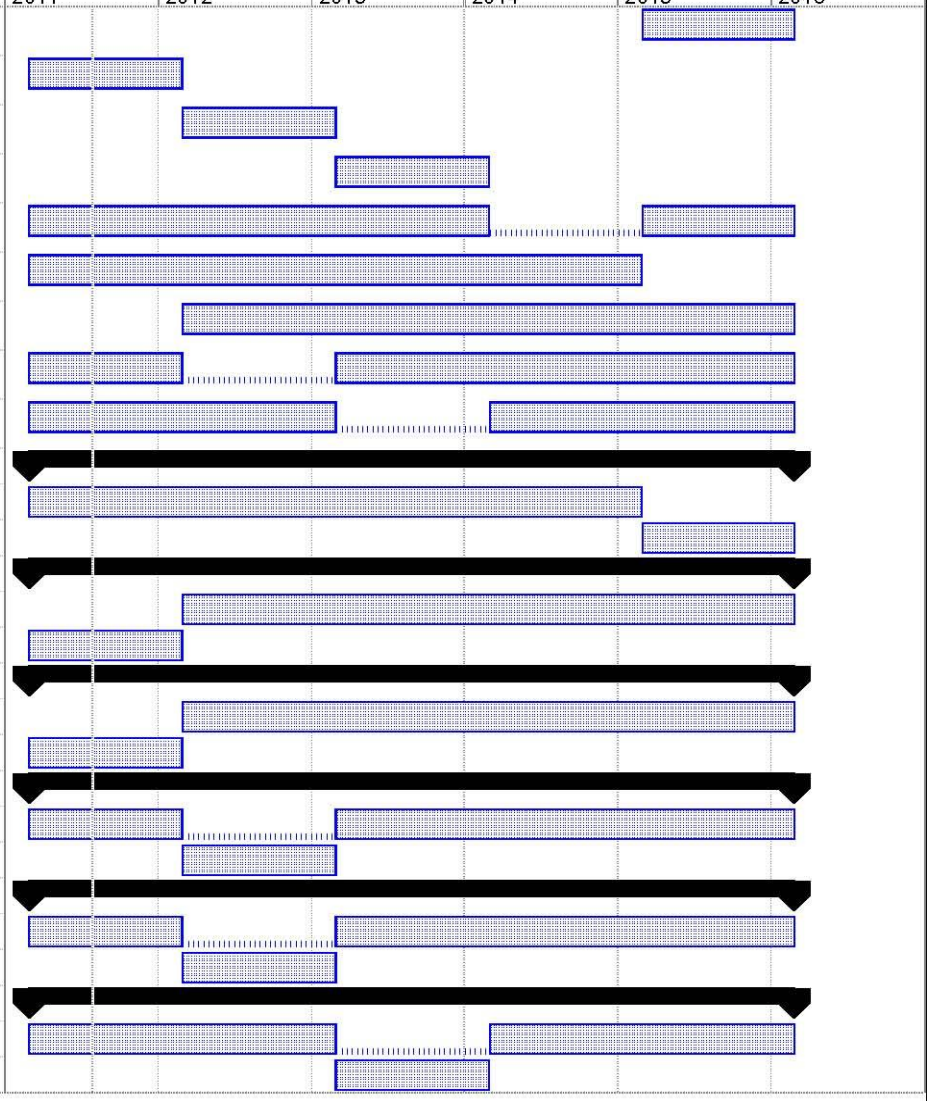


Project: TPL-003-004 Schedule (Final
Date: Thu 7/28/11

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

TPL-003 and TPL-004 Steady State Analysis Schedule
(Final July 28, 2011)

ID	Task Name	Duration
23	Zone 2: All double circuits in the set of ATC 100-kV lines and 100-kV tie lines for Zone 2	260 days
24	Zone 3: All double circuits in the set of ATC 100-kV lines and 100-kV tie lines for Zone 3	261 days
25	Zone 4: All double circuits in the set of ATC 100-kV lines and 100-kV tie lines for Zone 4	261 days
26	Zone 5: All double circuits in the set of ATC 100-kV lines and 100-kV tie lines for Zone 5	261 days
27	Zone 1: Last year's more severe C.5 list for Zone 1 (100+ MW load shed)	1044 days
28	Zone 2: Last year's more severe C.5 list for Zone 2 (100+ MW load shed)	1044 days
29	Zone 3: Last year's more severe C.5 list for Zone 3 (100+ MW load shed)	1042 days
30	Zone 4: Last year's more severe C.5 list for Zone 4 (100+ MW load shed)	1042 days
31	Zone 5: Last year's more severe C.5 list for Zone 5 (100+ MW load shed)	1043 days
32	**C.9 Analysis**	**1304 days**
33	Last year's more severe C.9 list (100+ MW load shed)	1044 days
34	Comprehensive C.9 contingency list (100+kV, All ATC)	260 days
35	**D.6 Analysis**	**1304 days**
36	Last year's more severe D.6 list (100+ MW load shed)	1042 days
37	Comprehensive D.6 contingency list (100+kV, All ATC)	261 days
38	**D.7 Analysis**	**1304 days**
39	Last year's more severe D.7 list (100+ MW load shed)	1042 days
40	Comprehensive D.7 contingency list (100+kV, All ATC)	261 days
41	**D.8 Analysis**	**1304 days**
42	Last year's more severe D.8 list (100+ MW load shed)	1042 days
43	Comprehensive D.8 contingency list (100+kV, All ATC)	261 days
44	**D.9 Analysis**	**1304 days**
45	Last year's more severe D.9 list (100+ MW load shed)	1042 days
46	Comprehensive D.9 contingency list (100+kV, All ATC)	261 days
47	**D.10 Analysis**	**1304 days**
48	Last year's more severe D.10 list (100+ MW load shed)	1043 days
49	Comprehensive D.10 contingency list (100+kV, All ATC)	261 days



Project: TPL-003-004 Schedule (Final
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Task
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