

System Operating Limits

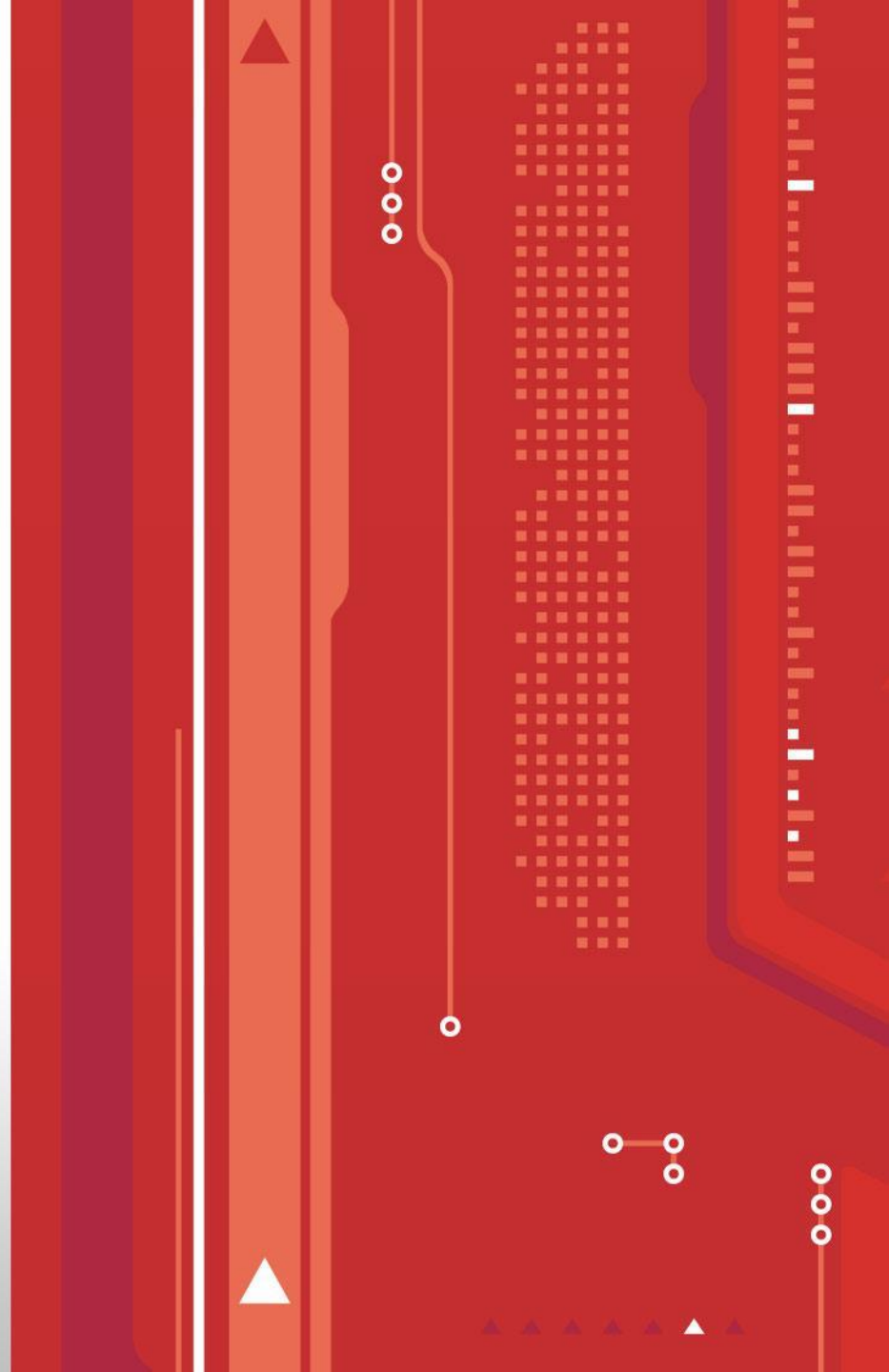
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Greg Sorenson, PE

Senior Compliance Engineer

gsorenson.re@spp.org

501.688.1713



Outline

- **NERC Definitions**
- **FERC Order comments**
- **Power flow, voltage, and stability**
- **System Operating Limits (SOL) development**
- **Internal Control Concerns**
- **Audit techniques for SOLs**

Related Violations We Have Seen....

- **FAC-008 -1, FAC-009-1, FAC-008-3 (facility ratings)**
 - Top 5 most violated Order 693 standards
- **TOP-002-2.1b, R11 (SOL studies)**
 - Many Transmission Operators (TOPs) had violations of this requirement
- **TPL 003-2b R1.3.10 (protections system in TPL studies)**
 - Long-standing failed protection systems not studied
- **TOP-004-2 R4 (unknown operating state)**
 - Common violation after an event occurs; could this be prevented?

NERC Definition - *System Operating Limits*

The value (such as MW, MVar, Amperes, Frequency or Volts) that satisfies the *most limiting* (emphasis added) of the prescribed operating criteria for a specified system configuration to ensure operation within acceptable reliability criteria. System Operating Limits are based upon certain operating criteria.

These include, but are not limited to:

- **Facility Ratings** (Applicable pre- and post-Contingency equipment or facility ratings)
- **Transient Stability Ratings** (Applicable pre- and post- Contingency Stability Limits)
- **Voltage Stability Ratings** (Applicable pre- and post- Contingency Voltage Stability)
- **System Voltage Limits** (Applicable pre- and post- Contingency Voltage Limits)

NERC Definitions

- ***Facility Ratings:***

The maximum or minimum voltage, current, frequency, or real or reactive power flow through a facility that does not violate the applicable equipment rating of any equipment comprising the facility.

- ***Stability Limit:***

The maximum power flow possible through some particular point in the system while maintaining stability in the entire system or the part of the system to which the stability limit refers.

- ***Interconnection Reliability Operating Limit (IROL):***

A System Operating Limit that, if violated, could lead to instability, uncontrolled separation, or Cascading outages that adversely impact the reliability of the Bulk Electric System.

NERC Definitions

- ***Total Transfer Capacity (TTC):***

The amount of electric power that can be moved or transferred reliably from one area to another area of the interconnected transmission systems by way of all transmission lines (or paths) between those areas under specified system conditions.

- ***Total Flowgate Capacity (TFC):***

The maximum flow capability on a Flowgate, is not to exceed its thermal rating, or in the case of a Flowgate used to represent a specific operating constraint (such as a voltage or stability limit), is not to exceed the associated System Operating Limit.

FERC Orders 748 and 705

- Order 748:
 - The TOP is the registered entity with primary responsibility for the determination of SOLs
- Order 705:
 - TTC and SOL studies should have similar assumptions
 - SOLs protect against exceeding Facility Ratings, Voltage Limits, and Stability Limits
 - Pre-contingency and post-contingency flows and voltages should be assessed and analyzed
 - Every facility does not have to have an SOL, however no Facility Rating should be exceeded and all voltage and stability limits are respected when the system is operated within the SOLs

FERC Order 754 and NERC TPL Filing

- Order 754
 - Normal clearing actions of Protective Systems should be studied
- NERC filing for TPL-003 and TPL-004 interpretation
 - Effect of Protection System failures should be studied in planning
 - FERC approved

FERC Orders* Approving Stipulation and Consent Agreements

- **Post-fault effects of:**
 - **Failed Protection Systems**
 - **Unrepaired Protection Systems components (i.e. carriers)**
 - **Reconfiguration of Protection Systems**
 - **Disabling of Protection Systems**

on the BES must be assessed in operational studies, and new SOLs determined, if needed

[*136 FERC ¶61,132](#), [137 FERC ¶ 61,176](#), [129 FERC¶ 61,016](#)

Voltage and Stability Concerns

1. Voltage Concerns

- Switching for maintenance may not occur at peak hour, which is typically main voltage study time
- Incorrect Voltage Limit determination contributed to 2003 blackout
- Studies may not identify all voltage limit problems depending on study method used
- Voltage transients may affect plant operation

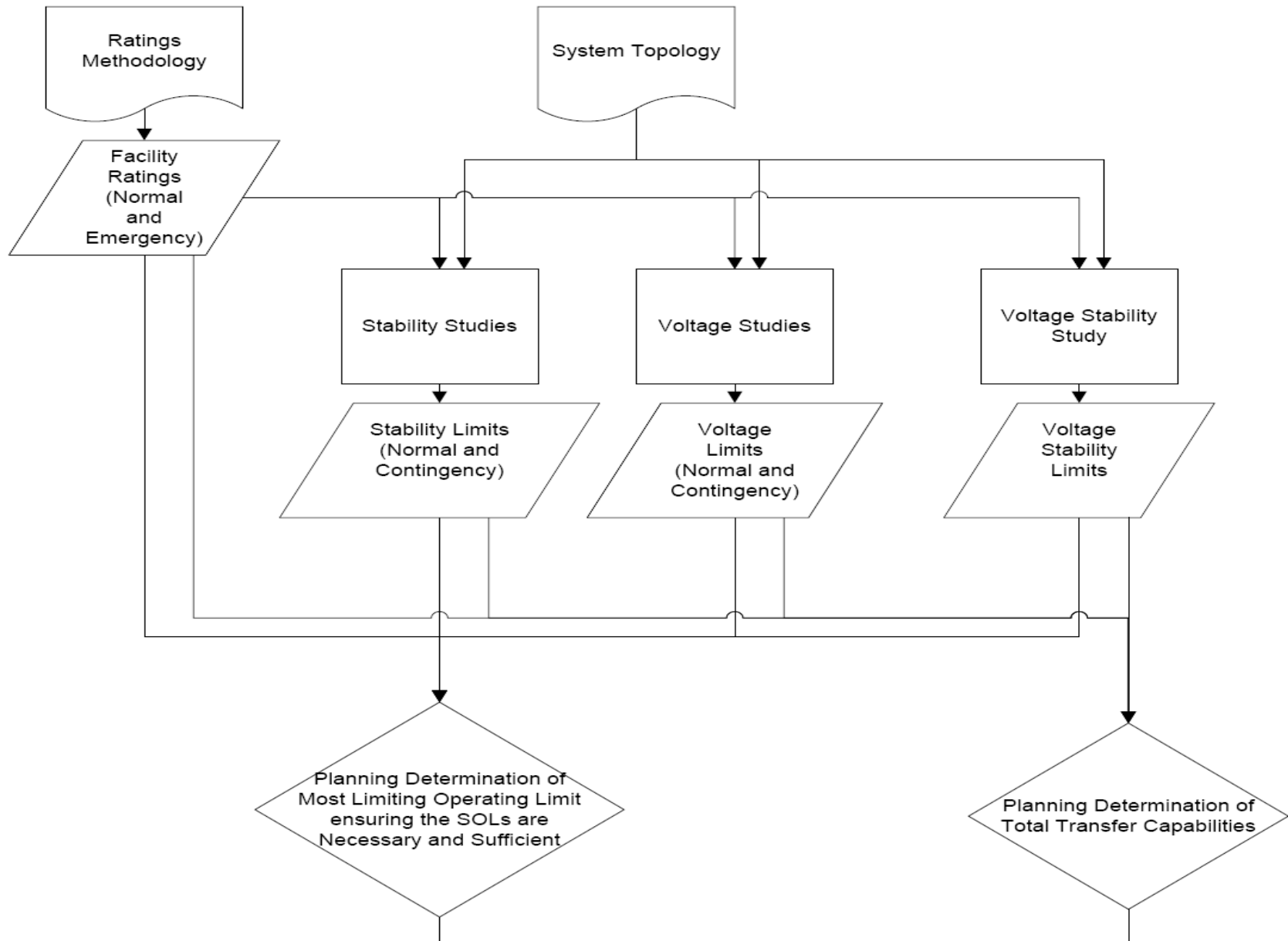
2. Stability Concerns

- Stability limits raised through TPL studies

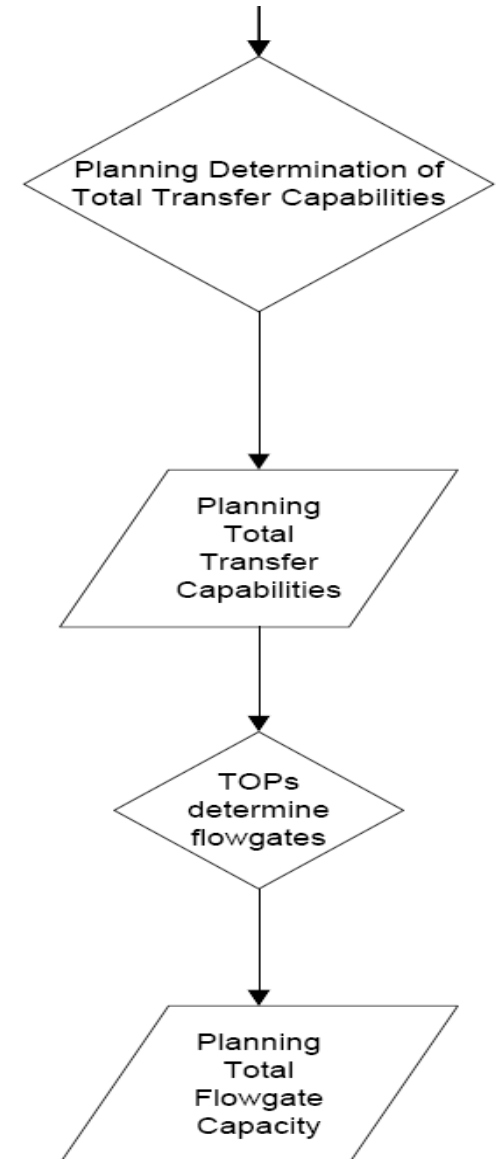
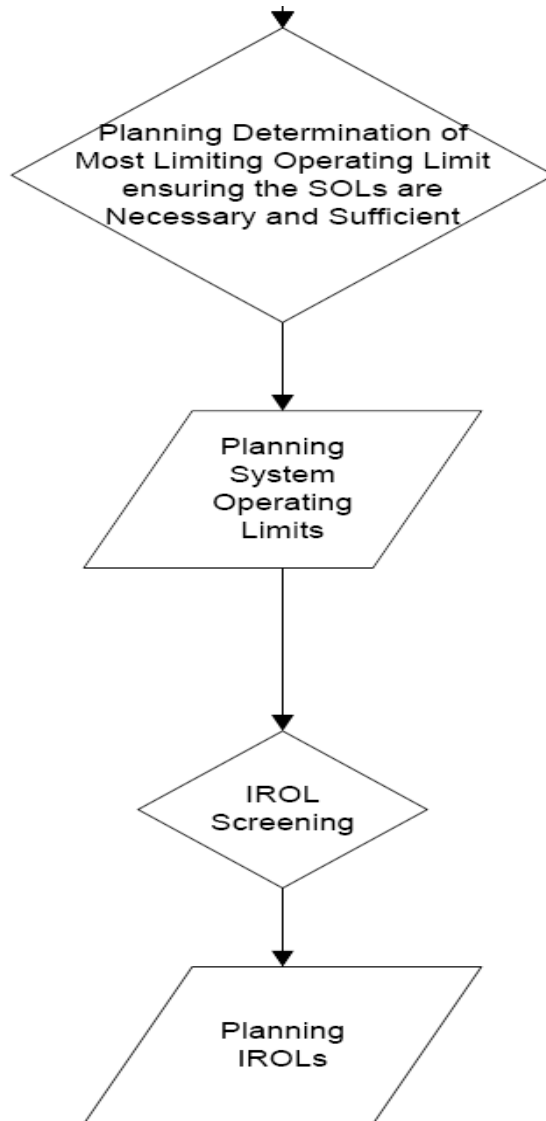
Voltage and Stability Concerns

3. Transformation of Voltage and Stability limits to a flow representation is possible
 - TPs/TOPs must be able to explain and demonstrate how these are incorporated if this method is used
 - TPs/TOPs must be able to explain how the flow representations capture all voltage and stability limits
 - Alarming in EMS and Real-Time Contingency Analysis (RTCA) are additional ways to show that voltage and stability concerns are addressed

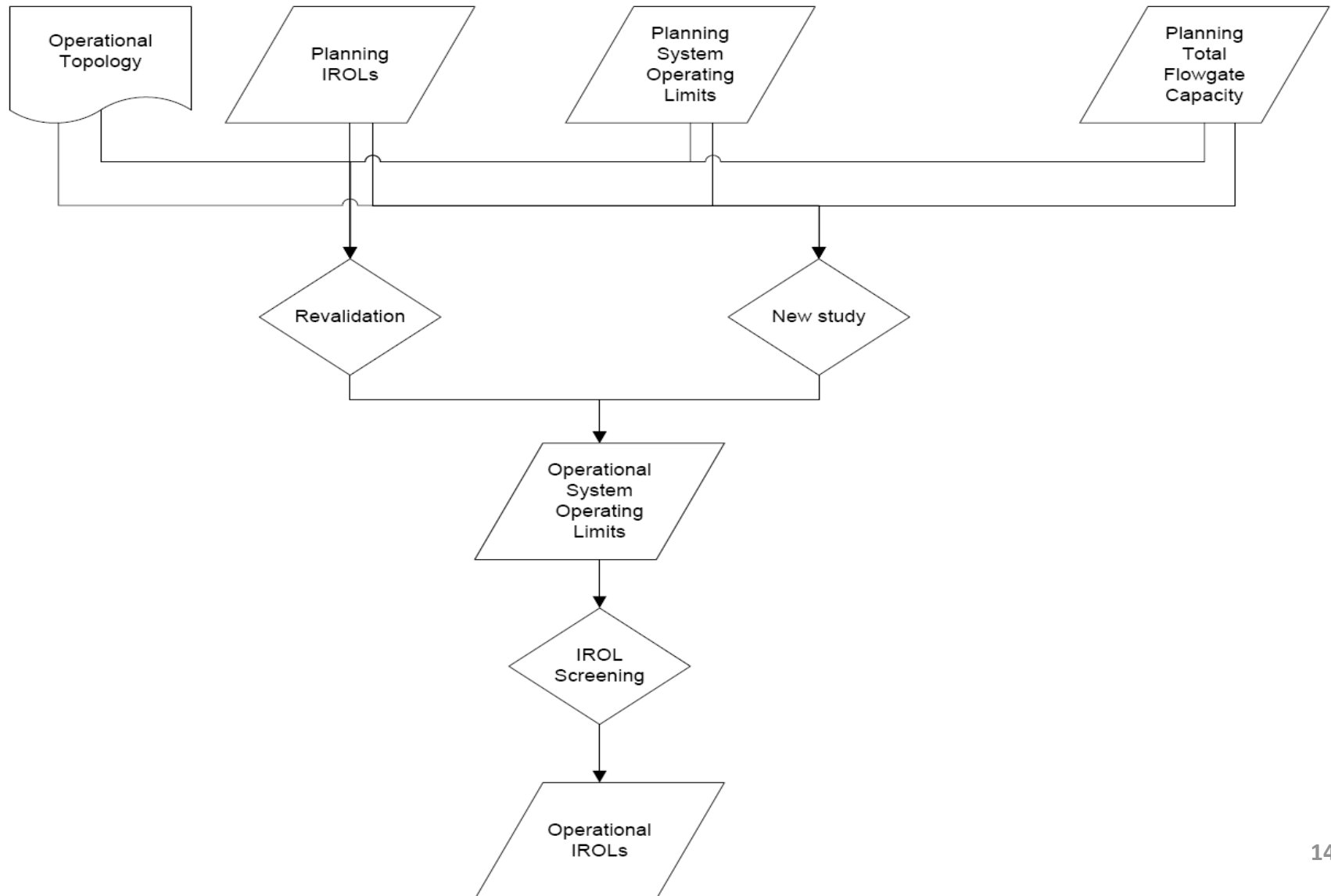
SOL Development



SOL Development



SOL Development in Operations Horizon



Planning vs. Operational Studies

- **All lines in service assumption vs. 10-40 lines out of service for maintenance across the SPP RTO**
- **All generation available vs. actual generation available**
- **Chosen dispatch vs. Market/Variable dispatch**
- **All Protection Systems Operational vs. Broken equipment**
- **Set hour vs. Peak, minimum, or switching hour**
- **Estimated in-service date vs. actual in-service date**
- **Fixed ratings vs. Dynamic ratings**

Planning Internal Control Examples (1 of 2)

Procedure/ Process	Control	Control Activity	Control Type
Facility Ratings	Construction Review	Facility ratings are reviewed after construction is complete to ensure as built is correct and rating correct	Detective
Model development	Configuration Management	All rating changes to systems are reviewed, approved, and double checked after implementation to ensure accuracy of all study models	Preventive
SOL Correction Plan	Pre-planned actions	Plan to reduce flow was developed ahead of time. Operator takes action when SOL exceeded.	Corrective
Outage Approval	Protection System review	Review to see effect of Zone 2 tripping near area of proposed outage. Review to see if an unusual situation is created that would cause Zone 1 to fail.	Preventive

Planning Internal Control Examples (2 of 2)

Procedure/ Process	Control	Control Activity	Control Type
OPM auto-mitigations	Feasibility Review	Sample OPM (optimal mitigation measures) re-dispatches to make sure they are feasible and make sense	Detective
SPP Project tracking	Mitigation for late projects	Develop and submit mitigation plans that describe actions needed for projects that will be completed after RTO need date	Preventive
Model benchmark	Model benchmark	Compare flows in model to flows in real world on a certain day/hour. Investigate unusual deviations	Detective
Model Series	MDWG Manual	Models will follow Model Development Working Group Manual specifications. Exceptions must be approved by Transmission Working Group.	Preventive

Operations Internal Control Examples (1 of 2)

Procedure/ Process	Control	Control Activity	Control Type
Monitoring SOLs	EMS Alarm	Systems are configured to alarm when SOLs are approached.	Detective
Model development	Configuration Management	All rating changes to systems are reviewed, approved, and double checked after implementation to ensure accuracy of all study models	Preventive
SOL Correction Plan	Pre-planned actions	Plan to reduce flow was developed ahead of time. Operator takes action when SOL exceeded.	Corrective
Outage Approval	Protection System review	Review to see effect of Zone 2 tripping near area of proposed outage. Review to see if an unusual situation is created that would cause Zone 1 to fail.	Corrective

Operations Internal Control Examples (2 of 2)

Procedure/ Process	Control	Control Activity	Control Type
SOL development	TOP Management Review	TOP reviews proposed SOLs and ensures that they will ensure that all ratings will be respected and voltage and stability limits considered.	Preventive
SOL Revalidation	System Topology review	Review of the plants in service and transmission lines in service since the last review of SOLs. Could changes affect the SOLs?	Preventive/ Detective
SOL Correction Plan	Independent Monitoring	TOP contacts SPP to confirm that both parties agree on who is taking what action if the situation worsens and that both will monitor.	Detective/ Corrective
Real-time SOL monitoring	RTCA System	TOP Operator reviews RTCA results at a specified interval and takes action when needed.	Preventive Control

Auditing the SOL Process/Evidence should answer...

- **Are Facility Ratings correctly determined?**
- **Are planning models and operational models correct?**
- **Are stability limits, voltage limits, and voltage stability limits correctly determined?**
- **Are both pre- and post- contingency situations studied?**
- **Are the assumptions underlying the studies clearly described?**
- **Are the planning SOLs sufficient for the current topology?**

Auditing the SOL Process/Evidence should answer...

- **Are Protective System actions and statuses correctly considered?**
- **Are all SOLs identified?**
- **Are SOLs screened for IROLs?**
- **Are System Operators aware of all SOLs on, affected by, affecting, or protecting the TOP's system?**
- **If a third-party (i.e. SPP RC or SPP PC) conducts the studies, how does the TP/TOP ensure accurate input to the studies and review study outputs?**
- **Are feasible plans developed as needed to address potential SOL violations?**

Sample Evidence May Include....

- **FAC-008-3 R6**
 - Sample of facility ratings and underlying component data to demonstrate ratings were developed per FAC methodology
- **TPL standards, TOP-002-2.1b R11**
 - Sampled facility ratings match models used for studies
- **TOP-002-2.1b R6, R11 and VAR-001-2, R9**
 - A sample of operating days will be reviewed to ensure SOLs were developed/revalidated and SOL mitigation plans were developed/implemented
 - If third party studies are used, was positive evidence of TOP review provided?

QUESTIONS?

Summary

- **TPs are obligated to develop Planning SOLs**
- **TOPs are obligated to develop Operational SOLs**
- **SOLs will protect system from exceeding facility ratings, voltage limits, and stability limits**
- **Planning SOLs form the basis for the Operational SOLs**
- **Internal controls can help ensure SOLs are identified and respected**
- **SPP RE auditing will look at model development, planning studies, SOLs, operating plans, next day studies, RTCA assumptions, operator use of tools**

Other Outreach

- [Oct. 8-9 Workshop](#), in Little Rock and via webinar
 - Includes break-out discussion on SOL
- Check out our [training videos!](#)

