Pacific Northwest
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Operationalizing Notifications from Interconnection-Wide Oscillation Monitoring Tools

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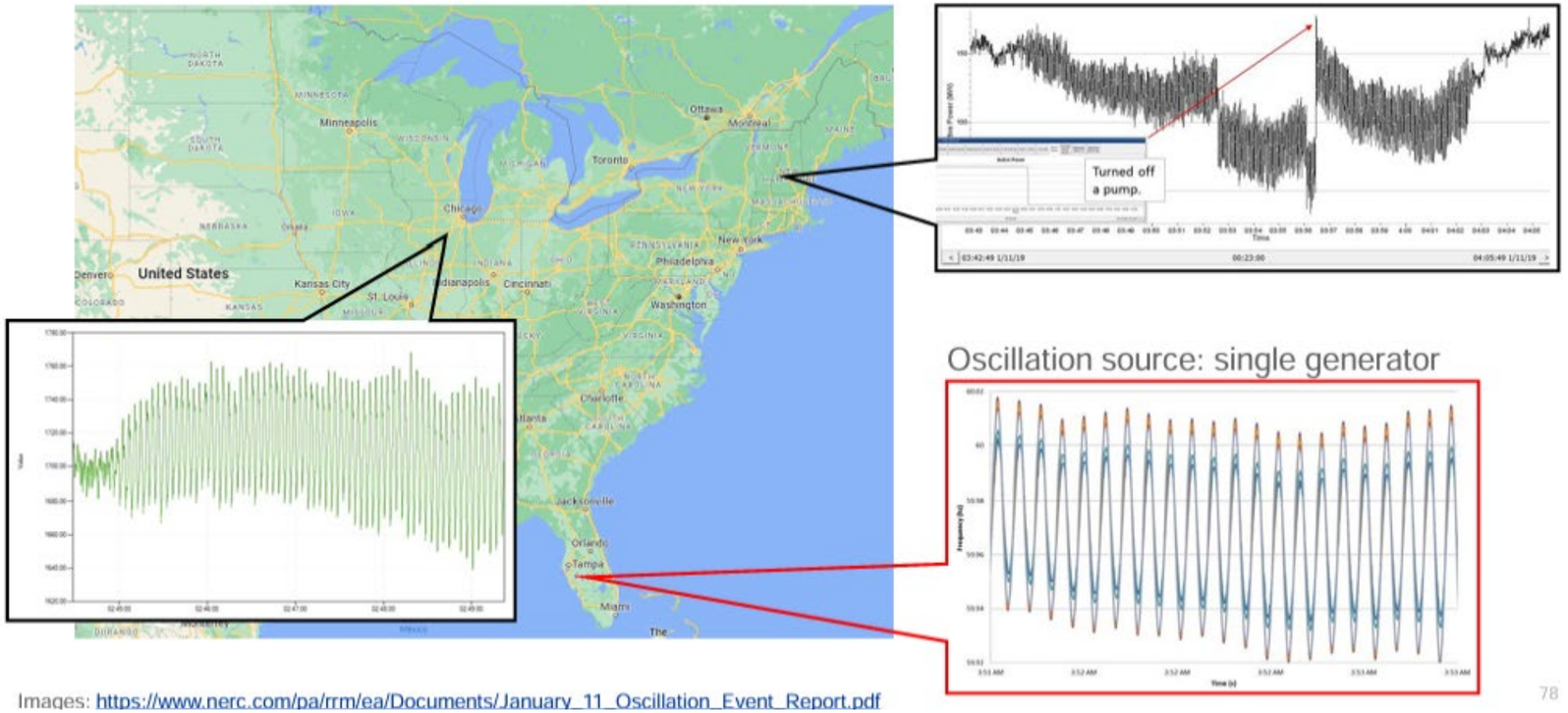
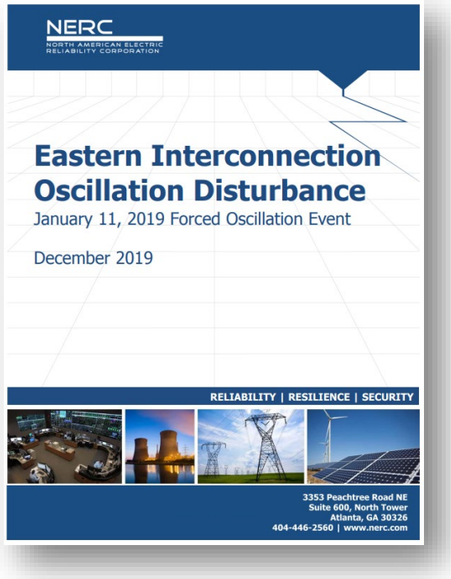
PNNL-SA-208017

The Need for Interconnection-wide Monitoring

- Reliability coordinators have excellent visibility within their footprints but may lack interconnection-wide information.
- Oscillation amplitudes may get amplified at locations away from the source due to resonance.

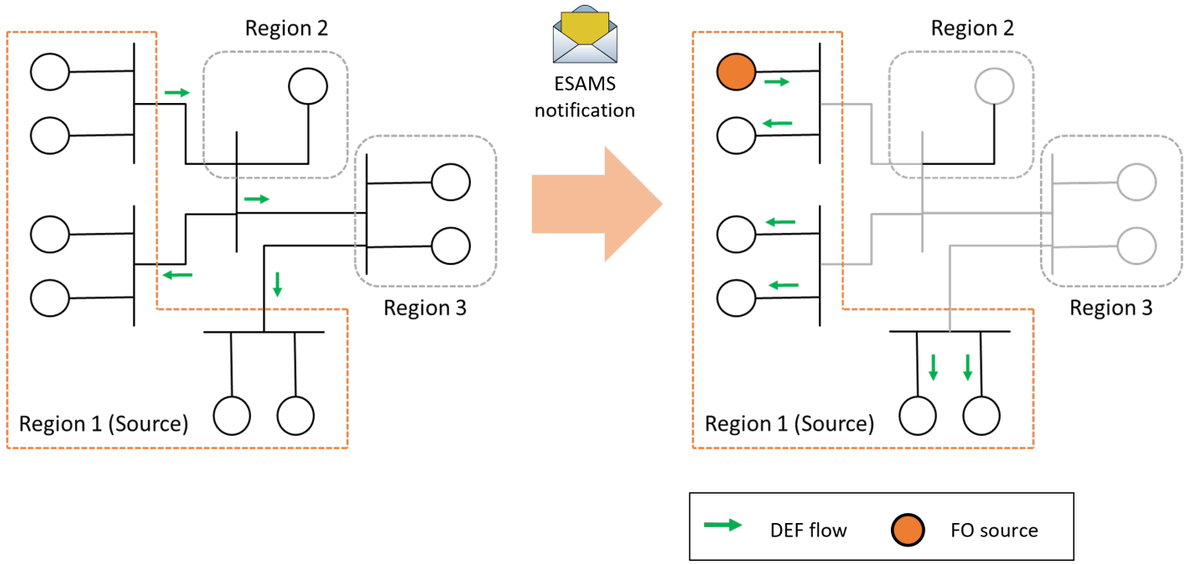


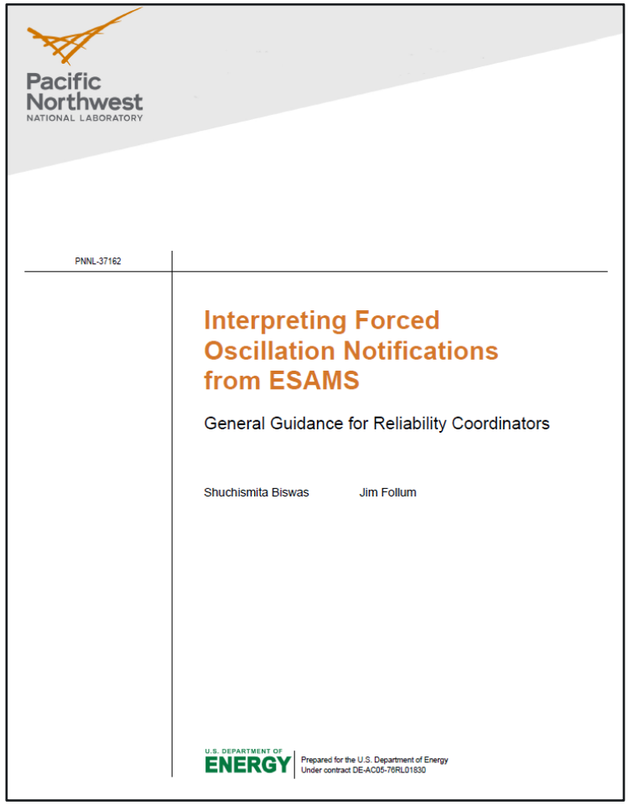
Images: https://www.nerc.com/pa/rrm/ea/Documents/January_11_Oscillation_Event_Report.pdf



"RCs should consider jointly developing interconnection-wide oscillation detection and source location applications…"

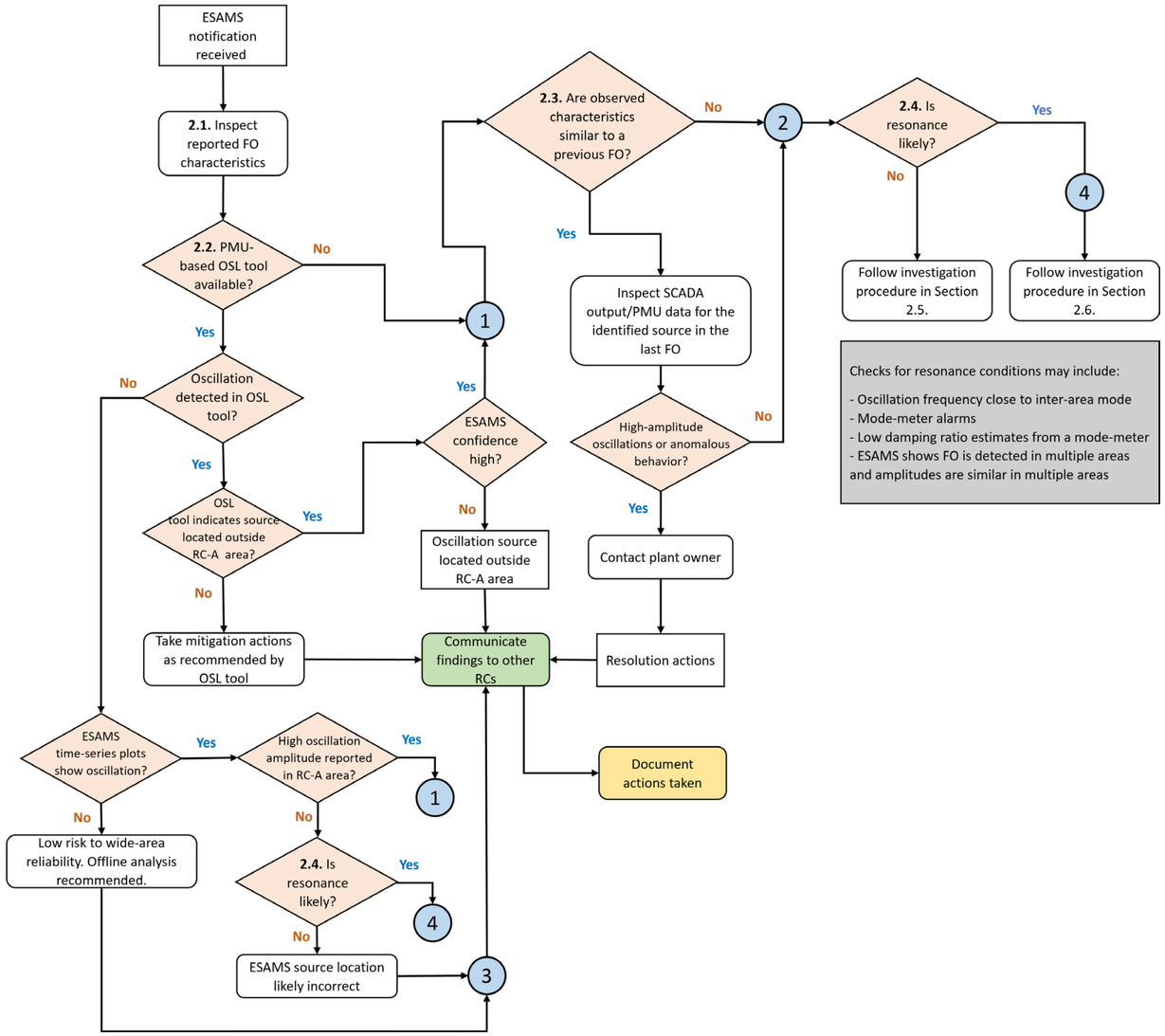
EI Situational Awareness Monitoring System (ESAMS)



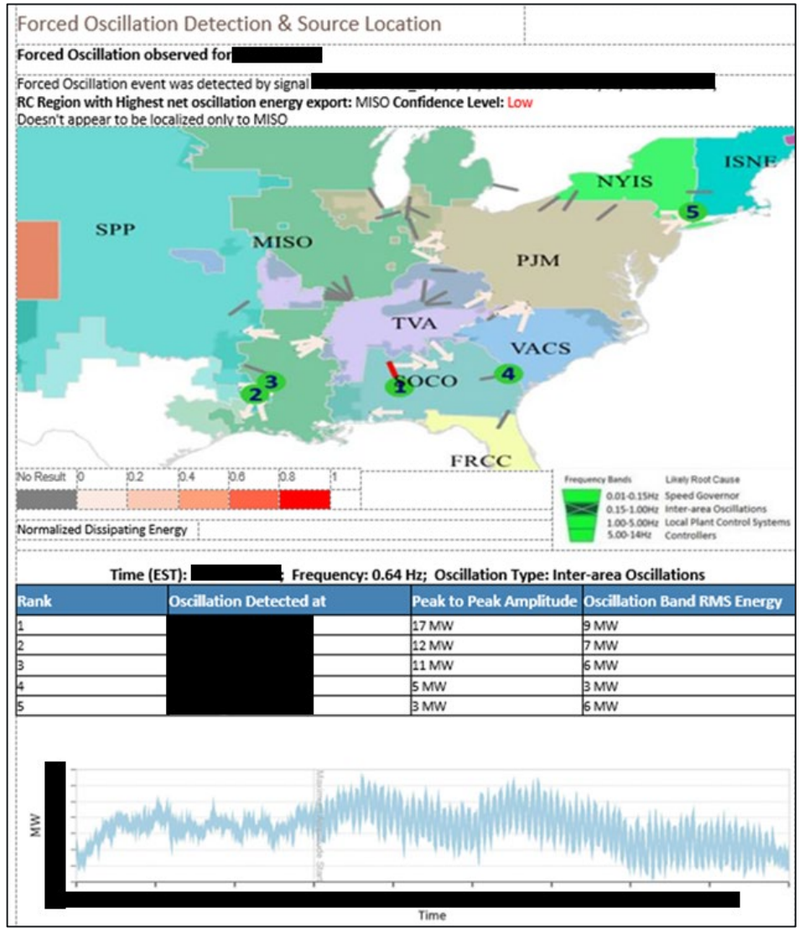


- Partnership between PNNL, EPG, and LBNL.
- Seven RCs participated in initial field demonstration.
- ESAMS is intended to complement, not duplicate or replace, system operators' situational awareness of local conditions, already available through their internal tools.
- How to operationalize ESAMS notifications?

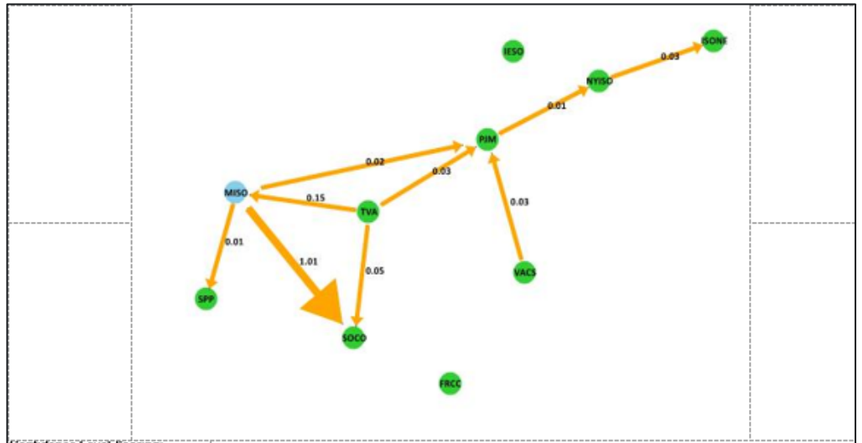
You Receive a Notification from ESAMS. What to do Next?



Information in ESAMS Notifications



Rank	Oscillation Detected at	Peak to Peak Amplitude	Oscillation Band RMS Energy
1	[redacted]	17 MW	9 MW
2		12 MW	7 MW
3		11 MW	6 MW
4		5 MW	3 MW
5		3 MW	6 MW



Confidence Level Scoring:

FO Source Identification	Region	Confidence Level	Criteria
REGION WITH HIGHEST POSITIVE NET ENERGY FLOW	MISO	Low (-2)	*High:>2* *Medium:2* *Low:< 2*
Supporting Information	**Finding**	**Confidence Scoring Elements**	**Scoring Algorithm**
DOES THIS REGION ALSO HAVE IMPORTS?	Yes	0	*No = +* *Yes = 0*
OTHER REGIONS WITH POSITIVE NET ENERGY FLOW?	3	-	*None = +* *1 = 0* *2 or more = -*
ROBUSTNESS OF FINDING	100%	-	*<80% = +* *>80% And ≤90% = 0* *>90% = -*
SOURCE REGION'S DATA QUALITY/AVAILABILITY	100%	+	*>90% = +* *>80% And ≤90% = 0* *<80% = -*
OVERALL MEASURE OF DATA QUALITY/AVAILABILITY	50.98%	-	

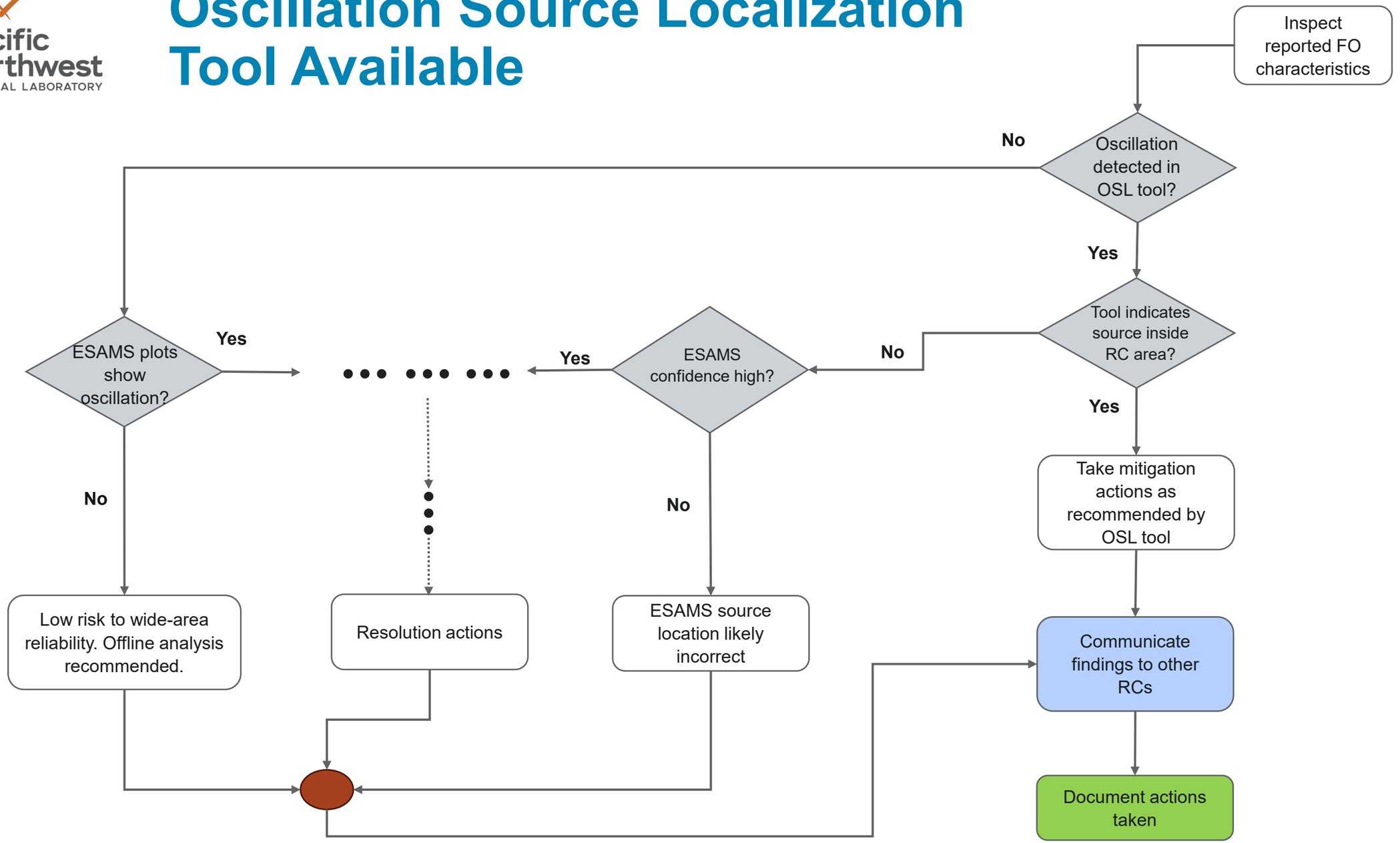
- Oscillation frequency
- Oscillation start and end times
- Highest observed amplitudes and their location
- Time series plots
- Energy flow diagram
- Confidence score
- Tie-line flows with a geographical context

Inspect Reported Oscillation Characteristics

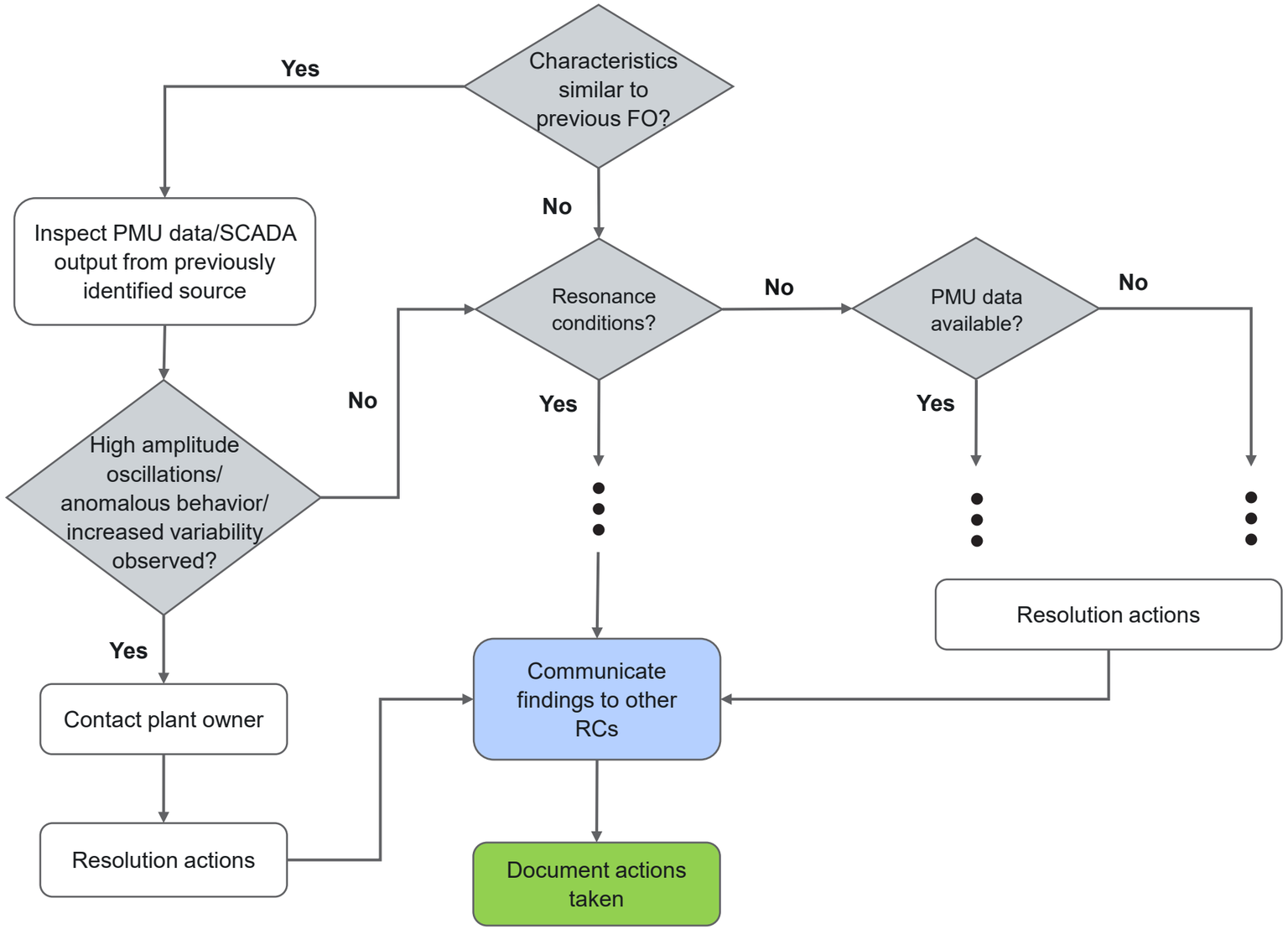
Case	Conditions	Likely Source
Case 1	Oscillation visible only in active power	A generator governor, cyclic load or sending end of HVDC line [2]
Case 2	Oscillation visible only in reactive power	An excitation system, or receiving end of HVDC line
Case 3	Oscillation visible in both active and reactive power, but active power amplitude considerably higher than reactive power amplitude	A generator governor, cyclic load or sending end of HVDC line
Case 4	Oscillation visible in both active and reactive power, but reactive power amplitude considerably higher than active power amplitude	An excitation system, or receiving end of HVDC line
Case 5	Similar oscillation amplitudes in both active and reactive power	An excitation system, or receiving end of HVDC line

Oscillation Band	Frequency Range (Hz)	Likely Source
1	0.01 - 0.15	Speed-governor control
2	0.15 - 1	Undetermined
3	1 - 5	Local plant control
4	> 5	Generator torsional modes, subsynchronous resonance, control interactions

Oscillation Source Localization Tool Available



Oscillation Source Localization Tool Not Available



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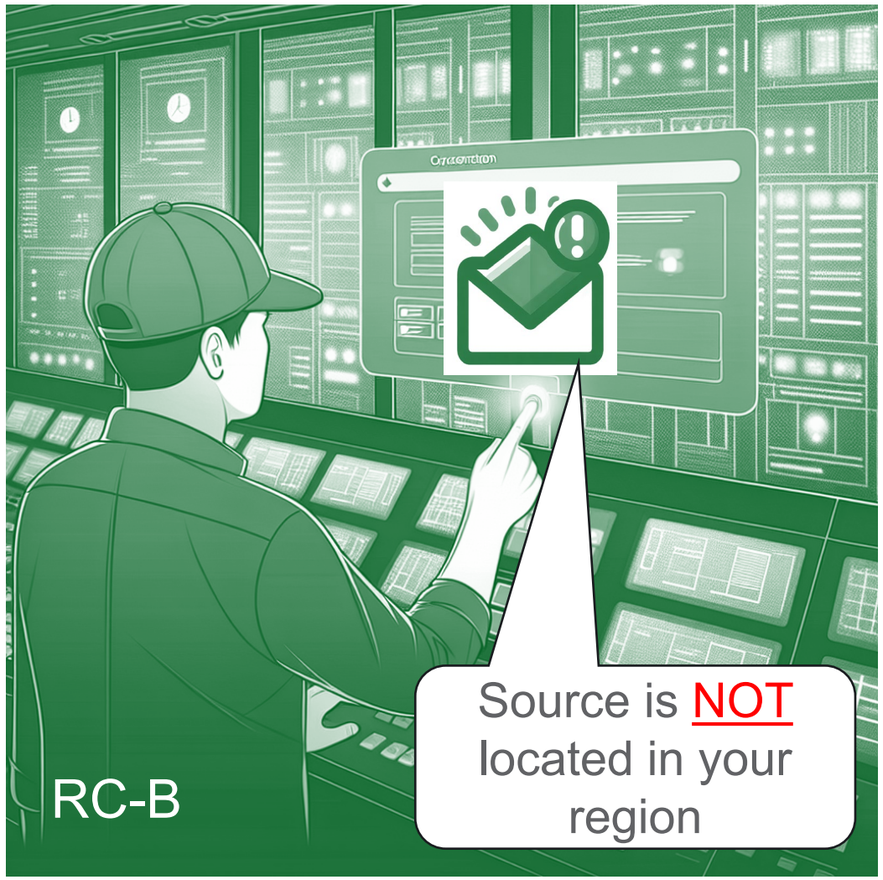

Confidence score	Are resonance conditions likely?	Is RC-A a neighbor?	High oscillation amplitude in RC-B area?	Is RC-B a net DEF exporter?	Is RC-B a net exporter to RC-A?	Recommended Action
High/Medium	Yes					Wait
	No	Yes	Yes	Yes	Yes	Investigate
	No	Yes	Yes	Yes	No	Wait
	No	Yes	Yes	No		Wait
	No	Yes	No	Yes	Yes	Investigate
	No	Yes	No	Yes	No	Wait
	No	Yes	No	No		Wait
	No	No	Yes	Yes		Investigate
	No	No	No			Wait
Low	Yes					Investigate
	No	Yes	Yes			Investigate
	No	Yes	No	Yes		Investigate
	No	Yes	No	No		Wait
	No	No	Yes			Investigate
	No	No	No			Wait

RC-A: Identified as source region
RC-B: Other RCs in the interconnection

Key Takeaways

- Interconnection-wide monitoring tools like ESAMS can aid forced oscillation mitigation actions in tandem with RC's internal monitoring tools.
- Next Steps for ESAMS:
  - Demonstration in Southern Company
  - Cloud Demonstration with ISO-NE and PJM
  - Enhance readability and interpretability of ESAMS notifications in collaboration with human factors experts
  - Include suggested actions for each RC

Want to provide feedback to the report?
Email Jim Follum. james.follum@pnnl.gov

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Thank you

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