DSTAR
Distribution R&D
for Today’s
Utility Environment

Lavelle Freeman

http://www.dstar.org/
What is DSTAR?

DISTRIBUTION SYSTEMS TESTING, APPLICATION, AND RESEARCH

DSTAR is a consortium of utilities organized to cooperatively sponsor practical distribution systems research. [http://www.dstar.org](http://www.dstar.org)
What Distinguishes DSTAR?

• Practical, near-term distribution focus
  – Equipment testing and product evaluation
  – Niche software for standards and engineering support
  – Whitepapers and reports on pressing industry issues
• Responsive, intimate, direct control by members
  – Members select, prioritize and direct project execution
  – Program members own an undivided share of IP
• Low overhead, efficiently managed organization
Active Member Utilities
Program 11, 12, and 13

Ameren Corporation
Aquila/KCP&L
Duke Energy
NRECA
PacifiCorp

Progress Energy
South Carolina Electric & Gas
Southern Company
We Energies
Wisconsin Public Service
DSTAR Program Structure

• Research project bundling
  – multiple topics in each “Program”
  – meets diverse needs of member utilities
• Membership in a Program provides all R&D fruits of projects in Program
• Program duration 1.5 - 2 years
• Member contribution is $40k or $90k per program (depending on size)
• Utilities can obtain retroactive membership for prior programs to secure results and deliverables
• Planning meeting twice per year
• GE Energy’s EA&SE group provides program management and administration services

Same Structure Since Inception in 1986
Some Research Area Examples

Engineering and economic productivity tools
- Engineering design and analysis software
- Total owning cost & economic analysis tools

System protection, operating safety, and reliability
- Ferroresonance guidelines
- URD overvoltage protection
- Padmount transformer fault withstand

Engineering guidelines and industry perspectives
- Distribution engineering eHandbook
- DG interconnection white paper
- Storm response best practices white paper
Program 11 Projects

Program 11 was recently completed

1. Anchor Corrosion detection white paper
2. Voltage flicker issues related to large new residential loads
3. Electronic distribution data handbook (ehandbook) expansion
4. Secondary Electrical Design Software (SEDS) - optimization feature and other enhancements
5. Implications of Communications Equipment Mounted in the Electric Space on Distribution Poles
6. Best practices for storm response white paper
7. Harmonic load calculator
8. Transformer DOE standards evaluation
9. Solid blade switch testing
10. Distribution automation whitepaper
Program 12 Projects

Program 12 is wrapping up

1. Software maintenance and website update activities
2. SEDS Enhancements – loss optimization, lighting design
3. Electronic Data handbook (eHandbook) expansion
4. Improving energy efficiency of utility systems
5. Impact of non-wood poles on reliability
6. Changing nature of loads and the impact on utilities
7. Guidelines for current-limiting fuse application
8. Capacitor control guidelines: choosing optimal type and settings
Program 13 Potential Projects

Program 13 is kicking off – now is the time to join!

1. Commercial load estimation tool
2. Best practices for equipment inspection, maintenance, and thermal imaging
3. Single-phase and three phase SEDS enhancements
4. Conservation voltage reduction (CVR) - testing, methods, and results
5. 3rd harmonic issues, impact, mitigation
6. Smart grid impact on distribution reliability
7. Arrester comparative testing, and justification of normal duty arresters
8. Centralized vs. distributed feeder automation and impacts on distribution performance
9. Impact of photovoltaic generation on distribution systems
10. Getting added value from scada and remote sensors
11. Smart grid technologies and data requirements for transformer health assessment
12. Integration of reliability information with system operations planning
13. Best practices for demand side management using dynamic pricing
Back-Up Material
Selected Smart Grid-Related Projects
Improving Energy Efficiency of Utility Systems

Project Overview

Develop system models that accurately reflect the losses at each level of the distribution system

- Primary
- Service transformer
- Secondary and service

Develop loss contribution factors for each system component

- Determine how much typical equipment contributes to distribution system losses
- Recommend and evaluate distribution design practices to reduce losses
Changing Nature of Loads and Impact on Utilities

Project Overview

Determine relevant “new” and existing loads, trends and expected growth

Investigate how nature of aggregate utility load changed by “new” load types and penetrations

Analyze and discuss impact on conventional utility planning practices

- power quality and reliability concerns
- load control and DSM programs
- peak shaving strategies
- conservation voltage reduction, loss reduction, volt/var support
- other planning and operation issues
Optimal Capacitor Control Guidelines

Project Overview

Literature search to determine how much has been done in this area and survey on cap controls and interviews with manufacturers.

Develop guidelines for “optimal” control of capacitors under various situations

- Construct example (prototype) feeders for rural, urban and suburban systems
- Apply various load profiles
- Solve the loadflow problem with various cap control type/settings,
- Compute losses and energy savings
- **Determine optimal control strategy**
Selected Operating Safety and Protection Projects
Investigations to Determine Ferroresonance Avoidance Guidelines

Full-scale field testing
Wye-wye padmounts
• low-loss silicon steel
• amorphous metal transformers
• stacked (laminated) core
Delta-primary padmounts
12.47, 24.9, 34.5 kV
Wide range of cable lengths
Applied loads
### Ferroresonance Avoidance Guidelines

**Risk-Averse Critical Cable-Length Guidelines for Ferroresonance Avoidance**

*Grounded-Wye Padmounts on 5-Leg Wound Steel Cores*

<table>
<thead>
<tr>
<th>Primary Voltage (kV): 12.47</th>
<th>kVA: 150</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Loss, in Watts, if known (0 if unknown): 0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cable Size</th>
<th>Cable Capacitance (pf/ft)</th>
<th>Critical Cable Lengths (ft)</th>
<th>175 mil 15 kV XLP Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWG or MCM</td>
<td></td>
<td>V &lt; 1.6 pu Maximum</td>
<td>V &lt; 1.25 pu Sustained</td>
</tr>
<tr>
<td>#4</td>
<td>49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td>56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#1</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/0</td>
<td>66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/0</td>
<td>71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/0</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/0</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Censored! Censored!

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*Easy-to-use guidelines developed for DSTAR*
Arrester Ferroresonance Duty

Common belief that ferroresonance will instantly fail an MOV arrester
• ferroresonance produces overvoltages well in excess of 2 p.u., lasting for as long as open phase exists
• arrester TOV is < 2 p.u. for just a few cycles!

Extensive DSTAR tests
• riser and heavy duty distribution arresters
• elbow arresters
• under-oil arresters
• 12.47 and 34.5 kV
Arrester Survivability Guidelines

Guidelines for:
short duration exposure (< 5 minutes)

long duration (indefinite)
DSTAR Investigation; Padmount Fault Withstand

Many utilities apply current-limiting fuses
• often applied on padmounts using poletop criteria
• are CLFs necessary in most of these applications?

DSTAR testing performed on a number of padmounted transformers
• 8 single-phase, 50 - 100 kVA
• 6 three-phase, 150 kVA

2” arc created deep under oil

Test to threshold of tank failure
DSTAR Padmount Fault Withstand Guidelines

Fault withstand correlated to a simple tank characteristic
Loadbreak Elbow No-Load Flashover Problem

This flashover occurred well after partial vacuum dissipated.
DSTAR Projects Covering URD Overvoltage Protection

P1-1  URD Overvoltage Protection

P1-2  URD Overvoltages Considering Transformers and Grounding

P1-3  Fast and Slow Surges

P2-2  Semi-Conductive Jacketed Cable Investigation

P2-3  Switching Surges in Underground Distribution Systems

P3-1  Supplemental Cable Tests and Improved System Grounding

P5-3  Gapped MOV Arrester Characteristics
DSTAR Projects Addressing Transformer Overvoltage Protection and Ferroresonance

P2-4  Ferroresonance Guidelines for Modern Transformer Applications

P4-1a  Ferroresonance Guidelines for Additional Padmound Transformer Types

P4-1b  Survivability of MOV Arresters Subjected To Ferroresonance Overvoltages

P4-1c  Ferroresonance Survivability of Under-Oil Arresters

P4-3  Secondary Surge Guidelines

P5-2  Floating Wye-Delta Overhead Bank Overvoltages

P5-6  Service Entrance Protection Coordination
DSTAR Projects Covering Operating Safety

P5-1  Investigations of Elbow and Insulated Cap Flashovers
P6-1  Investigations of Elbow and Insulated Cap Flashovers
P3-4  Padmount Transformer Tank Fault Withstand Capability
Selected Projects with Potential Reliability Impact
CFO Calculator

CFO Calculator

• Scope
  – Calculates pole system CFO
  – Determines best arrester spacing for CFO, shielding, and keraunic level

• System reliability impact
  – Reduce line flashovers
  – Potentially reduce number of arresters and, as such, reduce potential for arrester failure-related outages

• Reliability indices affected
  – SAIFI
Elbow and Overhead Arrester Testing

Elbow and Overhead Arrester Testing

• Scope
  – Consumer report-like testing
  – Tracking wheel and seal integrity testing
  – Tested Cooper, Hubbell, Elastimold, and Joslyn

• Reliability and Operational impacts
  – Potentially reduce the number of arrester field failures
  – Improved intelligence for arrester procurement

• Reliability indices affected
  – SAIFI
Transformer Fault Withstand Testing

Transformer Fault Withstand Testing

- **Scope**
  - 8 single-phase, 50 - 100 kVA
  - 6 three-phase, 150 kVA
  - 2” arc created deep under oil
  - Test to threshold of tank failure

- **Reliability and Operational impacts**
  - Reduce the number of applications using CLF’s and, therefore, inherent system reliability
  - Fault withstand correlated to a simple tank characteristic
Wildlife Protection Guide

Animal-Caused Outages Manual

• Scope
  – Assess the reliability benefit of animal protection programs
  – Discuss habits and impact of various wildlife on T&D systems
  – Review of protection measures and effectiveness

• System reliability impact
  – Reduce incidents of wild-life related outages by recommending best practices and devices
  – Enable cost-effective planning and analysis of measures

• Reliability indices affected
  – SAIFI
  – MAIFI
Best Practices for Storm Response

Best Practices for Storm Response

• **Scope**
  – Discuss storm preparation, system hardening, early warning, planning and organization
  – Identify best-in-class mobilization, staging, operation, damage assessment, communication
  – Review post-event ramp down, data analysis, lessons learned

• **System reliability impact**
  – Improve response during major events, reduced downtimes
  – More efficient use of resources
  – Improved customer relations

[DSTAR]
Transient Current in Capacitor Fuses

Transient Current in Capacitor Fuses

• Scope
  – Evaluate nuisance field fuse failures
  – Analyze typical switching transient fuse duty
  – Analyze typical lightning transient fuse duty
  – Evaluate typical harmonic duty

• Reliability and Operational impacts
  – Guidelines for avoiding nuisance fuse operation
  – Improved system operation due to fewer nuisance fuse operations
  – Improved system reliability

• Reliability indices affected
  – SAIFI
DSTAR Software Tools
## DSTAR Software Applications

<table>
<thead>
<tr>
<th>Software Application</th>
<th>Target User</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>e-Handbook</td>
<td>All</td>
<td>An electronic handbook covering a variety of distribution engineering and planning topics</td>
</tr>
<tr>
<td>TOCS</td>
<td>Central engineering/Planning</td>
<td>Detailed economic and loss of life calculations for transformers according to ANSI standard C57.91-1995</td>
</tr>
<tr>
<td>TLA</td>
<td>Field office technician</td>
<td>Calculates transformer life for given loading conditions according to ANSI standard C57.91-1995</td>
</tr>
<tr>
<td>CEPS</td>
<td>Central engineering/Planning</td>
<td>Calculates a variety of cable characteristics</td>
</tr>
<tr>
<td>SOCCS</td>
<td>Central engineering/Planning</td>
<td>Assist user in the economics calculation of underground versus overhead construction</td>
</tr>
<tr>
<td>EOCS</td>
<td>Central engineering/Planning</td>
<td>Detailed economic analysis of overhead conductor total owning cost with re-conductoring and without re-conductoring</td>
</tr>
<tr>
<td>GTA</td>
<td>Field office technician</td>
<td>Calculates guy wire and guy anchor tensions for dead-end and angle distribution poles</td>
</tr>
<tr>
<td>VDROP</td>
<td>Field office technician</td>
<td>Calculates voltage drop and flicker for three-phase loads fed radially from a transformer</td>
</tr>
<tr>
<td>CPA</td>
<td>Field office technician</td>
<td>Calculates cable pulling tensions and sidewall pressures for a given layout.</td>
</tr>
<tr>
<td>SEDS</td>
<td>Field office technician</td>
<td>Calculates secondary electrical parameters including cable loading, service voltages, voltage flicker, and service-entrance</td>
</tr>
<tr>
<td>GSVIC</td>
<td>Field office technician</td>
<td>Calculates secondary voltage imbalance on three-phase services.</td>
</tr>
<tr>
<td>CLPUS</td>
<td>Field office technician</td>
<td>Calculates cold load pick-up current for a feeder or circuit following a power outage.</td>
</tr>
<tr>
<td>TSRDS</td>
<td>Field office technician</td>
<td>Assists users in making the decision to scrap or repair a distribution transformer.</td>
</tr>
<tr>
<td>X-Derate</td>
<td>Central engineering/Planning</td>
<td>Calculates interference temperatures (ampacity) for a limited set of field conditions</td>
</tr>
<tr>
<td>OCS</td>
<td>Field office technician</td>
<td>Calculates ruling span, conductor construction sag &amp; blowout, and conductor span length for given pole loading</td>
</tr>
<tr>
<td>CFO</td>
<td>Central engineering/Planning</td>
<td>Calculates the CFO of an overhead pole structure using CFO-added methods</td>
</tr>
<tr>
<td>Harmonic</td>
<td>Central engineering/Planning</td>
<td>Calculates THD at point of common coupling for small industrial and large commercial loads</td>
</tr>
</tbody>
</table>
Secondary Electrical Design Software

For single-phase and three-phase secondary design

Calculates
- voltage drop
- flicker
- short circuit
- xfmr loading
- cable loading

Optimizes design based on total cost

Convenient graphic interface
Cable Pulling Assistant

Calculates
- pulling tension
- sidewall pressure
- jam ratio
- fill and clearance

Calculates pulls in both directions
Guy Tension Analyzer

Standard, span guy, and sidewalk guy calculations

Easy-to-use graphic interface
Cable Electrical Parameters Software

Calculates:
- dimensions
- areas
- resistances
- sequence impedances
- capacitance
- conductor and dielectric losses
- voltage regulation
- short-circuit withstand
- Riser and normal ampacity
Thank You!

For more information, contact DSTAR

http://www.dstar.org