Quarterly Program Review
July 25, 2001
Washington, DC

Distributed Utility Integration Test DUIT

DUA
Endecon Engineering
PG&E
Exelon (PECO)
CEC
Salt River Project

Encorp
Caterpillar
Solar Turbines
Onsite Energy
SMUD
Niagara Mohawk

Distributed Utility Integration Test

1) Build a team
2) Document appropriate technologies
3) Document features of appropriate site(s)
4) Develop a project plan
5) Develop a project plan for a DUIT facility at the Nevada Test Site

- One year contract - Completion scheduled Oct. 2001
- NREL Technical Monitor: Ben Kroposki
- DUIT team leaders: Joe Iannucci, Susan Horgan, Chuck Whitaker

Task 1: Integration Test Stakeholder Outreach and Consensus Building

Deliverable: Integration Test Concept Paper

➔ description of and rationale for the DUIT Project

- **As DP becomes more commonplace its electrical interactions will become more important to understand and more challenging to manage.**
- **DUIT will attempt to discover the challenges and benefits that will result from the extensive use of distributed energy resources.**
- **DUIT will help to define the distribution system of the future.**

DUIT Plan:

Technology Selection and Evaluation
Site Assessment and Selection
Identification of Electrical and Operational Issues
Potential Results and Policy Implications
Statement of work, costs and schedule

Task 2: DUIT Site Assessment

Objective:

- Evaluate potential test locations and recommend optimum site (or combination of sites), operation and testing of distributed generation technologies by the DUIT project.
- Includes an assessment for each site
- Completed July 2001

Sites Evaluated

Detailed facility information was obtained from the following locations for evaluation as DUIT testing sites:

- Dolan Test Center – Groveport, OH
- Modular Generation Test Facility (MGTF) – San Ramon, CA
- National Renewable Energy Laboratories (NREL) – Golden, CO
- Oak Ridge National Laboratory – Oak Ridge, TN
- Pacific Northwest National Laboratories (PNNL) – Hanford, WA
- Power Electronics Applications Center (PEAC) – Knoxville, TN
- Sandia National Laboratories – Albuquerque, NM
- Solar Test and Research (STAR) Facility – Phoenix, AZ
- Southwest Research Institute (SWRI) – San Antonio, TX
- University of California at Irvine – Irvine, CA
- University of Wisconsin – Madison, WI

Other Sites Considered

Several other locations were investigated but ruled out for in-depth evaluation. These included:

- **Colorado State University – Fort Collins, CO**
- **DTE Technology Solutions – Novi, MI**
- **Foothills Training Facility (APS) – Tempe, AZ**
- **Greenhouse Gas Verification Center – Research Triangle Park, NC**
- **Underwriters Laboratories (UL)**

Site Assessment Criteria

- Available space – number of test cells or bays, their sizes, and limitations
- MW Rating – largest single DR allowable; total allowed DG for facility
- Existing/permanent DRs on-site – potential for reducing acquisition costs of new equipment
- Existing testing equipment – controls, monitoring and instrumentation, switching load banks, etc.
- Host utility's level of interest, support and involvement, both financial and in terms of personnel time and expertise
- Ability to test in both radial and network circuit configurations
- Grid supply – voltage, MVA, switching arrangements, and limitations
- Fuel supply and storage – natural gas line size, pressure and flow rate (BTU/hr); diesel, hydrogen, gasoline, LPG availability and/or storage capability

Site Assessment Criteria

- Flexibility of facility to evolve or adapt to future/unforeseen testing needs
- Limitations – noise, emissions, other
- Ability to test multiple DRs at once, in interactive modes
- Number and expertise of testing staff
- Testing history/experience relevant to DUIT
- Costs - for required facility upgrades to accommodate DUIT testing, as well as for the testing itself. Factors to consider:
  - cost of DR technologies (purchase, rental, lease, O&M, fuel, etc.)
  - number of DR installations and removals
  - duration of tests
  - fuel costs
  - analysis and reporting requirements
  - requirements of host utility (meetings, trips, etc.)
  - special installation equipment required
  - control equipment for multiple DRs

Task 3: Technology Evaluation, Selection and Availability

Deliverable:Technology Selection Report

- Rotating DR
  - Synchronous MG-sets
  - Induction Generator Systems
- Grid Tie Inverters
- Inverter Based DR
  - Fuel Cell
  - Photovoltaic
  - Microturbine
- Storage Technologies
  - Flywheel
  - SMES
  - Conventional and Advanced Electrochemical

Inverter Supplier Table (Partial)

Supplier	Electrical Rating	Physical Size	Weight	Venting Requirements	Fuel Requirements	Indoor/Outdoor Rating	Ambient Temperature
Advanced Energy Systems	1KVA	19”Hx8”Wx6.5”D	43 Lbs.	None	None	Full outdoor	-40Deg. C 60Deg.C
Aerovironment							
Xantrrex/Trace Eng. Model ST	1 - 2.5	33.5”Hx13.25”Wx 5.3”D	35 Lbs.	None	None	Indoor, outdoor with optional rain shield	-39Deg. C 45Deg. C
Xantrex/Trace Tech. Model PV 10	10KVA	26”Hx18”Wx10”D	75 Lbs.	None	None	NEMA 4 outdoor rating	-20Deg.C 50Deg.C
Xantrex/Trace Tech Model PV 15, 20	15 – 20 KVA	30”Hx25”Wx13”D	175 Lbs.	None	None	NEMA 4 outdoor rating	-20Deg. C 50Deg. C
S&C Omnion Model 2400	2.2 – 6 KVA	28”Hx18”Wx8”D	74 Lbs.	None	None	NEMA 3R outdoor rating	-20Deg. C 40 Deg.C (45 for some products)
S&C Omnion Model 2500	1- 2 KVA	21.75”Hx12”Wx7. 25”D	1KVA – 35 Lbs. 2KVA – 40 Lbs.	None	None	NEMA 3R IP 32	-25 Deg. C 50 Deg. C
S&C Omnion	50 – 100KVA	75”Hx76”Wx38”D	50KVA – 2000 Lbs. 100KVA – 2200Lbs.	None	None	NEMA 3R	-30 Deg. C 50 Deg.C
Vanner Model RE24-4500DGT	4.5KVA	29”Hx20.5”Wx9.2 5”D	95 Lbs.	None	None	N.A.	4.5KVA@ 25Deg.C

Task 4: DUIT Project Plan

DUIT Plan:

- Technology plans
- Site specification
- Test Plan
- DAS requirements
- Costs and schedule

Test Plan: Issues for All Tests

- High DR penetration levels
- Legacy distribution systems
- Future distribution systems
- Interaction Between Different Distributed Resources
- Distributed Resource Types
  - Rotating: synchronous and induction
  - Inverter-based: fuel cell, storage, PV, microturbine

Task 4: Test Plan

- **Power Quality**
  - Harmonics
  - Power Factor
  - Flicker
  - DC Injection
  - EMI/EMF
  - Type Testing vs. Aggregate Testing
  - Start-up vs. Long-term

Test Plan: System Protection

- Abnormal Conditions
  - Voltage trip points
  - Frequency trip points
  - Fault detection
- Islanding
  - Inadvertent
  - Intentional
- Synchronization
- Immunity Protection

Test Plan: Distribution System Interaction

- Network Systems
- Fuse Protection
- Recloser Coordination
- Short Circuit Current Contribution
- Voltage regulation - incidental and intentional
- Substation backfeed

Test Plan Protocols - Format

- Brief Background on Test Topic
- Governing IEEE 1547 Sections
- Other Governing Standards and Sections (e.g., UL 1741, California Rule 21)
- Test Objectives
- Key Testing Parameters
- Expected Results
- Test Procedure
- Data Acquisition Requirements
- Control Requirements
- Facility Requirements
- DR Requirements
- Other Requirements
- Modeling Input Required

Testing Protocols - Status

In Draft and Out for Review:

- Anti Islanding - 4
- Substation Backfeed - 1
- Sectionalizer Test - 2
- Cold Load Pick-up - 1
- Reclosing Coordination - 1
- Synchronization - 1
- Short Circuit Current - 2
- Stability - 2
- Fuses - 2

Nearly Complete:

- Voltage Regulation - 2
- Capacitor Switching-1

To Be Completed:

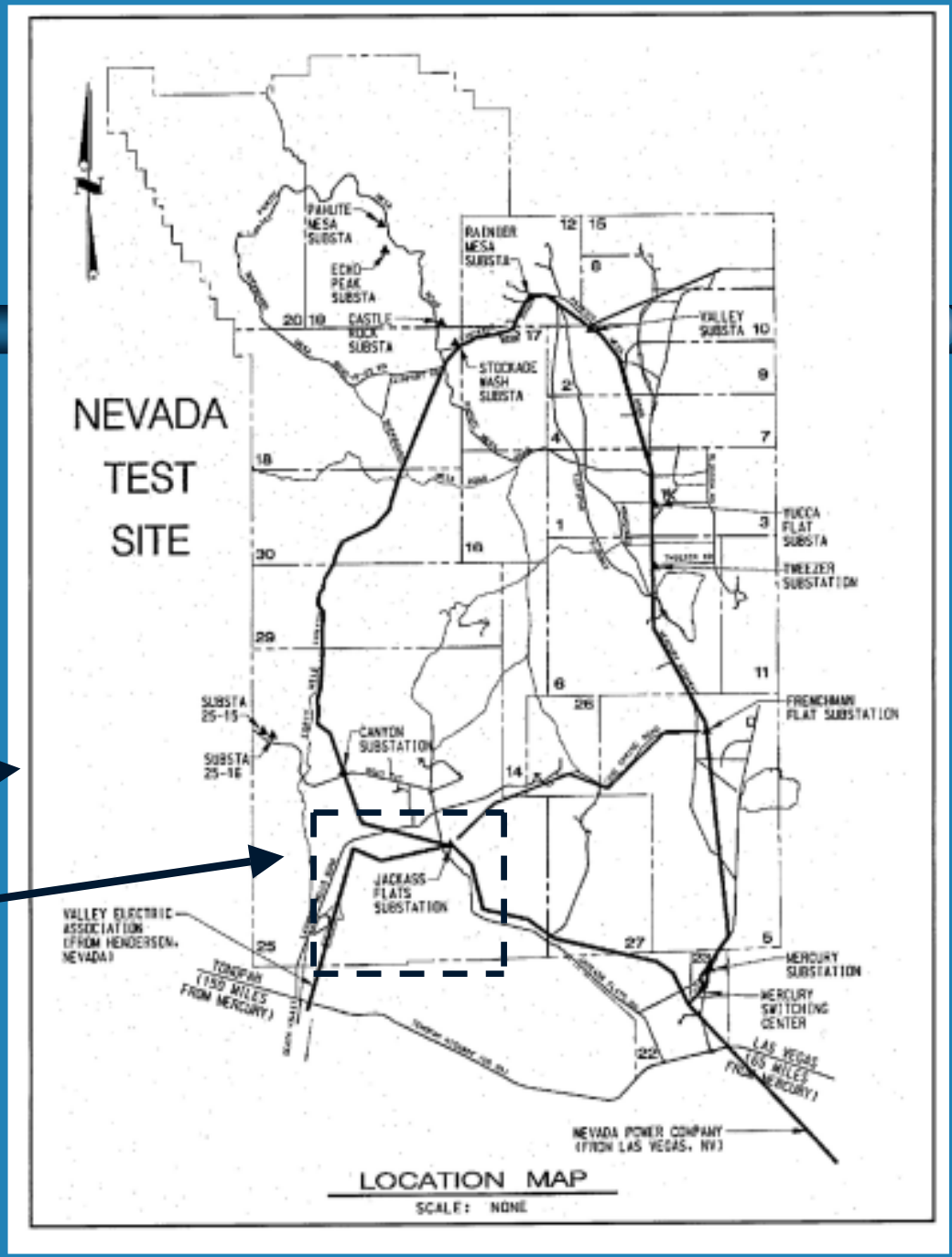
- Additional Islanding - 3 to 5
- Control Strategies
- Network Systems
- Abnormal Conditions
- Power Quality
- Faults on Adjacent Feeders
- O & M / Periodic Testing Needs

Task 5: NTS

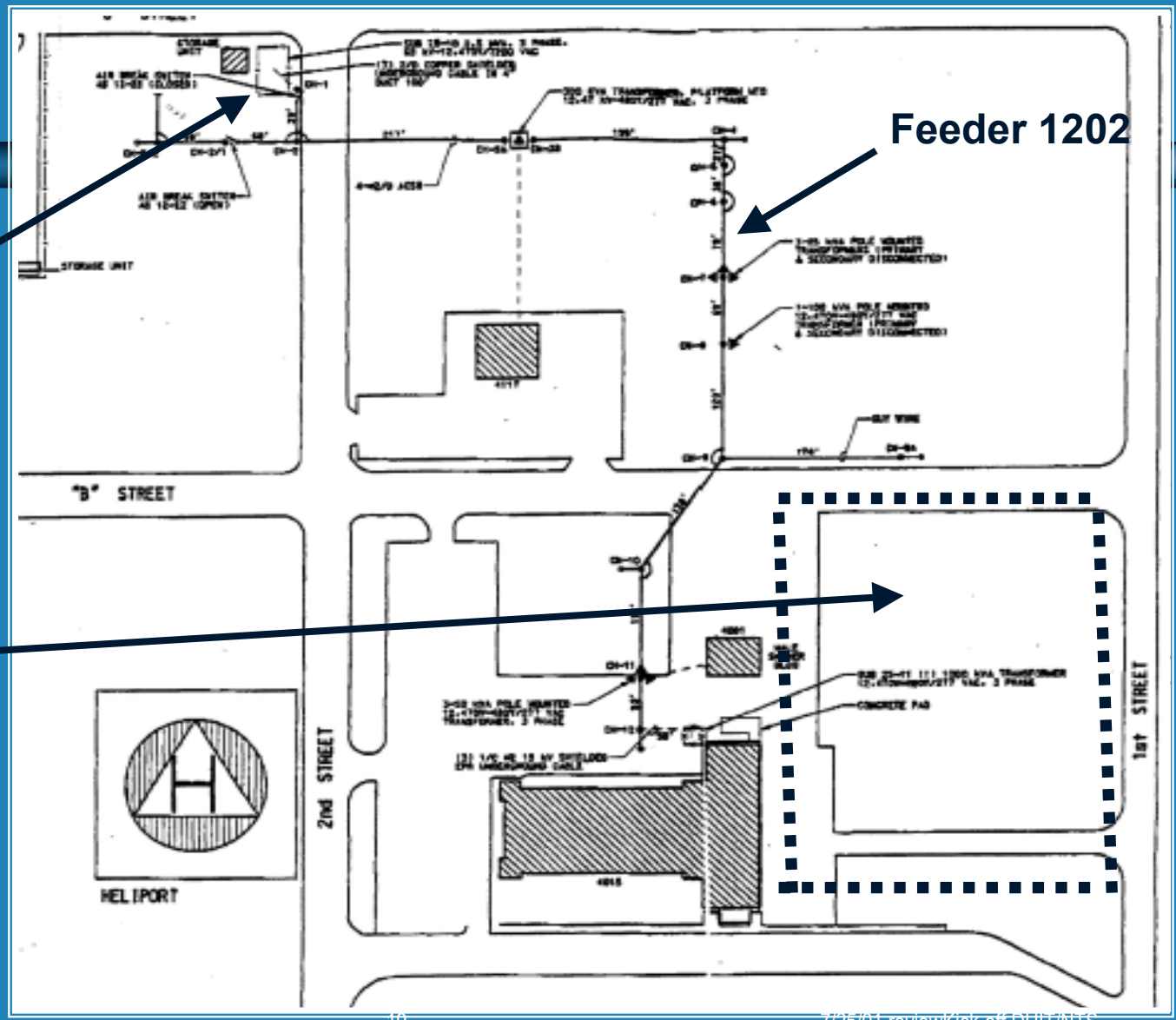
Distributed Power Test and Demonstration Plan

Area 51

Area 25



Area 25 Jackass Flats Substation

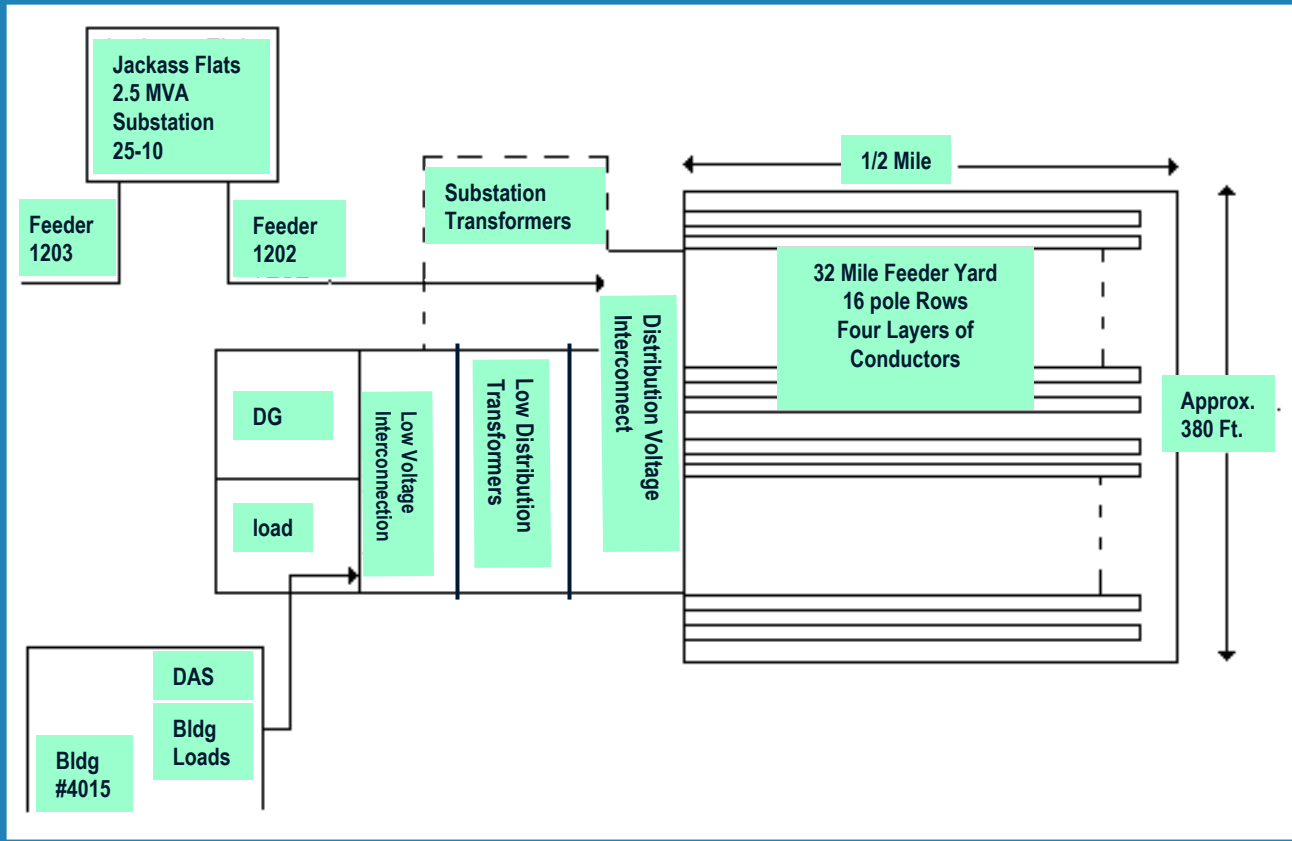


Feeder 25-1202 at Nevada Test Site

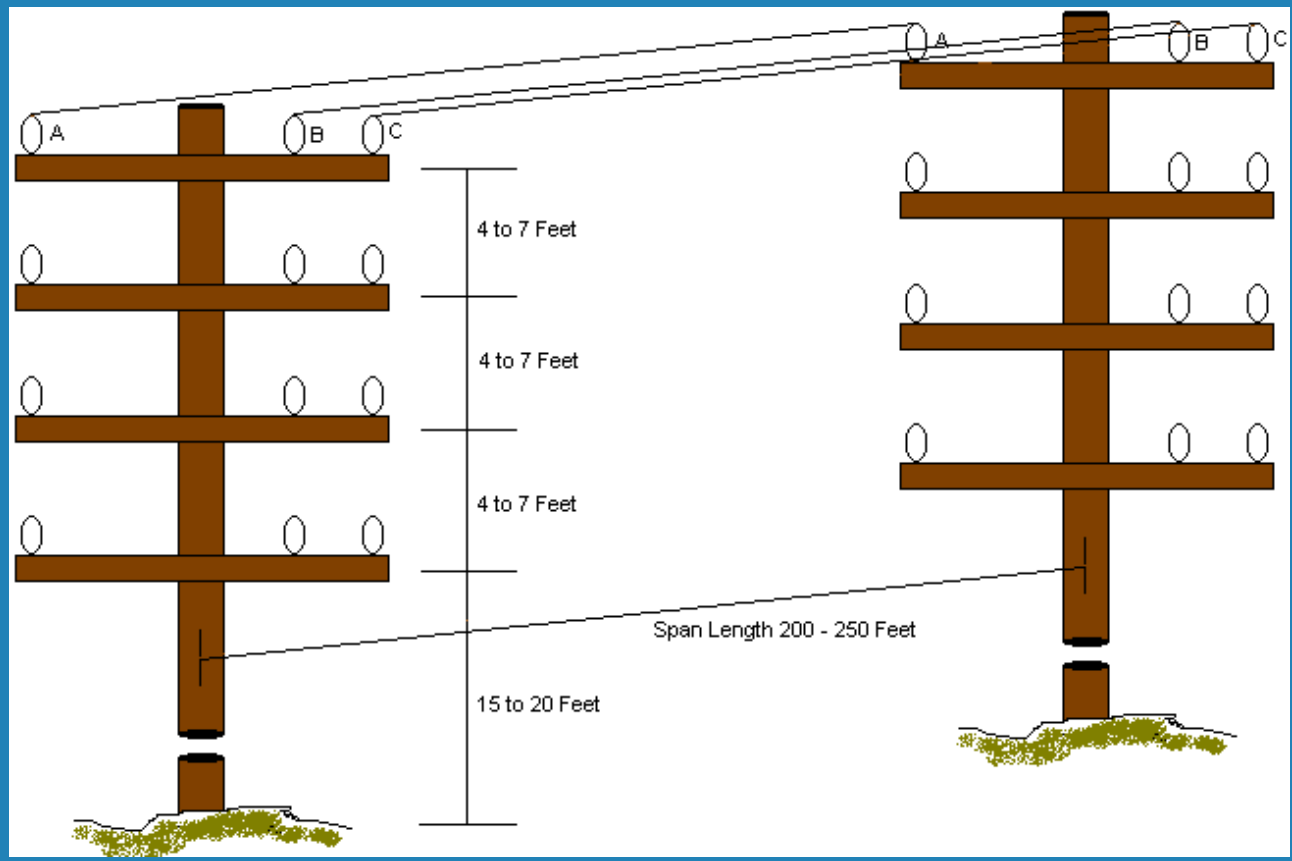
NTS Inventory and Assets

- Existing 2.5 MVA substation with two branch circuits
- Multiple building loads
- Wall mounted switch gear for tie in
- Load banks available
- Diesel gensets available
- 2.0 kW photovoltaic system
- Fuel availability (Diesel) **Liquid Natural Gas (LNG) Minimal permitting processes for fuels and environmental
- Spare electrical equipment
- Transformers, poles, conductors, switch gear
- Phone and data lines available at building locations

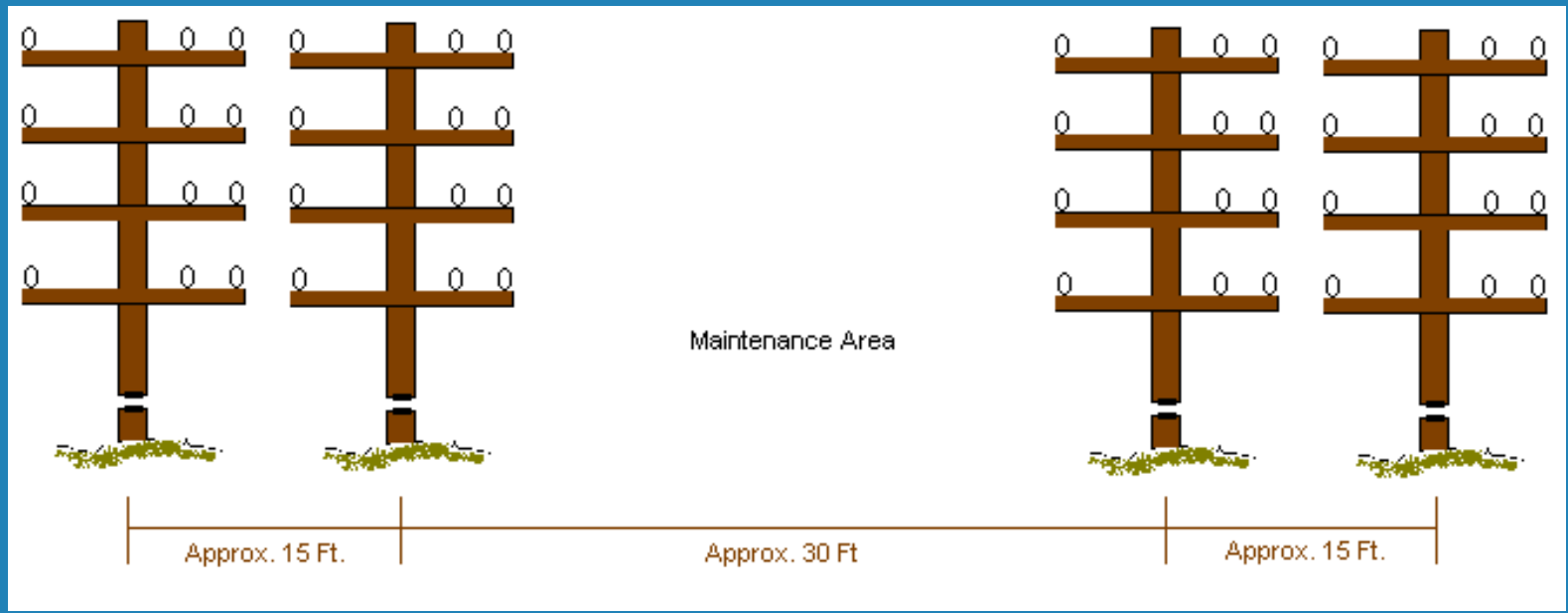
Conceptual NTS Test Facility



NTS DPP Facility - Multi-Layer Pole to Pole Concept



DUIT Test Facility - Row Spacing of Poles



DUIT Test Facility - Attributes

- Co-location of distributed resources and loads
- Real world distribution system field with 32 miles of feeder
- Distribution field can be configured as a network system
- Makes use of NTS material and personnel resources
- Flexible DAS for monitoring DR and loads
- Conducive to annual upgrades and project phasing

Potential Project Phasing

- Low voltage testing
- Medium voltage, lumped parameter (impedances) DS testing
- Medium voltage, Distribution system feeder yard

  - *Need to understand cost /benefit of lumped parameter vs. feeder yard*
  - *Some unique features of NTS that suggest feeder yard may be more economical*

Concept Test Facility - Needs

- Additional poles for the build-out of the distribution system field
- Additional concrete pads for DG and loads areas
- Cable and conductor for distribution system field and interconnection areas
- Extensive DAS for test monitoring
- Hardware for low and medium voltage interconnect areas
- Fencing for distribution field and interconnect areas

Deliverables Task 1-5

Deliverable Description	Due
Concept Paper on DUIT (Task 1)	Complete
Site Assessment Report (Task 2)	Complete
Technology Selection Report (Task 3)	Complete
Detailed Project Plan for DUIT (Task 4)	10/1/01
Detailed Project Plan for NTS (Task 5)	10/1/01
Final Report	10/30/01

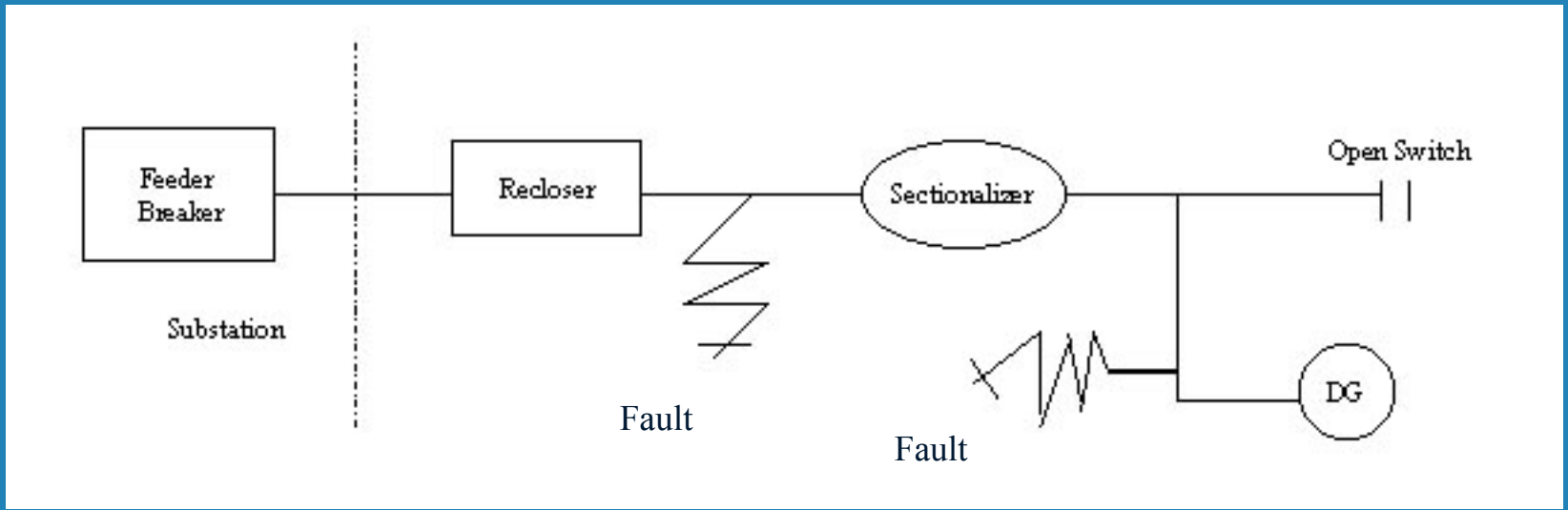
Back-up Slides: Test Plan Example

DUIT Test Plan: Sectionalizing Devices

Objective: Determine how the presence of DR on a feeder affects the operation of sectionalizers and their coordination with other protective systems, particularly reclosers.

- **Momentary (cleared) faults: the recloser should operate to restore the feeder before the sectionalizer operates.**
- **Sustained faults: the sectionalizer should operate for downstream faults before the recloser locks out.**
- **Need to determine under what specific scenarios and configurations DR causes sectionalizer to misoperate.**

Sectionalizer Test - Schematic



Key Test Parameters

- Fault location and type: 1-Φ, Φ-Φ, 3-Φ, bolted, high-Z
- Penetration level: number and size(s) of DRs
- Export vs. non-export conditions
- Stiffness ratio of system
- Length of feeder
- Types of DRs: synchronous, induction, inverter-based
- Types and sizes of loads
- Impedances between key points and devices

Test Procedure

- Set up system without DR; verify correct operation of sectionalizer for fault conditions (baseline case).
- Add DR to system.
- Simulate faults of required types and locations.
- Monitor and record recloser and sectionalizer operations and system voltages.
- Vary test by (as needed):
  - export/non-export
  - DR number and power level
  - system stiffness
  - feeder length

Data Acquisition Requirements

Parameter	Units	Range	Accuracy	Sampling Rate	Recording Rate
DR Voltage (3ϕ)	Volts	0-600	± 1 V	600 Hz	600 Hz
DR Current (3ϕ)	Amps	0-100	± 1 A	600 Hz	600 Hz
Utility Voltage (3ϕ)	Volts	0-15 kV	± .1 kV	600 Hz	600 Hz
Sectionalizer status	Seconds	0-5	± .01 s	.001 s	.001 s
Recloser status	Seconds	0-5	± .01 s	.001 s	.001 s
Sectionalizer current	Amps	0-100	± 1 A	600 Hz	600 Hz
Recloser current	Amps	0-100	± 1 A	600 Hz	600 Hz
Sectionalizer voltage	Volts	0-15 kV	± .1 kV	600 Hz	600 Hz
Recloser voltage	Volts	0-15 kV	± .1 kV	600 Hz	600 Hz

Other Requirements

- DRs (individual and in combinations)
  - Inverter-based, any prime mover
  - Synchronous generator
  - Induction generator
- Load banks
- Feeder system or feeder simulator
- Fault switch
- Fault impedance (load bank)