Demonstration of a Pre-Commercial Long-Length HTS Cable System Operation in the Power Transmission Network

DOE Peer Review Update
July 27-29, 2004
Washington, DC

American Superconductor
LIPA Long Island Power Authority
Department of Energy United States of America
Air Liquide
Nexans

LIPA Project Overview

- Long Island Power Authority – East Garden City Substation
- Electrical Operating Characteristics
  - Operating Voltage/Current – 138kV/2400A ~ 574MVA
  - Design Fault Current – 69,000A @ 15 line cycles (250ms)
- Physical Characteristics
  - Length – 610m
  - HTS Conductor Length – 128km
  - Cold Dielectric Design
- Hardware Deliverables
  - Three ~610 m Long Phase Conductors
  - Six 161kV Outdoor Terminations
  - One 161kV Splice (Laboratory Test)
    - No splices for grid installation required
  - One Refrigeration System + Laboratory Pulse Tube System
- Installation/Commissioning – 2005-2006

World's First Installation of a Transmission Voltage HTS Cable in the World

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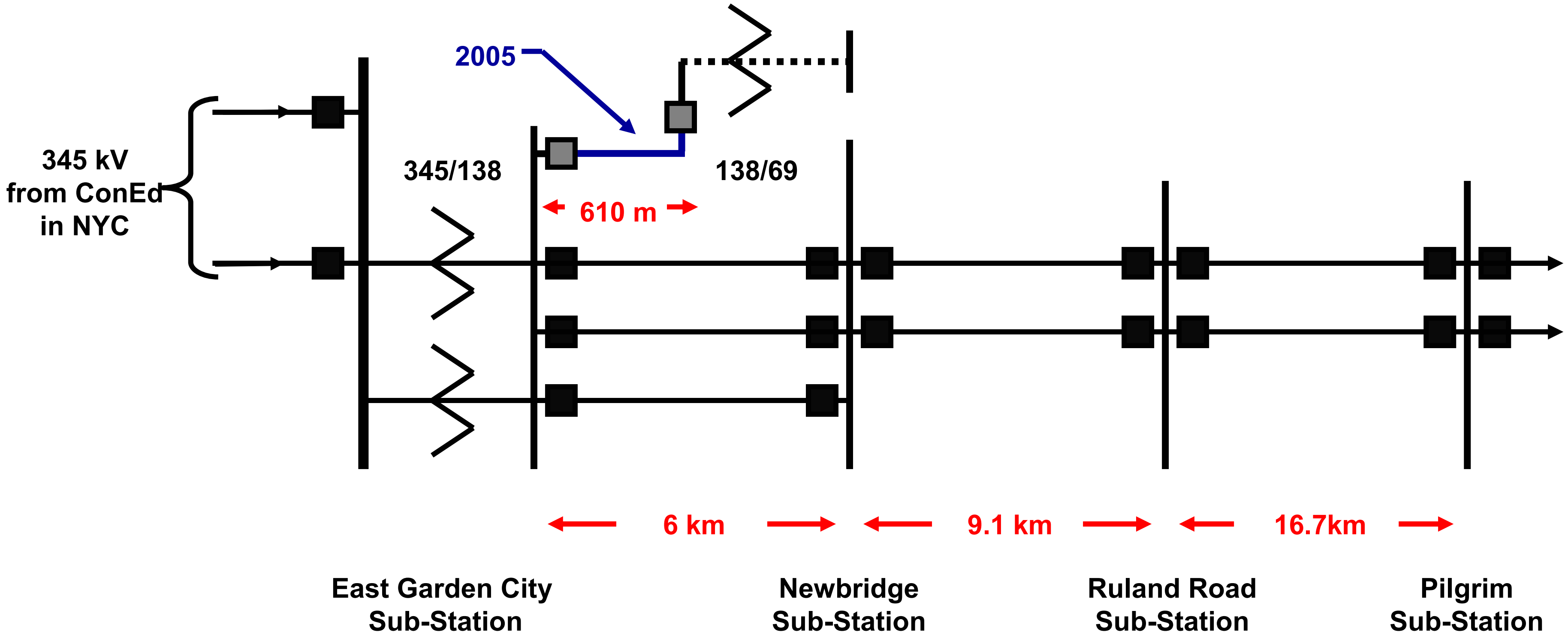
LIPA 138 kV HTS Cable Project – Phase 1



~610m 138kV 2400A HTS Cable

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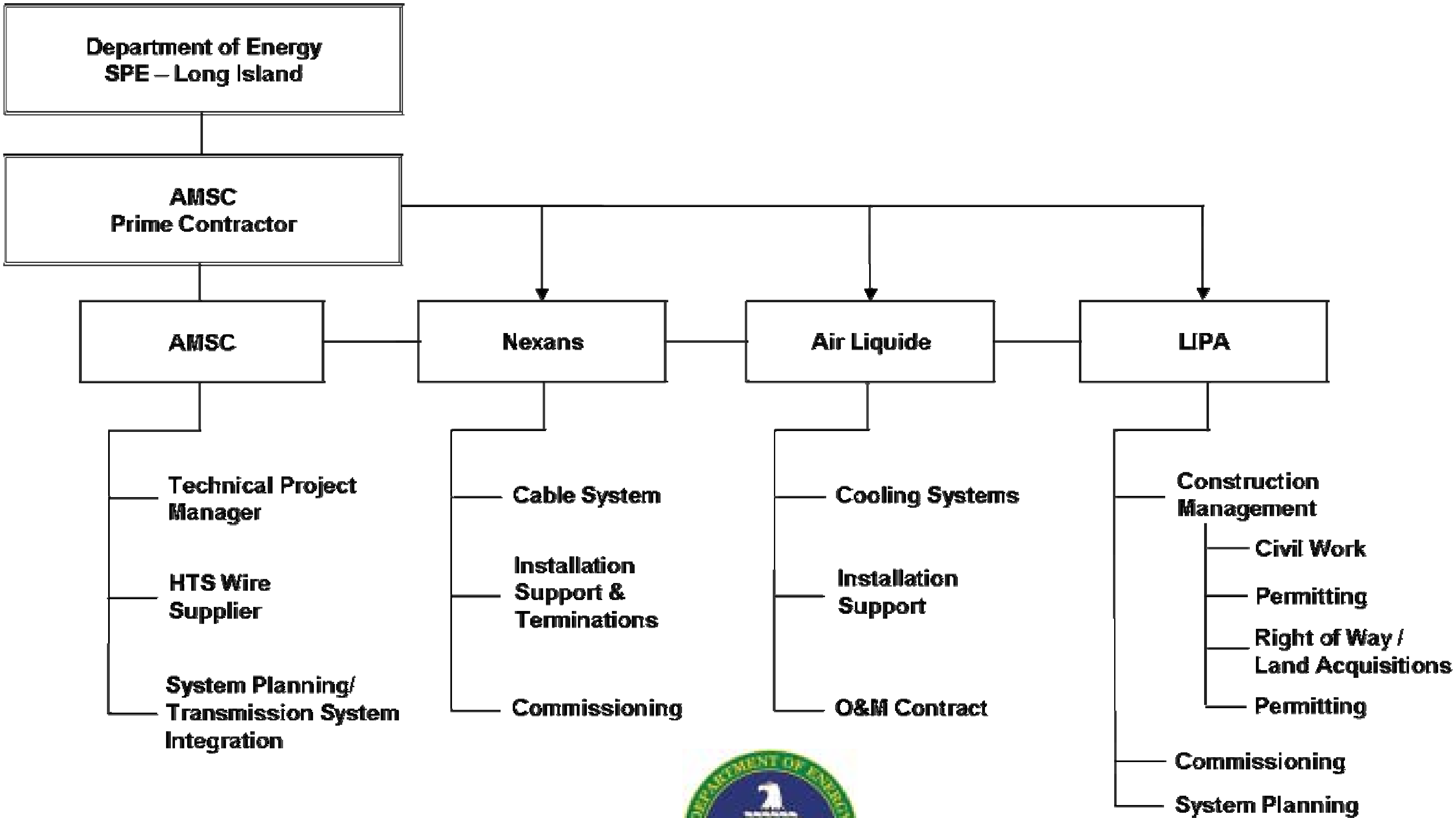
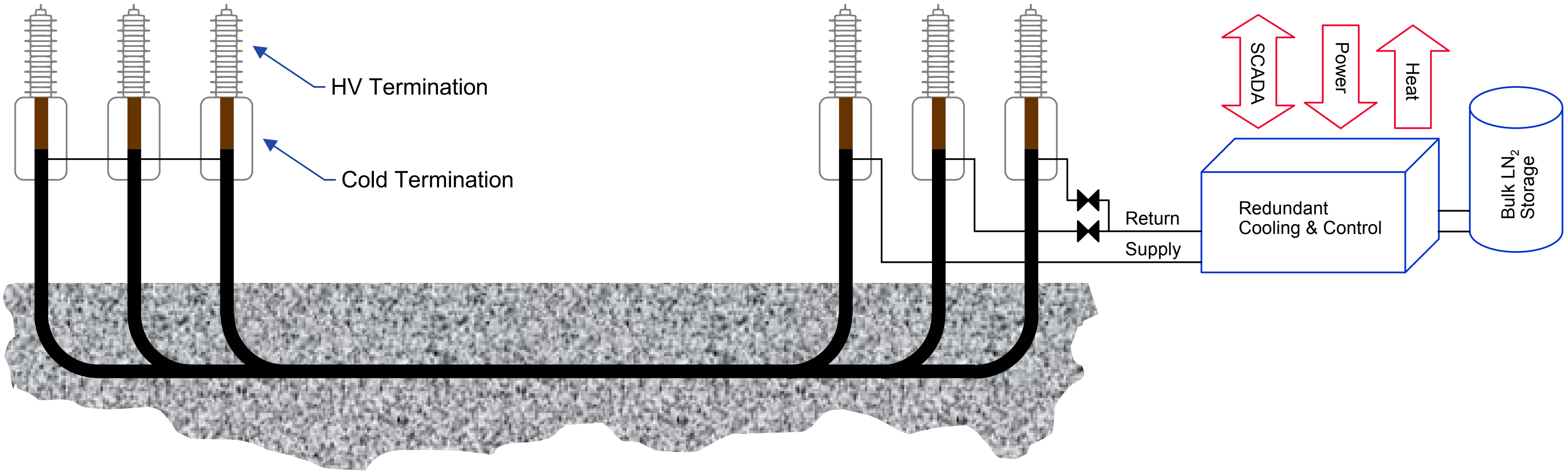
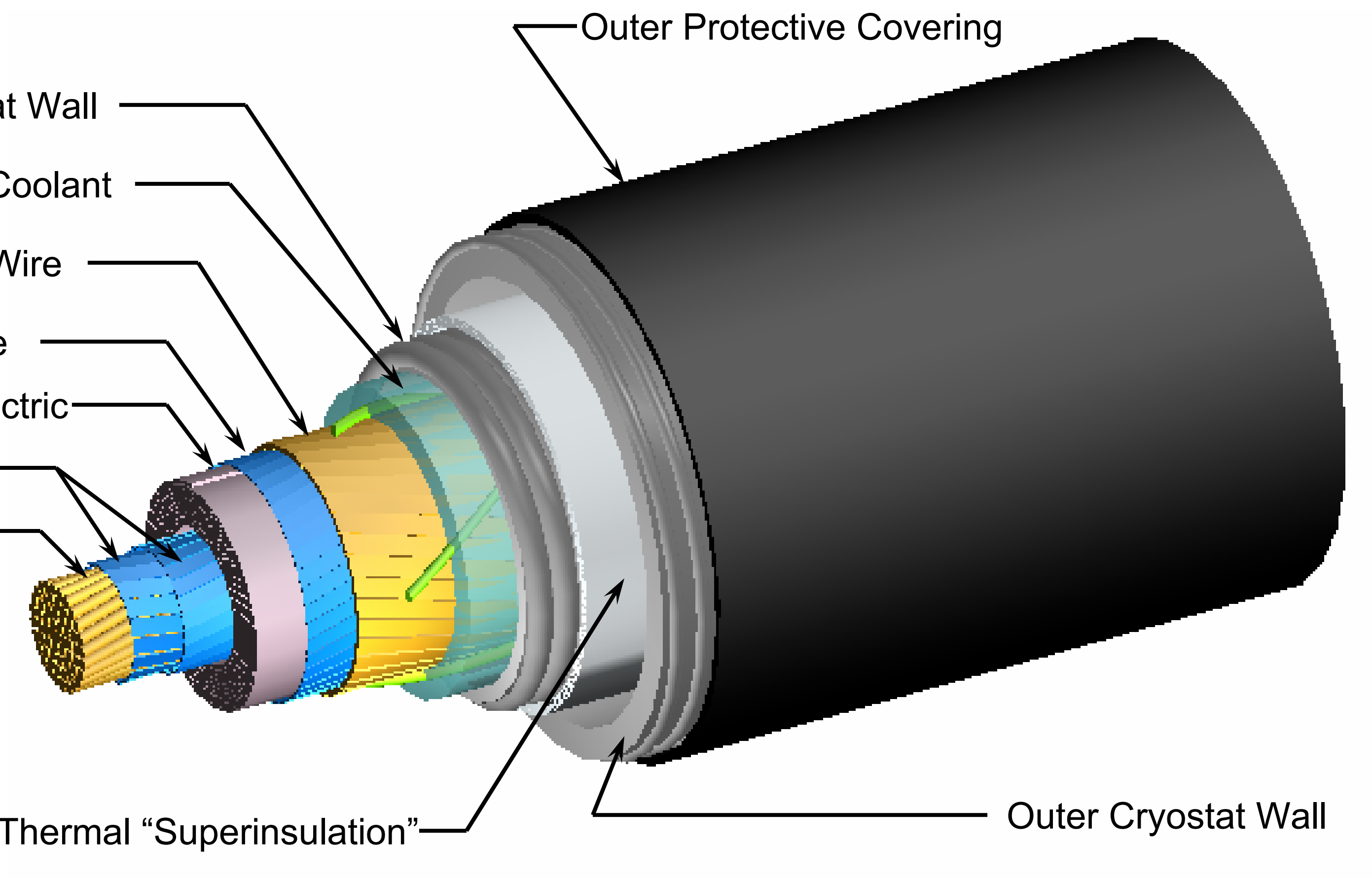
LIPA Cable Project and Project Team



LIPA HTS Cable System



Typical Cable Cross Section



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Project Status-Cable Subsystem, Nexans

- Cable
  - Modeling complete
  - Preliminary design complete
  - Fabrication of the first of several manufacturing "dummy" cables complete
  - Data analysis underway
  - Next manufacturing trial to begin in late July
  - Component testing underway
- Terminations
  - Design complete
  - Component testing underway to verify design
  - Prototypes (2) to be built this CY

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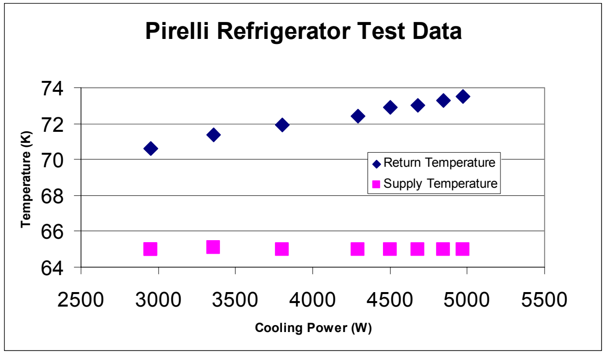
Project Status-Refrigerator Subsystem, Air Liquide

- Refrigerator
  - Re-use of Detroit refrigerator from previous Pirelli SPI Cable Program
  - Upgrades to system will include improved telemetry to allow for remote monitoring and control and possible capacity upgrade
  - Will be operated 6 months prior to cable commissioning

- Advanced Refrigerator Development
  - High frequency pulse tube
  - Optimized for efficiency and temperature
  - Integrated into cooling system as "non-critical" cooling



Project Timeline

• Cable design finalized	Feb ‘05
• ~120 KM wire shipped to Nexans	March ‘05
• Refrigerator commissioning start	June ‘05
• Prototype cable testing complete	Sep ‘05
• Cable fabrication start	Sep ‘05
• Cable installation work start	Dec ‘05/Jan ‘06
• Commissioning	March/April ‘06
• On grid	April ‘06
• Test of joint complete	October ’06
• Cable test complete	April ‘07

Risk Management 1/2

- Use of FMECA (Failure Mode Effect and Critical Analysis)
  - Used by Nexans Norway for estimating risks within projects
  - Formal way of risk and effect estimation
- Definition of probability classes

- Minimum probability	1	<=1 % probability
- Low probability	2	1-10 % probability
- Moderate probability	3	10-50 % probability
- High probability	4	>50 % probability

- Definition of consequence figures

- Minimum consequence	1
- Moderate consequence	2
- Serious consequence	3
- Very serious consequence	4

2004 Performance: Risk Management

- Use of FMECA (Failure Mode Effect and Criticality Analysis)
  - Definition of probability level (1-4)
  - Definition of consequence level (1-4)
  - Calculation of risk factor
- Initial risk estimate resulted in 29 risks
  - 11 high level risks - handled through preventive actions and sometimes contingency plans
  - Low level risks – handled sometimes through preventive actions and contingency plans – some of them accepted
- Risk estimate update
  - 7 risks disappeared through
    - Measurements
    - Calculations
    - Change of concept
  - 1 risk added

	Probability				
Consequence		**1**	**2**	**3**	**4**
	4	4	8	12	16
	3	3	6	9	12
	2	2	4	6	8
	1	1	2	3	4

Typical Risk Item Assessment

Tag #	Operation	Hazard	Cause	Effect	Quantity	Corrective Action (curative)	Probability	Probability Factor	Consequence	Risk Factor	Preventive Action	New Probability	New Probability Factor	New Consequence	New Risk Factor	Contingency Plan
2	Termination Design - Key Point: Connection to Cooling System	Loss of LN2 at current lead (bushing) junction	Lack of tightness of current lead (bushing)	Delay Costs	4 - 6 months 80 k€	Reorder of parts	10%	2	4	8	No use of vacuum as a dielectric	10%	2	1	2	Add security pressure valve for this part
		Loss of LN2 at junction cable cryostat / termination	Lack of tightness, shrinkage of cable/cryostat	Delay	3 months	Define new connection method between cable cryostat and termination	1%	1	2	2	Johnston coupling concept from NEXANS Hannover used (validated on several cryogenic installation) - bellows included in cryostat	1%	1	1	1	Repair potential leak on site (Helium test)
		Loss of LN2 at connection with cooling system	Lack of tightness	Delay	1 month	Reorder of parts, new tests	1%	1	2	2	Johnston coupling concept from NEXANS Hannover used (validated on several cryogenic installation) - bellows included in cryostat	1%	1	1	1	Repair potential leak on site (helium test)

Conclusions

- Project is proceeding smoothly
- Modeling and analysis mostly completed
- Manufacturing trials underway
- Proven refrigeration system
- Earned value analysis shows project tracking to schedule and budget

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