

Quo Vadis High- T_c ?

Cultivating a Mass(ive) Market

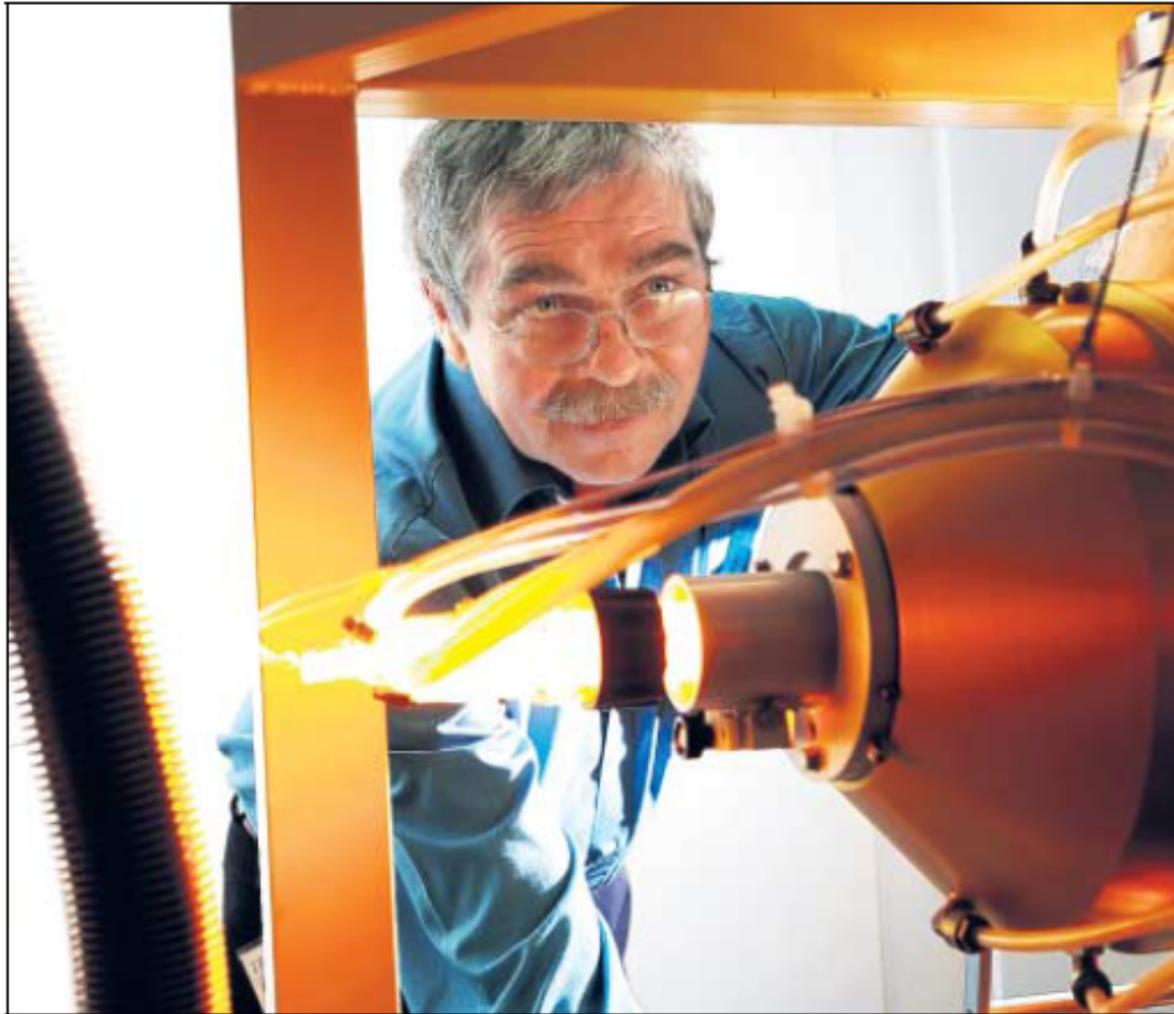
Paul M. Grant
W2AGZ Technologies

<http://www.w2agz.com/doe-wdw06.htm>

DOE Wire Development Workshop, St. Petersburg, FL 31 January 2006

"Ich war wie in Trance"

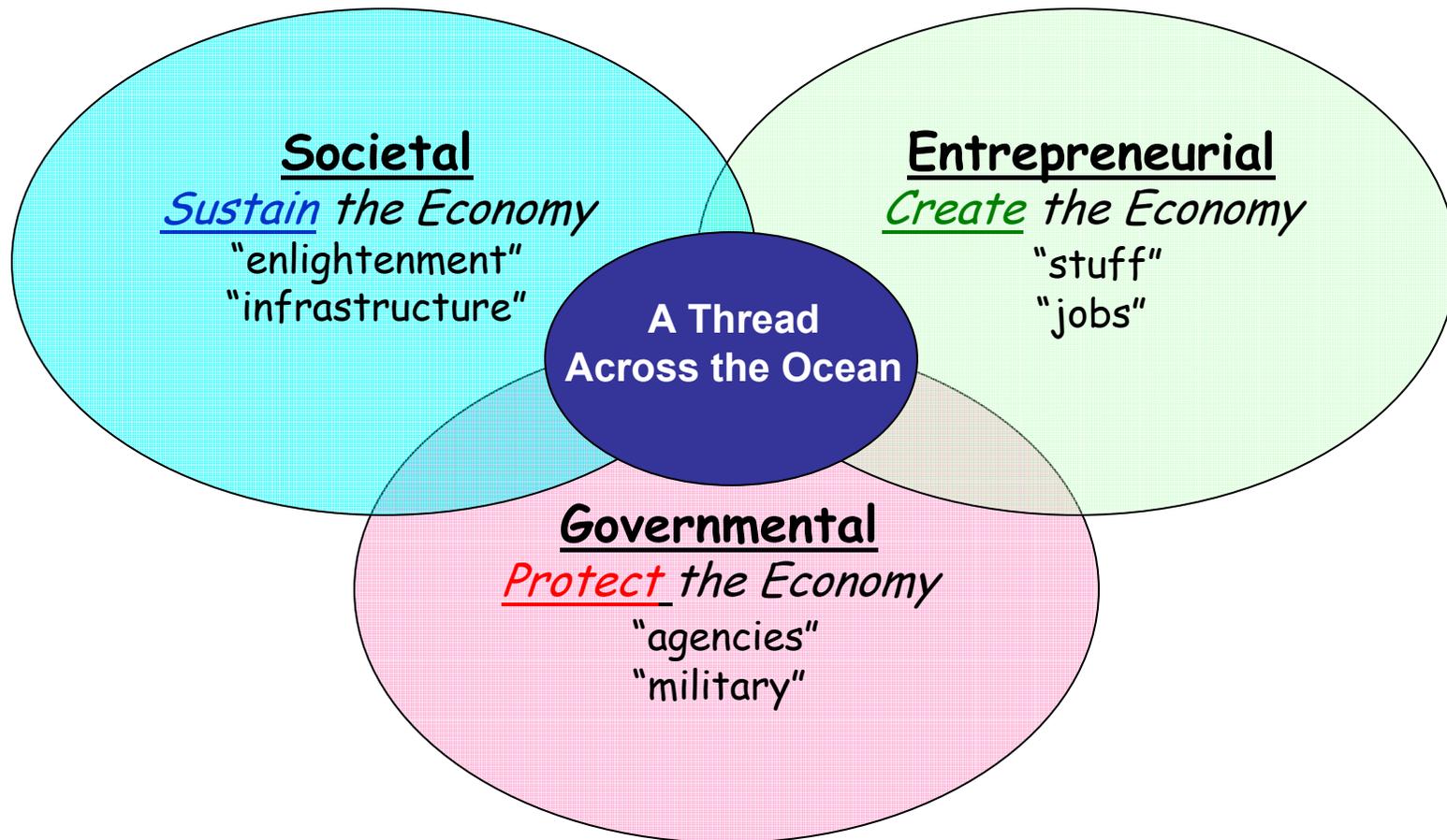
Vor genau 20 Jahren entdeckten Forscher am IBM-Labor Rueschlikon die Hochtemperatur-Supraleitung



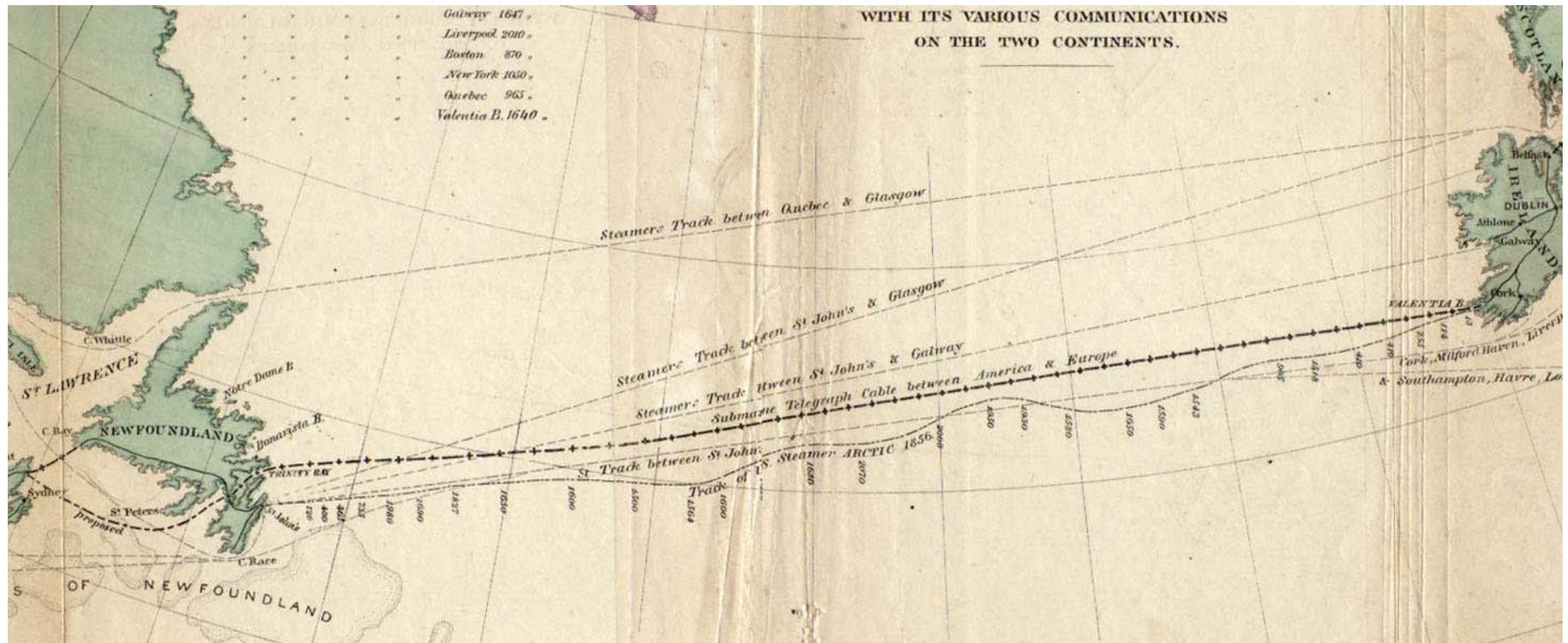
Georg Bednorz in seinem Labor in Rueschlikon. (Ursula Meisser)

NZZ am Sonntag – 22 Januar 2006

The Economic Troika That Drives and Exploits Technology Innovation



"A Thread Across the Ocean"



"The Story of the Trans-Atlantic Cable (1854 – 1866)"

John Steele Gordon

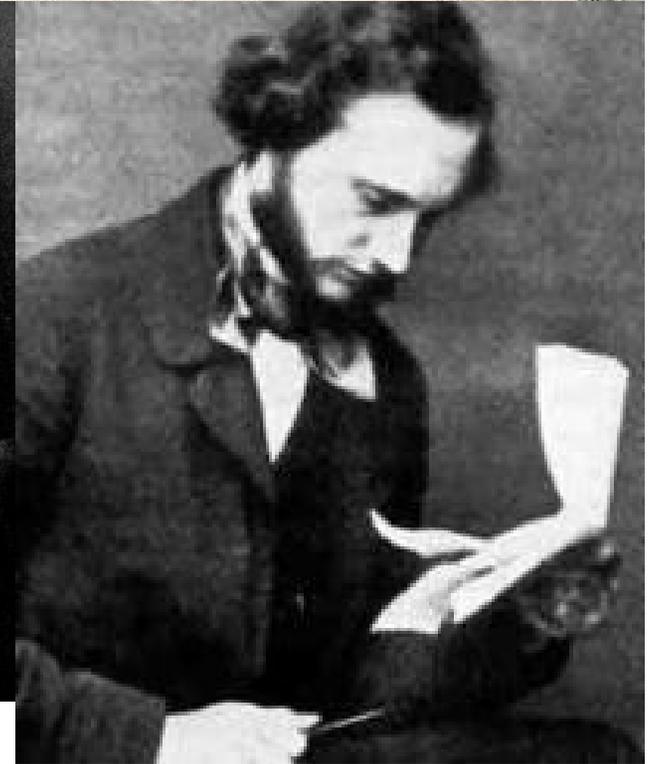
"A Thread Across the Ocean"



Cyrus Field
American Capitalist



Isambard Kingdom Brunel
English Engineer

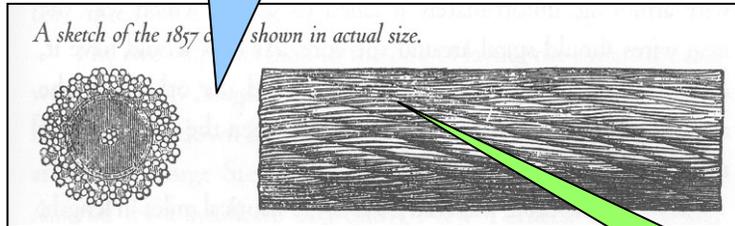


William Thomson
Irish Physicist

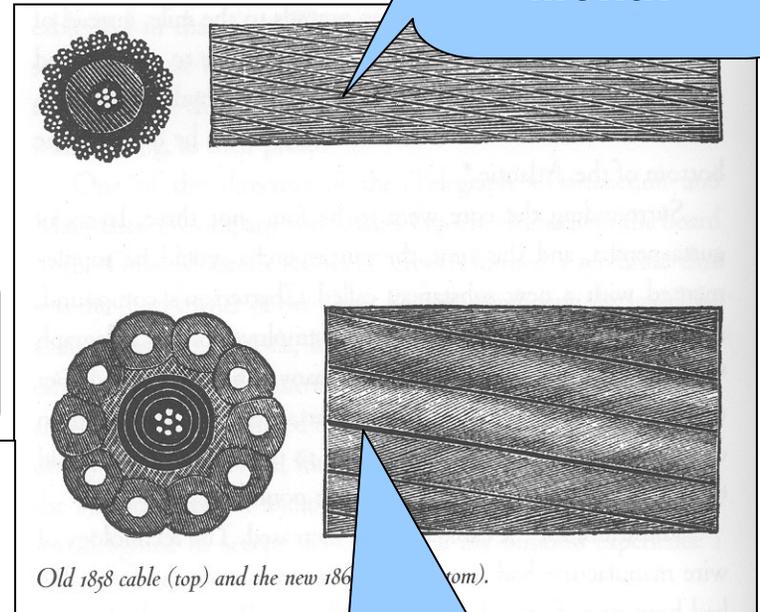
John Steele Gordon

Atlantic Cable Timeline & Designs

1857
"Broke"



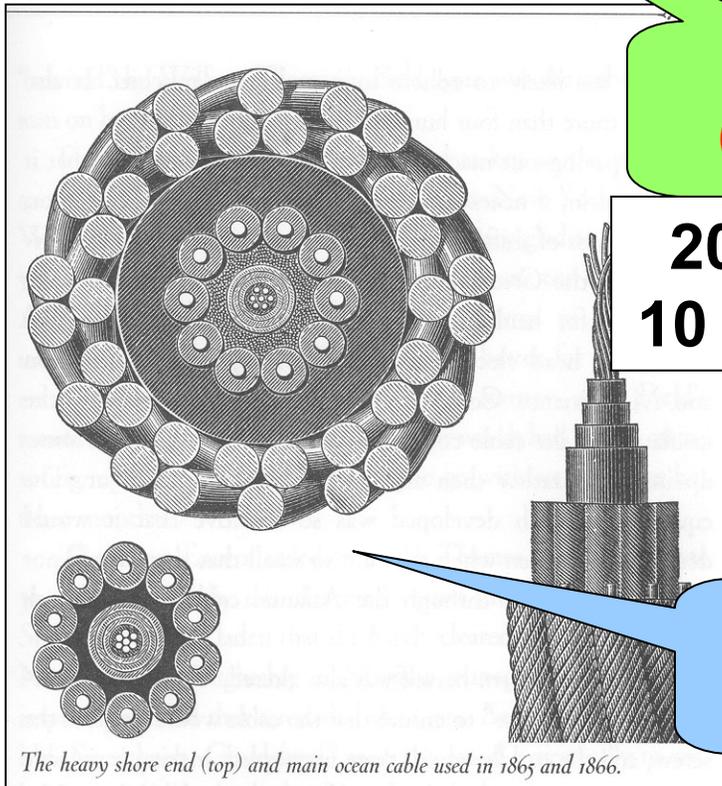
1858
"Worked for a Month"



2 \$/m
(2005)

200 A @
10 \$/kA×m

1865
"Parted"
(Recovered in 1866)

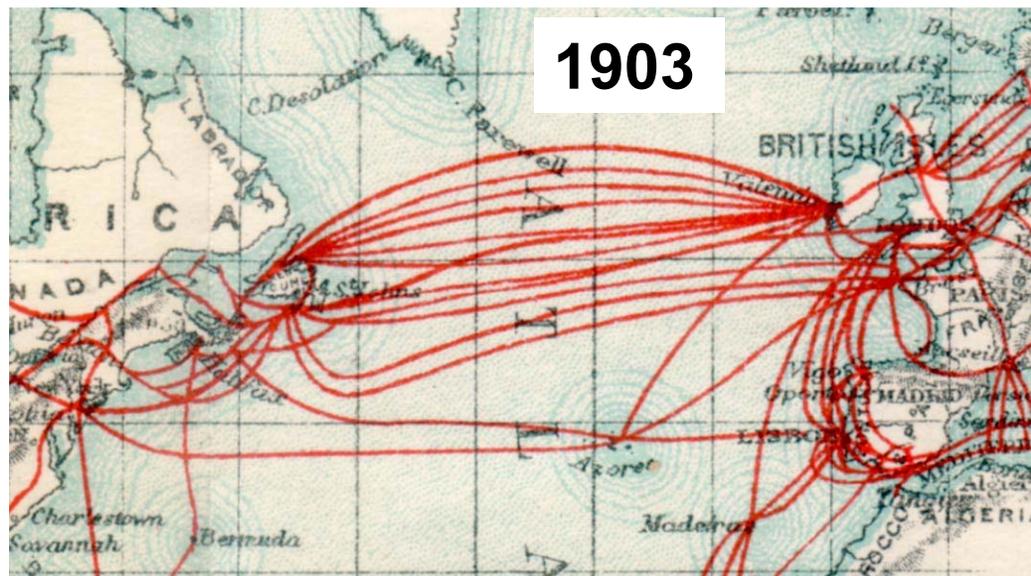
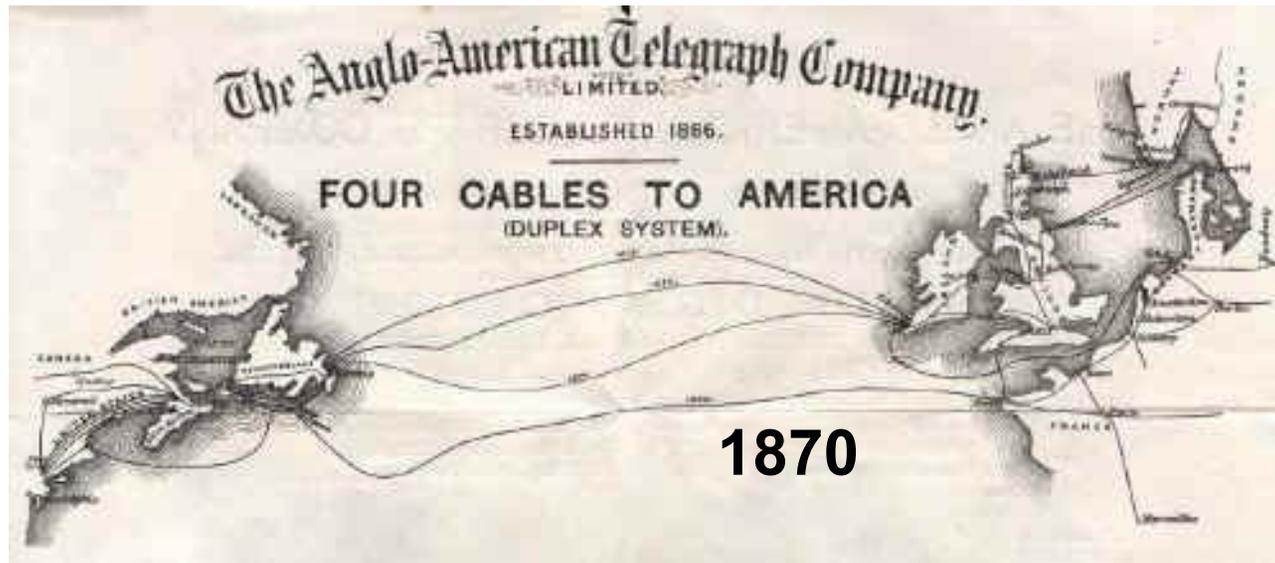


1866
Success!

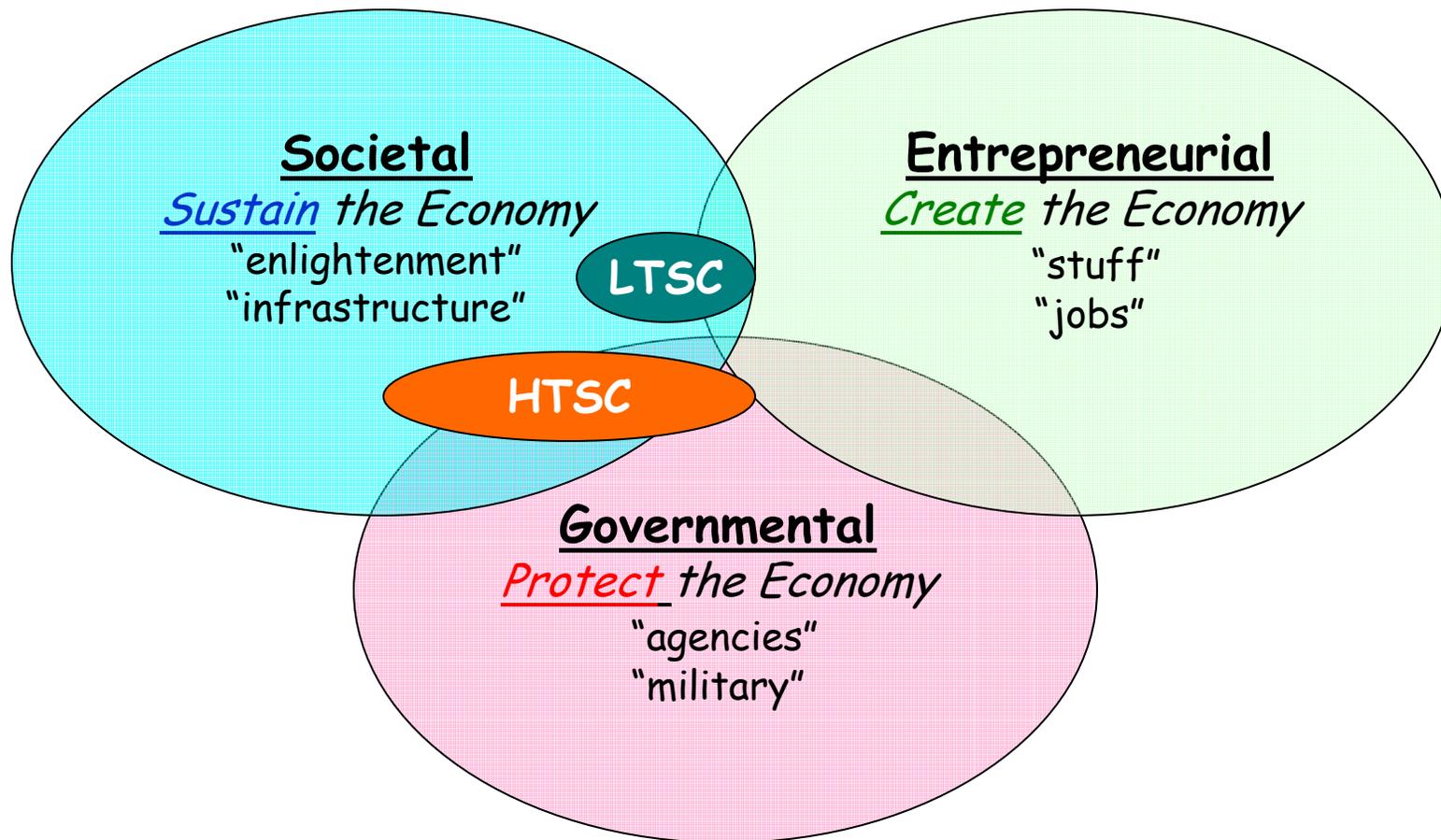
What Kept Them Going?

- The investors knew, that if communications with Europe could be cut from 2 weeks to 2 minutes, they'd all get...
- **FILTHY RICH!**
 - Estimates are that the total cost of the project in 2005 dollars was \$100 M
 - First year 1867 revenue in 2005 dollars was \$10 M !!

The After-Story



The Economic Troika That Drives and Exploits Technology Innovation





EMPIRE CONNECTION



Specifications

2-1000 MW HVDC Bipolar Circuits

- Circuit 1: 130 miles, Greene County → Bronx County
- Circuit 2: 140 miles, Albany County → New York County
- Each Circuit: +/- 500 kV, 1000 A Bipolar (2 cables ea.)

Financials

\$750 M (\$400 M "VC", \$350 M "Futures")

- Loan Payment (4%, 40 yrs, 750 M\$) = 35 M\$/yr
- Labor, Overhead, Maintenance = 5 M\$/yr
- Tariff = 0.5 ¢/kWh
- Profit (NOI) @ 50% Capacity = 4 M\$/yr
- Profit (NOI) @ Full Capacity = 48 M\$/yr

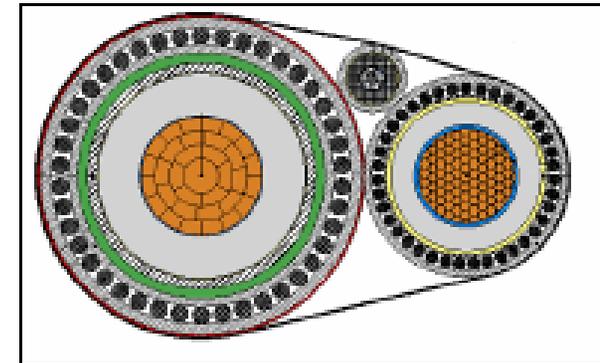
Why didn't it go forward?

Wire C/P = 100 \$/kA×m

HTSC Cost = \$87 M

NEPTUNE

Regional Transmission System™



HVDC Cable Cross-Section

Pirelli (Prysmian) Energy Cables

\$190 M

Sayerville, NJ → Levittown LI, NY

- 600 MW (+/- 250 kV, 1200 A)
- 65 miles (105 km)
- \$400 M
- 2007

Financials

40 yrs @ 4%: \$ 20M
LOM: 1 M
NOI (100%): 5 M

T	C/P	Cost (\$M)
77 K	\$/kA×m	
Cu	7	1.8
HTSC	100	25.1

Why Neptune and not the EC?

- Neptune cut a long term deal with LIPA...a "captive customer"
- EC was expecting provision of 500 MW to NYPA...didn't happen and final financing fell through
- "Street Buzz:" ConEd was uncomfortable with "single source" upstate supplier
- All other "merchant transmission" projects in jeopardy
- Exception (Maybe): SF Trans-Bay...IPPs complain about PG&E bottlenecks...opportunity for SCDC cables?
 - Write to Arnold

Factoids: Neptune & HTSC

- Bus-Bar Price 3 ¢/kWh
- Power @ 100% Capacity 600 MW
- Annual Energy Delivered 4.7 TWh
- Annual Delivered in USD \$141 M

- Transmission Losses 3 %
- Wasted Dollars \$4.2 M

- HTSC Wire @ 100 \$/kA×m \$25 M
- Wire Cost Payback 6 Years !

Why Did Pirelli "Park" HTSC Cable Development?

- It was **NOT** due to the problems encountered at Detroit Edison!
- Pirelli Timeline (\$100 M, 1993 - 2002)
 - 1993 SPI for EPRI/Pirelli Proto
 - 1998-1Q SPI for Detroit Edison
 - 1998-4Q "Blister/Balloons" found in Proto
 - 2001
 - May Pirelli submits LIPA SPI proposal to DOE
 - July Pirelli offers Energy Cables for sale
 - Sept SPI to Pirelli for LIPA
 - Dec Leaks found at Frisbie
 - 2002 Pirelli withdraws from LIPA (business case needed, not more demos)
 - 2005 Pirelli sells Energy Cables to G-S (Prysmian)

Is There a Mass(ive) Market for HTSC Cables?

- Sale of Pirelli Cable Systems (now Prysmian) to Goldman-Sachs, July 2005
 - 12,000 Employees, 52 Plants (Energy + Telecom)
 - Sale Price \$1.7 B
- 2004 Revenue & Profit
 - Revenue \$4.2 B
 - EBIT \$144 M
 - Profitability 3% !
- Assume 50% of EBIT comes from Energy Cables, and a 20% Up-tick is targeted from future sales of HTSC Cables, then:
 - EBIT (HTSC) = \$14 M

2005 Utility Specifications Desired for SC UGD Cable (1)

- Cable shall be rated for 5000 amps continuous and nominal 13.8 kV application.
- Cable shall be 15kV class and have 110kV BIL insulation.
- Cable conductor shall have superconducting properties when the temperature, magnetic field strength and current flux densities so warrant. When these same parameters drive the conductor outside of the superconducting range the conductor shall have the properties of a non conductor (insulator).

2005 Utility Specifications Desired for SC UGD Cable (2)

- Cable shall maintain superconductivity up to a minimum of 60°C ambient external sheath temperature when operated at rated current and 15kV L-L.
- Cable shall have physical characteristics such as to permit its being pulled into existing Company ducts. (tensile strength, diameter, bending radius, coefficient of friction, etc.)
- Cable system conductor shall be capable of being connected to both itself and non-superconducting materials (copper and aluminum) using crimp type connectors.

The Bottom Line

- There is no near-term mass market for HTSC utility application regardless of C/P (there is no “tipping point”)
 - Utilities in Japan and China have already made that decision, and probably Europe as well
 - In the US, only the LIPA project has a possible follow-on (and that’s problematic)
- Even if there were a “killer app,” and there isn’t, utilities would remain reluctant to deploy superconductivity because:
 - The technology is a hassle
 - It has to compete with FACTS, “low sag” transmission lines and conventional cables (just keep “digging up the streets”)

Is There Hope Beyond Utilities?

- The Military
 - Generation: Power to Punish the Bad Guys
 - Motors: Run Silent, Run Deep...Run Lite, Run Quickly
 - Caveat: If there had been a past military "killer app," LTSC wasn't that big a deal to employ
- Public Works
 - SuperCables: Like "Solar Roofs," they'll be good for the folks...and deserve help, like REA and TVA received, from the Government Sector

Two IBM Physicists (1967)

Superconducting Lines for the Transmission of Large Amounts of Electrical Power over Great Distances

R. L. GARWIN AND J. MATISOO

- Nb_3Sn ($T_c = 18 \text{ K}$) @ 4.2 K
- 100 GW (+/- 100 kV, 500 kA)
- 1000 km
- Cost: \$800 M (\$8/kW) (1967)

\$4.7 B Today!