Unanticipated Costs of Increasingly Networked Digital HVDC & FACTS Infrastructure

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Purpose of the Paper

Provide Vendors, Consultants, and Academia in industry a perspective about the lifecycle challenges and costs experienced by a “typical” Transmission Facility Owner (TFO) when dealing with modern highly networked HVDC & FACTS facilities

Provide Owners without a modern HVDC link insight into unintuitive costs

ATCO Newell Converter Station

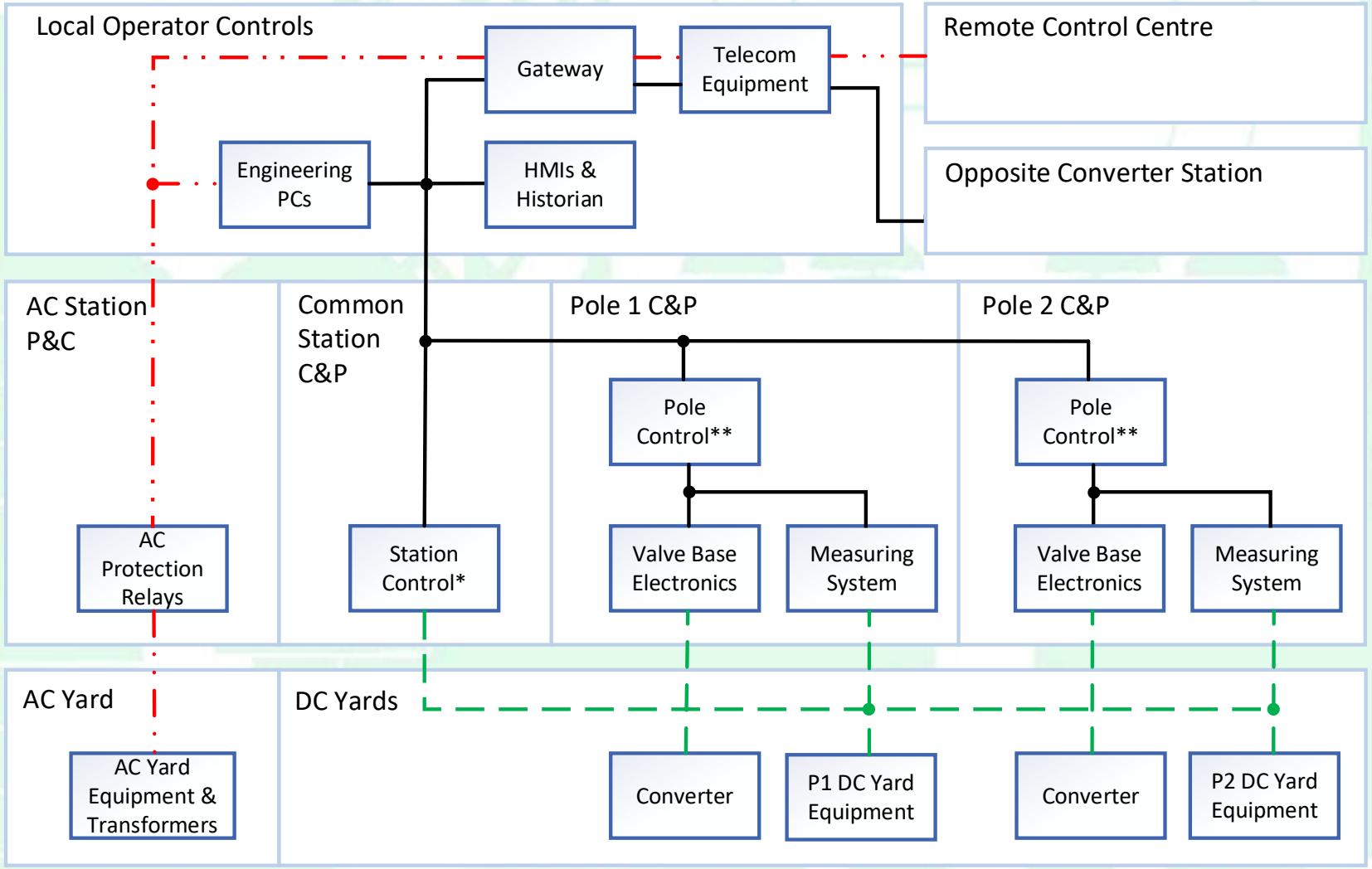
HVDC & FACTS Lifecycle Costs are Difficult to Predict for an Owner with Traditional AC Experience

This presentation focuses on two areas from the paper

1. The industry is used to traditional Control & Protection (C&P) systems with >>15-year lifespans but modern systems have <15-year lifespans. Why?

2. How do cybersecurity requirements affect O&M costs?
   A. Through cost of baselining
   B. Through cost of patching

What makes an HVDC C&P system unique?



Various TCP/IP standards, also found in AC substations

C&P Network (IP)

Measurement and Control (Serial or IP)

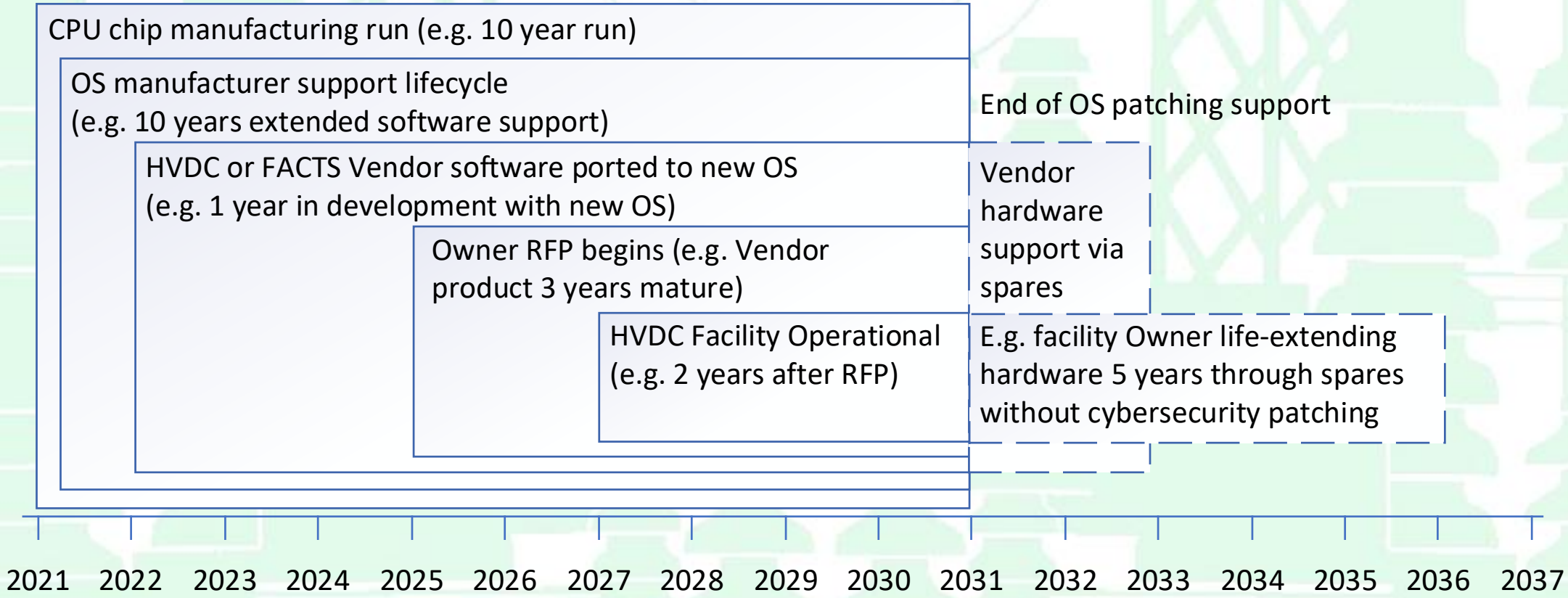
* The Station Control controllers may also be further split on a per pole or per bipole basis

** The Pole Control controllers may also be split into Pole Control & Valve Group Control if there are multiple valve groups per pole

The shorter lifecycle of modern HVDC C&P systems

Example of a theoretical next-generation product coming onto the market this year

- Similar examples exist for subsystems from all manufacturers



1. Owner Learnings

Complex dependencies on third-party products requires additional cooperation with Vendors

- Require the Vendor to provide a product maturity report upon providing the bid proposal, and further provide an anticipated third-party end-of-support of key subsystem components during the design stage of the HVDC or FACTS project
- A sparing strategy should account for the increased risk of part unavailability after anticipated end-of-software support
- The entire HVDC or FACTS control system is heavily interdependent, and likely cannot be replaced in parts like an AC control system

Where do Owners Struggle with NERC CIP?

NERC CIP standards enforce good cybersecurity practices. CIP is applicable to much of North America, but many outside jurisdictions make them locally applicable as well.

The difficulty of following CIP can be summarized in two bullets:

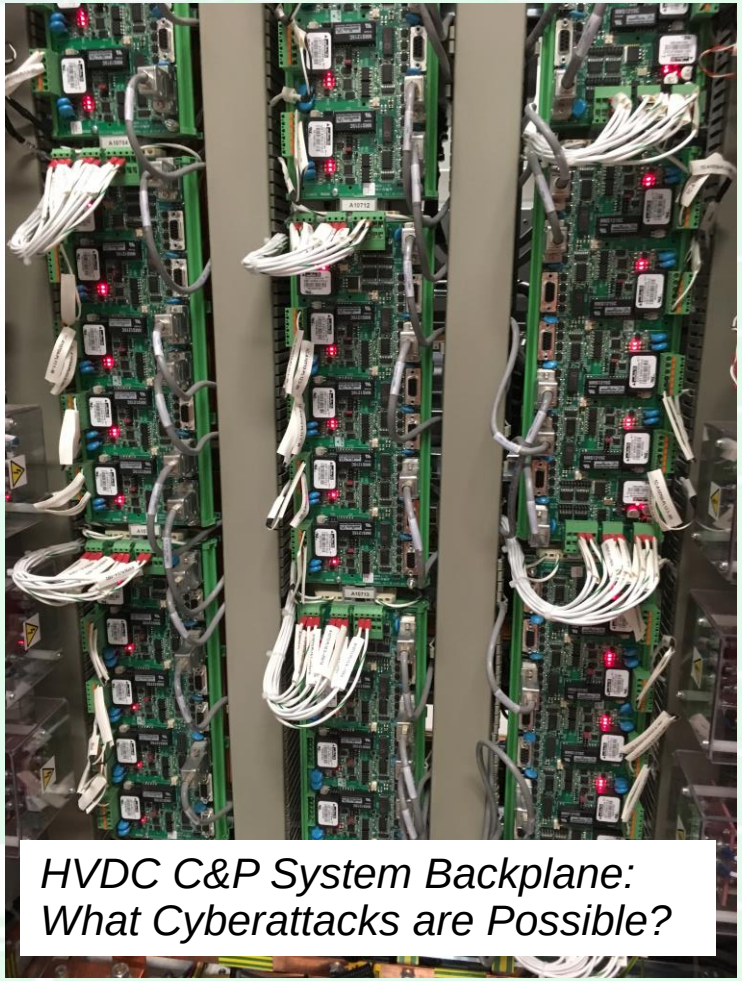
A. Baselining the Owner's assets (so the Owner knows what vulnerabilities are applicable)

B. Patching known vulnerabilities appropriately

2A) Owner Baseline Learnings (& Industry Opportunities)

Cybersecurity baselining means knowing enough about the cyber systems to determine both what is at risk of attack, and if an attack has occured

- Continual baseline verification is a laborious manual task OR requires sophisticated automated tools (both options have high O&M cost)
- HVDC C&P systems are sensitive to “active scanning” tools, and will typically require additional O&M to baseline
- A suggestion for industry: can vendors integrate automated baseline features into their C&P system?



HVDC C&P System Backplane: What Cyberattacks are Possible?

2B) Owner Patching Learnings

Owners must consider that if they are not choosing 1 or 2, then they are choosing option 3:

1. Build a patching test bed as part of the original project costs (high capital $)

2. Purchase a vendor patch-testing subscription service (high O&M $)

3. Patch without testing (high risk to reliability)

Spare Converter Transformer Cooling Controller:
The simplest "in-service" device to test

Questions?

Some more food for thought:

- How does an HVDC & FACTS Owner patch their assets after software end-of-support?
- How does an HVDC & FACTS Owner use a vendor's Software Bill of Materials (SBOM), especially for a portfolio containing multiple generations of products from multiple vendors?
- NERC CIP O&M costs are dependent on a TFO's internal procedures, tools, policies, and processes. How does an Owner validate a Vendor's design to minimize CIP O&M?