Q. **Reference: Assessment of Labrador Island Transmission Link (LIL) Reliability in Consideration of Climatological Loads, March 10, 2021 (Haldar Report) by Dr. Asim Haldar, Ph.D., P. Eng. page 22.**

Explain the difference between the damage limit state (DLS) analysis and the ultimate limit state (ULS) analysis and if, in Dr. Haldar's opinion, both are appropriate to consider when evaluating the reliability of the LIL. In the response state whether both types of analysis are widely used in the industry to evaluate transmission line design and reliability.

A. *The following response has been provided by Haldar and Associates.*

CSA 60826 requires that the reliability analysis and level should be based on the damage limit state ("DLS"), while the failure is only considered under security loads (non-climatological loads). DLS refers to initial damage from an intact system under a reliability class of load condition (loads normally associated with extreme wind and ice events and ice shedding). Failure only refers to security loads (broken conductor, tower failure etc.), and the design philosophy in this case is purely deterministic and not based on return period. Security loads were not considered in Haldar's study. Industry practice is to use DLS under extreme load event to determine the reliability level of the line and corresponding return period (approximate). No reliability is attached under a failure event due to security loads, (e.g., BWC, tower collapse etc.). DLS in overhead line design is alike ultimate limit state ("ULS") design (strength based design) used in general civil engineering structures (e.g., buildings, bridges, offshore structures etc.).

Newfoundland and Labrador Hydro provides the following additional information.

The DLS is a requirement of the CSA standard and is based on the system's governing critical component. In the case of the Labrador-Island Link ("LIL"), the governing critical component[1] is

[1] Governing component is that by which the system strength is dictated as it proves to be the weakest link.

the optical ground wire ("OPGW"). A violation of the DLS does not automatically imply that the line has failed structurally (e.g., collapse of a tower, foundation, etc.). In the case of the LIL, it represents the overstressing of the OPGW past its set design limit, which is not expected to have an effect on the structural system of the LIL, nor is it expected to affect any level of power transfer over the LIL. However, it does have the potential to fail operationally and may lead to structural failure if the condition persists without mitigation for a long period of time, which supports the importance of regular inspection cycles.

The ULS is outside the CSA standard. This scenario was considered given that the governing component of the LIL is the OPGW, and considering a return period and failure rate on the governing component only does not realistically represent the possibility of a structural failure of the LIL. The ULS reflects an ultimate failure scenario in which if this limit is reached, the system components would be stretched to their ultimate limit; thus, resulting in a greater chance of a forced outage of power delivery. In the analysis presented in the Haldar and Associates report, the strength factors for all cable and structural elements were increased to their maximum limits (i.e., 90% for all cable elements and 100% for all structural elements). The ULS scenario would represent the possibility of a structural issue occurring on the LIL under this analysis, which could have the potential to result in an extended bipole outage.

It is Newfoundland and Labrador Hydro's ("Hydro") view that both scenarios have merit with respect to the evaluation of reliability, and although industry practice typically is in line with the standards set out within the CSA, Hydro believes that the LIL has the greatest risk of an extended bipole outage under a ULS scenario which considers a cable system mechanical failure.