RAI Volume 2, Chapter 2.1.1.2, Second Set, Number 13, Supplemental Question 11:

With the proposed subsurface antennas located at only one end of each of several-hundred meter long emplacement drifts, clarify whether signal repeaters or other communication devices supporting wireless communications with the transport and emplacement vehicle (TEV) and remotely operated vehicle will be required within emplacement drifts to ensure reliable communications with these vehicles when they are operating at the furthest points within the emplacement drifts from the antennas. If so, describe how such equipment will be qualified to withstand the anticipated normal ambient temperatures and faulted ambient temperatures that could develop assuming no subsurface ventilation may be available for a period as long as 30 days.

1. SUPPLEMENTAL RESPONSE

The communication system within the emplacement drift using subsurface antennas without utilizing repeaters, as described in SAR Section 1.4.2, has been chosen as the preferred method of TEV communication. As described in SAR Section 1.4.2.4.1, the in-drift communications system is classified as not important to safety (non-ITS) and will be further developed during the detailed design phase. If, as the design progresses, better alternatives are identified or the antenna approach is found to be inadequate (e.g., requiring repeaters in the emplacement drift), other alternatives or developing technology that emerges will be evaluated for use. This approach was identified in the clarification call with the NRC and agreement was reached for the DOE to provide design concepts in addition to the antenna approach described in SAR Section 1.4.2.4.1.5. Other communication systems exist, such as slotted waveguide and rail transmission, that could also satisfy system requirements and are discussed in Sections 1.2 and 1.3. Each of these three existing technologies is judged to be adequate to provide reliable communications in the anticipated environmental conditions and distances. The primary criteria associated with selecting an adequate communication system within the emplacement drift would be focused on two factors: (1) attainment of adequate throughput over the length of the drift; and (2) minimization or elimination of the need for equipment that might require replacement (e.g., repeaters) due to the radiation and thermal conditions in the drift.

1.1 ANTENNAS

SAR Figure 1.4.2-9 proposes antennas to be located within the subsurface turnouts, and the supplemental response to RAI 2.2.1.1.2-1-014 discusses the design using antennas for wireless communications with the TEV within an emplacement drift. However, since antennas inside the emplacement drift would be located in harsh operational conditions, maintenance activities would be required to ensure adequate equipment performance. The wireless communication system utilizing antennas is in accordance with IEEE Std 802.11g/D6.1, *Draft Supplement to Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher-Speed Physical Layer Extension in the 2.4GHz Band*. This system would provide payload data rates of up to 54 Mbps, and would provide adequate capacity for communications with the TEV while inside the emplacement drift. The use of antennas meets the requirements of the subsurface

communication system. However, if better alternatives are identified as the design progresses, such as the options described below, the use of antennas may be reconsidered and appropriate design criteria developed.

1.2 SLOTTED MICROWAVE WAVEGUIDE

An alternative subsurface communication system design that may be considered as the design progresses is using slotted microwave waveguide as shown in Figures 1 and 2. As shown in Figure 1, the optical nodes that are located in the electrical equipment alcoves interface with radio frequency equipment that drives redundant slotted microwave waveguides. The slotted microwave waveguide serves to communicate with the TEV as it travels through the access main and into the emplacement drifts. Each run of slotted microwave waveguide originating from an electrical equipment alcove will split and carry communication signals to segments that run approximately half the distance to the next alcove (approximately 900 ft). A slight overlap of the radio frequency signal coverage area will occur between different sections of slotted microwave waveguide that originate from adjacent alcoves. This will ensure that there is no break in communications with the TEV. Figure 2 shows the typical access main to turnout geometry. The figure specifically details the slotted microwave waveguide transition from the access main to the entrance of the emplacement drift.

The wireless communication system utilizing slotted waveguide would utilize IEEE Std 802.11g/D6.1, *Draft Supplement to Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher-Speed Physical Layer Extension in the 2.4GHz Band*. This system would provide payload data rates of up to 54 Mbps, and would provide adequate capacity for communications with the TEV while inside the emplacement drift and likely without the need for repeaters.

1.3 RAIL TRANSMISSION

Another alternative subsurface communication system design uses power line carrier transmission. The power line carrier design configuration would utilize the existing TEV third rail (consisting of multiple conducting rails) as the transmission media. One or more transmission circuits could therefore be established through the third rail configuration. The communications link would be established through the same connections as the TEV power connection to the electrified third rail. The third rail power system utilizes conductor bars mounted by insulators to support brackets positioned on the outside of the TEV crane rails. The TEV is fitted with collectors which consist of spring-loaded units that provide a continuous, positive contact to the conductor bars. The TEV has two collectors per vehicle side; the collectors on one side are energized at any given TEV location, which provides a physical connection through rail crossings. The use of a power line carrier configuration provides effective and low-maintenance communications with the TEV throughout the length of the emplacement drifts.

Power line carrier communications have evolved into broadband over power line networks. Proposed IEEE Std P1901, *Draft Standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications*, allows for data rates up to 100 Mbps over power lines and would provide adequate capacity for communications with the TEV while inside the emplacement drift without the need for repeaters.

1.4 EQUIPMENT QUALIFICATION

SAR Section 1.4.2.4.1 states that the communications system is non-ITS and performs no ITS functions; therefore, the communication system is not qualified by the equipment qualification program described in SAR Section 1.13 for harsh environments. However, the detailed design analysis will incorporate communication equipment designed for its expected normal ambient environmental conditions (mild or harsh), depending on its physical location (inside or outside the emplacement drift). If components are used within an area that requires replacement over time, maintenance procedures for such replacements will be developed.

Natural ventilation will occur in the subsurface following a loss of forced subsurface ventilation, limiting temperature excursions and their effects on equipment. Communications equipment in the main drift will be evaluated on a case-by-case basis, prior to restoring it to operation. The TEV will be designed to sustain operability following a loss of forced subsurface cooling. Similar to other subsurface equipment, if the TEV were affected by the loss of subsurface ventilation, its systems would also be evaluated prior to returning to operation.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

IEEE Std 802.11g/D6.1. 2003. *Draft Supplement to Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher-Speed Physical Layer Extension in the 2.4GHz Band*. New York, New York: Institute of Electrical and Electronics Engineers.
TIC: 254396.

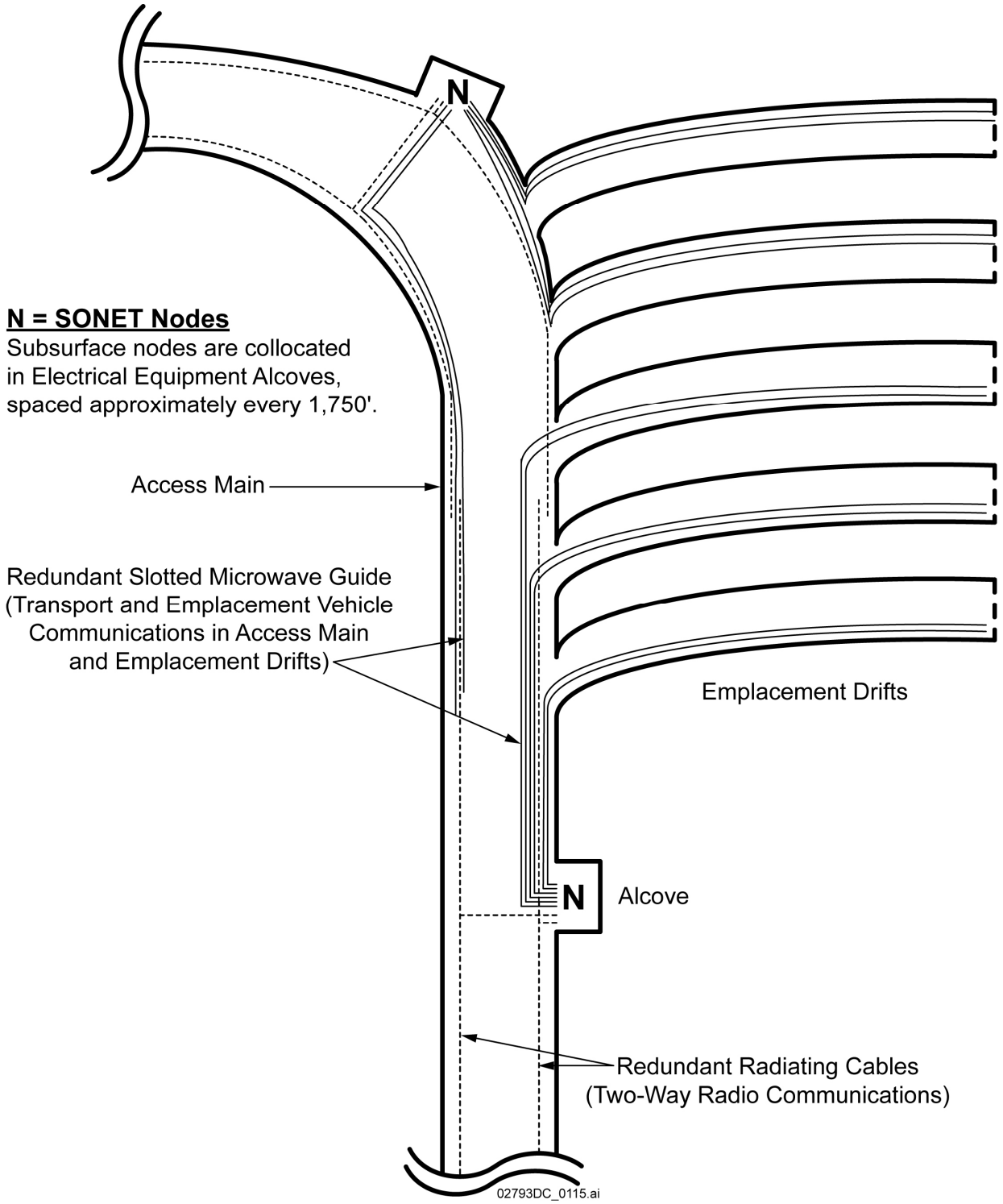

Figure 1. Site Topology—Slotted Microwave Waveguide Configuration—Access Main and Emplacement Drift

NOTE: SONET = synchronous optical network.

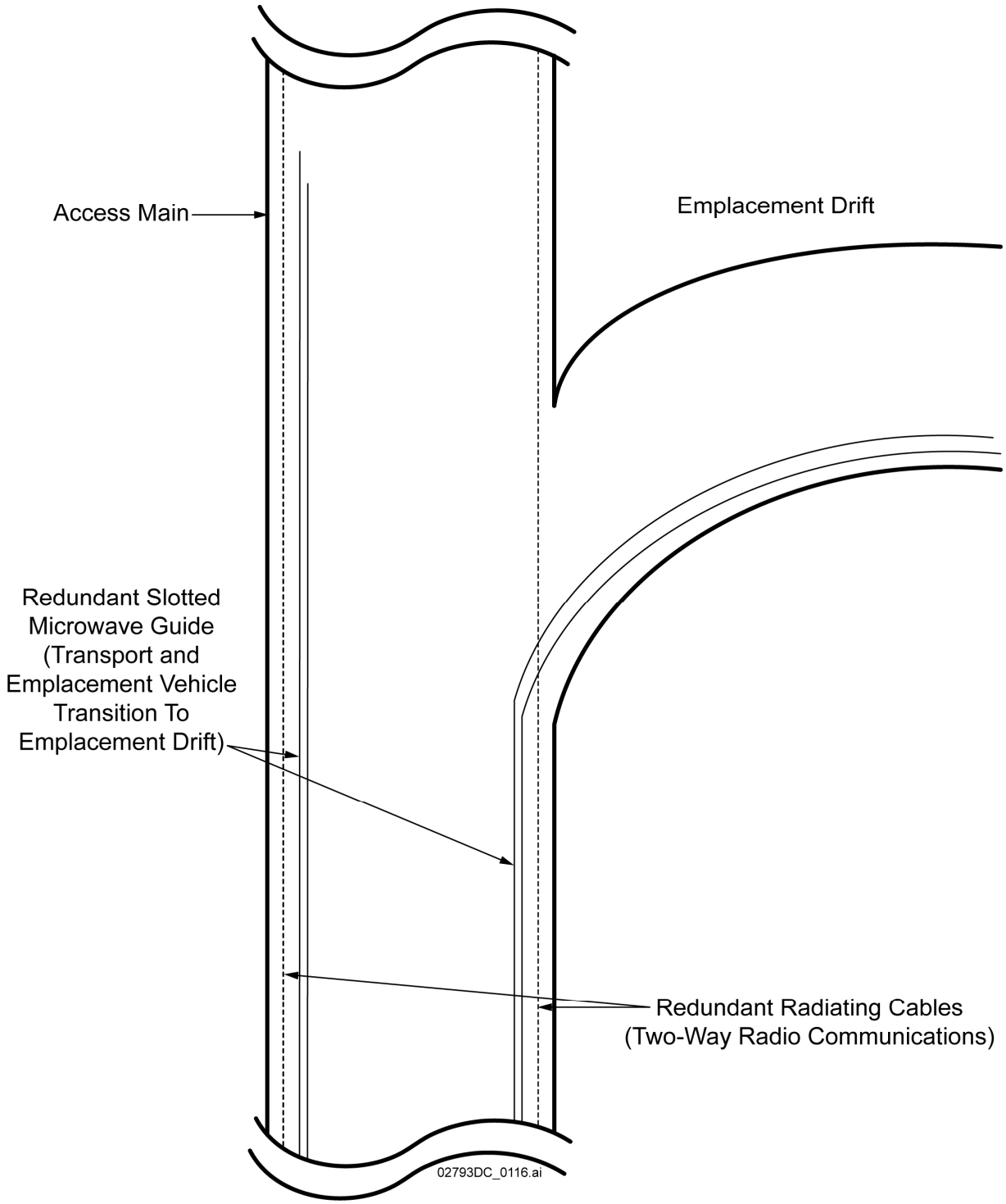

Figure 2. Site Topology—Slotted Microwave Waveguide Access Main to Emplacement Drift Turnout Geometry