

1. Displacement or permanent deformation of either the end shoe or blockout mounting brackets greater than  $\frac{1}{2}$  in. (13 mm) from their nominal dimensions would require replacement of the component.
2. Tearing or fracture of the base material of the brackets or any welds would constitute replacement of the component.
3. Damage to the anchorage of either bracket that deforms the anchors or partially or fully disengages the anchor would require resetting of the anchorage with new anchors. For the end shoe bracket, this may only require installation of new mounting bolts if the bracket itself is undamaged. The blockout mounting bracket could be replaced using the two unused anchors holes if one of the original anchors is damaged or becomes disengaged.

## **12.5 Integration with other barrier systems**

The guardrail to PCB transition design developed in this research focused on the MGS guardrail system and the 12.5-ft (3.81-m) long, F-shape PCBs previously developed through the Midwest States Pooled Fund Program. While the transition was designed specifically for these two barrier systems, there may be a desire to integrate this transitions with other barrier systems including existing G4(1S) W-beam guardrail or alternative PCB designs.

Because a majority of the guardrail currently on the highway system consists of the G4(1S) guardrail design, there is a high likelihood that there will be a need to attach the guardrail to PCB transition to these older existing barriers. The two obstacles that must be overcome to transition between the G4(1S) system and the MGS guardrail used in the transition are the difference in the rail height and the difference in splice location. Previous guidance has been given that the transition in the rail height from the G4(1S) to the MGS can occur by gradually increasing the height of the rail at a constant slope over a distance of 25 ft to 50 ft (7.62 m to 15.21 m). Several options exist

for transition the rail splices from the posts to the mid span including omitting a post and addition of a post at  $\frac{1}{2}$  spacing. Three options are acceptable, but each requires a slightly different layout depending on the splice transition method preferred. In addition, each guardrail to PCB transition option requires a slightly different connection point to the nested MGS guardrail used in the guardrail to PCB transition design in order to ensure that there is a short length of standard MGS prior to the beginning of the guardrail to PCB transition. The three recommended G4(1S) to MGS transitions are detailed below.

1. Omitted Post Option – The transition between the rail splice locations for the G4(1S) to MGS transition can be accomplished through omission of a post after the rail height transition is completed as shown in Figure 98. Recent research has shown that the omission of a single post in the MGS and creation of a 12.5 ft (3.81 m) unsupported span is acceptable under MASH TL-3 impact conditions [15]. As such, it is recommended that the splice transition can done following the rail height transition through omission of the post at the first splice following the height transition. This creates a 9 ft-4  $\frac{1}{2}$  in. (2.86 m) span between the G4(1S) spacing and the MGS spacing. Attachment of the MGS to the nested rail that begins the guardrail to PCB transition may begin at the first splice following the splice transition.
2. Half Post Spacing in MGS – A second option for transitioning from G4(1S) to MGS consists of adding an additional post following the rail height transition, as shown in Figure 99. For this transition, a post at  $\frac{1}{2}$  post spacing is added after the second post following the rail height transition, and standard MGS begins after that point. Attachment of the MGS to the nested rail that begins the guardrail to PCB transition may begin after one 12.5-ft (3.81-m) long section of standard MGS following the splice transition.

3. Half Post Spacing in G4(1S) – A third option for transitioning from G4(1S) to MGS consists of adding an additional post prior to the rail height transition, as shown in Figure 100Figure 99. For this transition, a post at  $\frac{1}{2}$  post spacing is added after the final post in the G4(1S) prior to the rail height transition, and standard MGS post spacing begins after that point. Attachment of the MGS to the nested rail that begins the guardrail to PCB transition may begin after one 12.5-ft (3.81-m) long section of standard MGS following the rail height transition.

Conversion of the blockout depth from the 8-in. deep G4(1S) blockouts to the 12-in. deep MGS blockouts may occur at whatever point in the G4(1S) to MGS transition is convenient.

Finally, the guardrail to PCB transition designed and evaluated in this research focused on the 12.5-ft (3.81-m) long, F-shape PCBs used by a majority of the states in the Midwest. However, there may be potential to use this transition design with similar, alternative PCB designs if some basic criteria are met.

1. The reinforcement of the alternative PCB design would need to provide equal or greater capacity to the barrier segment used in this research.
2. Alternative PCB segment connections must have comparable or greater structural capacity and torsional rigidity about the longitudinal barrier axis when compared to the as-tested PCB configuration.
3. Alternative barrier geometry may affect the performance of the system. As such, barrier height should be maintained at the 32 in. (813 mm) height of the PCB evaluated herein in order to maintain a similar propensity for vehicle snag. Differences in the barrier face geometry, such as New Jersey and single-slope barriers, may be acceptable, but are not recommended at this time without further study. There are concerns that the difference in face geometry may affect vehicle interaction with the PCB in the overlapped barrier

region and would require development of revised connection hardware for the W-beam end shoe and blockouts.

4. The PCB segments with alternative lengths could potentially be used but are not recommended without further study due to concerns for potential differences in the PCB deflection and stiffness
5. Any alternative PCB should have similar mass per unit length to the as-tested PCB system to provide similar inertial resistance, stiffness, and dynamic deflections.
6. Finally, as the transition was evaluated to MASH TL-3, it is recommended that any PCB design used with the transition be MASH TL-3 as well. It is also recommended that any alternative PCB design have similar MASH TL-3 dynamic deflection values to the as-tested PCB. Significantly increased or decreased dynamic deflection behavior may adversely affect the performance of the guardrail to PCB transition system.

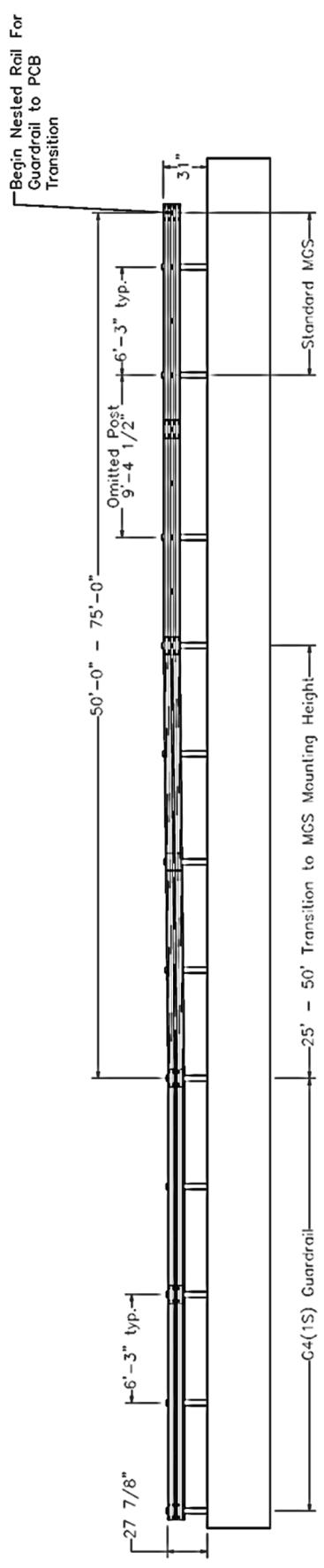


Figure 98. Schematic for Transitioning between G4(1S) and MGS Prior to Guardrail to PCB Transition, Omitted Post

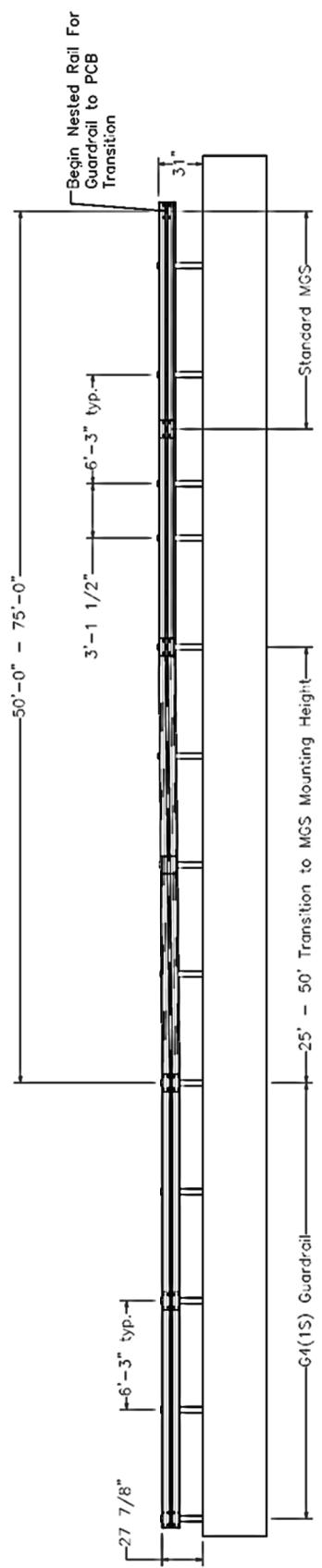


Figure 99. Schematic for Transitioning between G4(1S) and MGS Prior to Guardrail to PCB Transition, Half Post Spacing in MGS

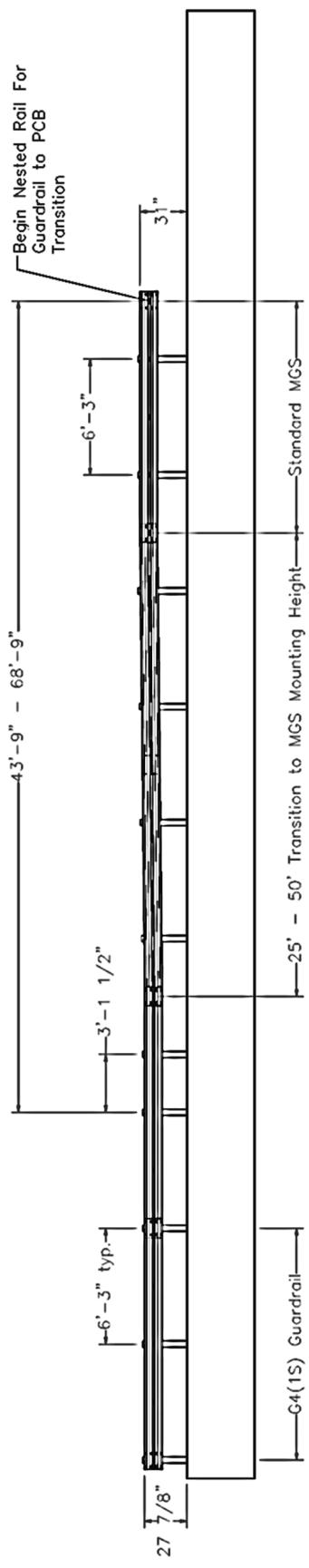


Figure 100. Schematic for Transitioning between G4(1S) and MGS Prior to Guardrail to PCB Transition, Half Post Spacing in G4(1S)