MASH Implementation
Phase I

Informational Workshop Meeting

August 29, 2017 & September 5, 2017

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Agenda

1. What is MASH?

2. Why use MASH?

3. What hardware is being replaced?

4. What is being implemented?
   a) Highway Standard Drawings (New, Revised, and Eliminated)
   b) Qualified Products List (QPL)
   c) Pay Items
   d) Specifications

5. What is not changing with implementation of MASH?

6. What is coming in the future?

7. Department Resources
MASH abbreviation for “Manual for Assessing Safety Hardware” is the testing and evaluation criteria for the safety performance of highway features and hardware.

- Historical view of Crash Testing
  - 1993 NCHRP Report 350
    - Added Crash test level criteria; Levels 1-3 based on speed: TL-1 31 mph, TL-2 43 mph, TL-3 62 mph, and TL 4 – 6 added large trucks
  - 2009 MASH updated test vehicles to reflect changes in the American fleet
  - 2016 MASH (second edition of MASH) refined testing for Cable Systems
MASH

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Gross Vehicle Weight</th>
<th>NCHRP-350 to MASH</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Car</td>
<td>1,800 lbs. to 2,420 lbs.</td>
<td>20 to 25 Degrees</td>
<td></td>
</tr>
<tr>
<td>Pickup Truck</td>
<td>4,400 lbs. to 5,000 lbs.</td>
<td>Single to Quad Cab</td>
<td></td>
</tr>
<tr>
<td>Single Unit Truck</td>
<td>17,600 lbs. to 22,000 lbs.</td>
<td>50 to 56 mph</td>
<td></td>
</tr>
</tbody>
</table>

- MASH implemented due to changes in the American vehicle fleet (weight & center of gravity) and refined testing parameters based on more experience in crash testing the extreme limits to better represent real world situations in a controlled environment.
Jan 2016 AASHTO/FHWA Joint MASH Implementation Agreement was nationally adopted. The AASHTO Standing Committee on Highways with approval of FHWA voted/accepted the implementation of MASH agreement which accomplished four things;

1) Defined the roles of AASHTO and FHWA;
   - AASHTO Technical Committee on Roadside Safety is responsible for developing and maintaining the evaluation criteria
   - FHWA continue to issue Letters of Eligibility of Hardware for Federal-aid reimbursement
2) Urged agencies to establish a process for upgrading existing outdated equipment that is not successfully tested to NCHRP Report 350 or later testing criteria
3) Encouraged states to upgrade hardware when damaged beyond repair with MASH 2016 compliant safety hardware
4) Established phased in approach of safety hardware based on contract letting dates. One exception is temporary work zone devices are based on manufactured date and normal service life

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**Why MASH**

- **Implementation Agreement**
  - **December 31, 2017**: w-beam barriers and cast-in-place concrete barriers  **PHASE 1**
  - **June 30, 2018**: w-beam terminals
  - **December 31, 2018**: cable barriers, cable terminals, and crash cushion
  - **December 31, 2019**: bridge rails, transitions, all other longitudinal barriers (including portable barriers installed permanently), all other terminals, sign supports, all other breakaway hardware and temporary work zone devices (based on manufactured date).

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MASH Implementation: Additional Information, Phase One

This directive augments EB-2017-3 (Lanelet Guidance: MASH Implementation, Roadside Research), which identified certain requirements for projects with bid opening dates after December 31, 2017 and noted the need for follow-up information. This directive identifies specific resources (e.g., Standard Drawings, contract items) needed to prepare contract documents. Given the scope and timeline of MASH implementation activities and topics, the Department is reaching out to provide information through other communication channels.

Resources for Construction Contracts
To complete the design and contract documents for the first of three transition phases the following new MASH compliant, w-beam guardrail Highway Standard Drawings are under review for approval and will be available through the Department’s Standard Drawings web page for use in contracts:

- HW-010.20, MASH W-Beam Hardware
- HW-010.21, Metal Beam Rail (R-B MASH) Guardrail
- HW-010.22, Metal Beam Rail (MD-B MASH) Guardrail
- HW-010.23, Metal Beam Rail (R-B MASH) Half and Quarter Post Spacing
- HW-010.24, Metal Beam Rail SPGM Section Types II and III
- HW-010.25, Metal Beam Rail Transition 350 to MASH

The following existing Highway Standard Drawings are being modified for MASH implementation and will be available through the Department’s Standard Drawings web page for use in contracts:

- HW-91.01, R-B End Anchorage Type I and II
- HW-91.02, MD-B End Anchorage Type I
- HW-1850.03, Type B Impact Attenuation System (Tangential)
What Hardware is Being Replaced?

Highway Design Manual
Chapter 13 – Disposition of Existing Rail

**All new w-beam rail must meet MASH**

- R-B 350
- MD-B 350
- Modified R-I

- Highway Design Manual – Chapter 13 section 13-9.03.01 Roadside Barrier
- The same hardware is being used to build MASH guiderail as our current NCHRP-350 tested guiderail, just a different way of assembling them.
- Standard sheets have been cleansed of design and/or spec information to reduce duplication of information, example:
  - Material specification covers shop bent w-beam. This is no longer covered in the general notes. Designer needs to call out the radii on plans when the rail is to have a radii of 150’ or less.
- Material change with MASH – only 12 Gauge used for MASH guiderail – no longer using 10 Gauge as previously noted in the general notes.
- R-B stands for Roadside Barrier
For MASH tested guiderail, the w-beam has been raised from 29” to 31” in height and the splice point was shifted to mid-span location. This effectively reduced the concentration of stresses developed upon impact of the system.
- Trial Installation, note W-beam splice is lapped in the direction of traffic from right to left.
- Permitted to omit a single post. For locations where omitting two or three posts requires CRT posts installed as indicated on Sheet HW-910_24.
- 6” depth of Processed Aggregate needs to be shown for new construction projects on typical sections
- On upgrade projects, Processed Aggregate will be used to back up existing vertical edges of pavement
- Lap w-beam on each side based on the direction of traffic to avoid snags
- Mid-span splices are located at same location for both sides
- Curbing is not recommended if the rail is between 1’ and 10’ from the edge of road
- Processed Aggregate limits extend 1’ past the face of the rail
- MD-B stands for Median Barrier
- The w-beam has been raised from 29” to 31” in height and the splice point has been shifted to a mid-span location
- Half Post Spacing (Formerly System 5) is shown as one rail length, yet this length can be extended if desired
- Quarter Post Spacing (Formerly System 6) requires 25’ of Half Post Spacing on both sides of the Quarter Post Spacing and includes this in the Quarter Post Spacing pay item
- Rub rails are no longer used in conjunction with reduced post spacing
- W-beam design deflections can be found in the Highway Design Manual, no change in values with the implementation of MASH.
**METAL BEAM RAIL (R-B MASH)**

**HALF & QUARTER POST SPACING**

- Quarter Post Spacing (Formerly System 6) requires 25' of Half Post Spacing on both sides of the Quarter Post Spacing and includes this in the Quarter Post Spacing pay item.
- This sheet will replace the existing posted Standard Drawing HW-910_05 “Metal Beam Rail R-B 350 Span Section Type I, II, & III
- Major changes:
  - No longer only shown for culverts, system can be utilized for any obstruction preventing post installations
  - Removed diagram for 1 omitted posts since the R-B MASH guiderail system allows for a single post omission
  - This system must be installed tangentially
- Headwalls adjacent to this system are limited to a 2 inch MAX reveal because anything higher could obstruct the return flight of the vehicle
- Fencing on top of headwalls with this span section should avoid having any horizontal piping
- MASH tested deflection ranged between 48 and 77 inches
- Transition method is appropriate for both single and double faced guiderail
- The purpose of this transition is to adjust the w-beam rail height and splice location
- Transitions will be paid for under the longitudinal item, a callout should still be provided for a transition
- Trial Installation
- W-Beam Delineators
  - Physically installed at the mid span splice connections for either R-B MASH or MD-B MASH guiderail, but is allowed at post connections in reduced post spacing sections
- Delineators not to be installed within 75 feet of any w-beam terminal impact head.
- Installation location criteria included in notes
Revised Specifications

- 9.10 Supplemental
- M.10.02 (Owned Special Provision)
  - Paragraph No. 9 – Plastic Blockouts
- Impact Attenuator (Tangential)
- Impact Attenuator (Flared)
- Impact Attenuator (Median/Gore)

- Form 817 Section 9.10 pay item descriptions revised to no longer include the “350” terminology
  - Revisions are included in the July 2017 Supplement
- New owned special provision for Form 817 Section M.10.02 to require MASH compliant plastic blockouts
- Revised owned special provisions for Type B Impact Attenuation Systems
  - Streamlined, eliminating redundant information that was already addressed in the QPL and elsewhere
  - Requires the installation of either an NCHRP 350 system or a MASH system depending on the type of longitudinal barrier installed
- Typical grading for turn-down end anchor standard drawing is being removed
- Highway design manual indicates anchors to be installed outside the Clear Zone
  - The entire anchor system should be installed outside of the clear zone, including the post closest to the anchor
  - A dimension should be provided on plan sheets from either the edge of road or edge of travel to the post closest to the end anchor
- It is desirable to not install curbing in the sections where the rail is flared
  - If curbing is included in a project, strive to introduce the curbing after the rail has become parallel to the edge of road
- Plan sheets and Cross sections should include site specific grading information
- Highway Design Manual Figure 13-6C should be referenced for guidance on grading for turn-down end anchors
- Any information not available in the Highway Design Manual shall be referenced from the Roadside Design Guide
- 29” Rail height removed
  - These are typical roadside barrier anchors that can be installed at either 29” or 31” rail height
- Entire anchor system should be installed outside of the clear zone in leading end conditions
- Design information for type of end anchor based on Design Speed has been removed
  - 45 mph or greater = Type I
  - Less than 45 mph = Type II
- Plan sheets should specify whether a Type I or Type II end anchor is to be installed
- 29” Rail height removed
  - These are typical median barrier anchors that can be installed at either 29” or 31” rail height
- Entire anchor system should be installed outside of the clear zone
- Link to video of vehicle crashing into turn-down end anchor: https://www.youtube.com/watch?v=EQ6CPIM1ZCs
**QUALIFIED PRODUCT LIST**

( QPL )

**Impact Attenuation Systems - Continued:**

SPECIFICATION: CTDOT Special Provision Item # 1803064A & 1803071A

PREAPPROVAL CRITERIA: Crash Tested in accordance with “National Cooperative Highway Research (NCHRP) Report 350 - Recommended Procedures for the Safety Performance Evaluation of Highway Features” Test Level 3 criteria; or, Crash tested in accordance with “AASHTO Manual for Assessing Safety Hardware (MASH)” Test Level 3 criteria.

Comments: For all attenuators, see the CTDOT Highway Design Manual for guidance.

<table>
<thead>
<tr>
<th>System</th>
<th>Manufacturer/Supplier</th>
<th>Compatible Barrier System</th>
<th>Crash Test Specification</th>
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<tbody>
<tr>
<td>SoftStop</td>
<td>Trinity Products</td>
<td>RB-350, RB-MASH</td>
<td>MASH</td>
</tr>
<tr>
<td>MSKT-SP</td>
<td>Road Systems, Inc.</td>
<td>RB-350, RB-MASH</td>
<td>MASH</td>
</tr>
<tr>
<td>MAX-Tension</td>
<td>Burger Systems by Lindberg</td>
<td>RB-350, RB-MASH</td>
<td>MASH</td>
</tr>
<tr>
<td>BEAT</td>
<td>Road Systems, Inc.</td>
<td>6” Box Beam</td>
<td>NCHRP-350</td>
</tr>
<tr>
<td>WY-BET</td>
<td>Trinity Products</td>
<td>6” Box Beam</td>
<td>NCHRP-350</td>
</tr>
</tbody>
</table>

- QPL means Qualified Products List, it provides:
  - Specification requirements
  - Crash testing criteria
  - Location to be installed (Tangential, Flared, Median/Gore, Non-Gating, Non-Gating High Incident)
  - Manufacturer/Supplier
  - Compatible Barrier Systems
- The QPL is a living document that gets updated as hardware becomes available
- Crash results of SoftStop Trial Installation
Each W-Beam Terminal has different size / shape Impact Head

- Impact heads come in different shapes and sizes
- Traffic standard sheet TR-1205_01 provides reflector guidance for impact heads
- Attenuator Reflector sign #50-5032
- Revised standard sheet for tangentially installed systems
TYPE B IMPACT ATTENUATION SYSTEM
(TANGENTIAL)

- Grading was changed to better match the Roadside Design Guide
- Clarified limits of curbing in front of Impact attenuator
- New pay items for MASH compliant guiderail
  - Table of Equivalent NCHRP 350 Item numbers to assist in estimating

<table>
<thead>
<tr>
<th>Equivalent 350 Item No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>0910170</td>
<td>0910300 Metal Beam Rail (R-B MASH)</td>
</tr>
<tr>
<td>0910171</td>
<td>0910310 Metal Beam Rail (MD-B MASH)</td>
</tr>
<tr>
<td>0910184</td>
<td>0910322 Metal Beam Rail Span Section Type II</td>
</tr>
<tr>
<td>0910185</td>
<td>0910323 Metal Beam Rail Span Section Type III</td>
</tr>
<tr>
<td>0910172</td>
<td>0910301 Metal Beam Rail (R-B MASH Half Post Spacing)</td>
</tr>
<tr>
<td>0910169</td>
<td>0910302 Metal Beam Rail (R-B MASH Quarter Post Spacing)</td>
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<td>0910168</td>
<td>0910351 Convert Metal Beam Rail (R-B 350) to (R-B MASH)</td>
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<td></td>
<td>0910352 Convert Metal Beam Rail (R-B 350 SYSTEM 5) to (R-B MASH)</td>
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<td>0910353 Convert Metal Beam Rail (R-B 350 SYSTEM 5) to (R-B MASH Half Post Spacing)</td>
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<td></td>
<td>0910354 Convert Metal Beam Rail (R-B 350 SYSTEM 5A) to (R-B MASH)</td>
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<td>0910356 Convert Metal Beam Rail (R-B 350 SYSTEM 6) to (R-B MASH)</td>
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<td>0910167</td>
<td>0910357 Convert Metal Beam Rail (R-B 350 SYSTEM 6) to (R-B MASH Quarter Post Spacing)</td>
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<td>0910358 Convert Metal Beam Rail (MD-B 350) to (MD-B MASH)</td>
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<td>0912605</td>
<td>0912900 Reset Metal Beam Rail (R-B MASH)</td>
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<tr>
<td>0912614</td>
<td>0912901 Reset Metal Beam Rail (MD-B MASH)</td>
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</table>
**What is NOT Changing in Phase 1**

- Bridge Attachments
- Curved Guiderail Treatment
- Anchor in Earth Cut Slope & in Rock Cut
- Crash Cushions
- Pre-Cast Concrete Barrier

- Bridge Attachments are remaining unchanged in the Phase I Implementation of MASH
- All current NCHRP 350 bridge attachments continued to be used
- If you are designing a new run of MASH Guiderail connecting into a bridge, install NCHRP 350 bridge attachment along with Transition guiderail (HW-910_25)
- If you are installing R-B MASH Guiderail and an NCHRP 350 Bridge attachment, both hardware standard drawings will need to be included in the contract since the MASH hardware sheet does not have the W8x13 Post
- New Bridge attachments will be coming for the last deadline (End of 2019)
What is not Changing in Phase 1

- Bridge Attachments
- Curved Guiderail Treatment
- Anchor in Earth Cut Slope & in Rock Cut
- Crash Cushions
- Pre-Cast Concrete Barrier

- The Curved Guiderail System is remaining unchanged in the Phase I Implementation of MASH
- If you are designing a new run of MASH Guiderail connecting to a curved guiderail treatment, be sure to include transition guiderail (HW-910_25)
- R-B 350 is allowed to be installed if transition length is not available such as at short lengths of rail with bridge attachments and curved guiderail
What is not Changing in Phase 1

- Bridge Attachments
- Curved Guiderail Treatment
- Anchor in Earth Cut Slope & in Rock Cut
- Crash Cushions
- Pre-Cast Concrete Barrier

- The Earth Slope and Rock Slope anchors are remaining unchanged in the Phase I Implementation of MASH
- These anchors are specific to their height and are not to be confused with the turn-down end anchor
- If you are designing a new run of MASH Guiderail connecting to an Earth Slope or Rock Slope anchor, be sure to include transition guiderail (HW-910_25)
What is not Changing in Phase 1

- Bridge Attachments
- Curved Guiderail Treatment
- Anchor in Earth Cut Slope & in Rock Cut
- Crash Cushions
- Pre-Cast Concrete Barrier

Crash Cushions are remaining unchanged in the Phase I Implementation of MASH
- Crash Cushions are impact attenuators that are attached to or placed in front of rigid concrete barriers or rigid fixed objects
- Crash Cushions will be included in the Phase II implementation for the end of 2018
What is not Changing in Phase 1

- Bridge Attachments
- Curved Guiderail Treatment
- Anchor in Earth Cut Slope & in Rock Cut
- W-Beam Terminal End (Median Application)
- Crash Cushions
- Pre-cast Concrete Barrier

- Pre-cast Concrete Barriers are remaining unchanged in the Phase I Implementation of MASH
- Temporary Pre-cast Concrete Barrier for work zones will be changed with last implementation at the end of 2019
- The current F-shape Concrete barrier design appears to be similar to what’s being MASH tested

December 31, 2019
- F-shape or 9.1 degree single slope effectively limits potential rollovers
- 45” is higher than what is currently being tested for MASH test level 4 concrete barrier
- Required depth of embedment is currently being researched
- For now we will continue to use our 45” high F-Shape concrete barrier until more information becomes available
What is coming in the future

- Qualified Products list (QPL) Updates
- Additional W-Beam End Terminals
- Downstream anchor
- Anchor in Earth Cut Slope & in Rock Cuts
- Phases 2 and 3
- Highway Design Manual Revisions

- The QPL is a living document that will be updated as items become approved
- Additional terminals to come
  - Manufacturers are testing Flared and Median applications
- Downstream anchor to come
  - MASH tested Downstream anchor will be coming soon for trailing end anchoring within the clear zone
- Anchor in Earth Slope & Rock Slope
  - MASH testing is currently being performed, changes may come in the future. Continue using current standard with transition.
- Phases 2 and 3 will be coming to stay on target with federal requirements for federal-aid reimbursement
  - Contains Department and outside resources
  - Q&A Dialogue
  - Important announcements
  - Email address to send in questions