Roadside Safety Pooled Fund

Texas A&M Transportation Institute

Proving Ground

Test Report No. 609731-5&6
Test Report Date: August 2021

EVALUATION OF MODIFIED MINNESOTA SWING-AWAY MAILBOX

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16. Abstract

The objective of the study was to test and evaluate a modified swing-away mailbox support in accordance with *MASH* criteria.

Two high-speed tests (*MASH* Test designation 3-61) were performed to evaluate two different impact scenarios associated with the cantilevered design of the swing-away mailbox, each using a 2420-lb (1100-kg) passenger vehicle impacting the test article at a speed of 62 mi/h (100 km/h).

In the first test (609731-5), the left quarter point of the vehicle was aligned with the centerline of the mailbox unit. The cantilevered design of the MnDOT swing-away mailbox potentially permits the mailbox assembly to engage the windshield of the vehicle without the front of the vehicle impacting the vertical support. This test condition evaluated whether the cantilever support prevents contact with, and limits damage to, the windshield of the impacting vehicle.

In the second test (609731-6), the right front quarter point of the vehicle was aligned with, and impacted, the vertical mailbox support. The quarter point of the vehicle was selected as the point of impact to permit evaluation of the interaction between the cantilevered arm and mailbox assembly with the windshield after release of the support from its base.

The Modified Minnesota Swing-Away Mailbox met the performance criteria for *MASH* Test 3-61 whether impacting (1) the cantilever arm and mailbox assembly, and (2) the vertical mailbox support.

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lb/in^2

*SI is the symbol for the International System of Units

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Chapter 1. INTRODUCTION

1.1. PROBLEM STATEMENT

The Minnesota Department of Transportation (MnDOT) has a swing-away mailbox support for use in locations where snow and ice removal during the winter presents a problem. The MnDOT design utilizes a cantilevered arm that permits snowplow operation beyond the shoulder or curb line, thereby reducing snow drifting on the roadway and reducing the potential for damage to the mailbox support.

The MnDOT swing-away mailbox support was tested and evaluated by the Texas A&M Transportation Institute (TTI) in 1993 *(1)* in accordance with the guidelines outlined in *National Cooperative Highway Research Program (NCHRP) Report 350 (2)* and the American Association of State Highway and Transportation Officials (AASHTO) *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (3)*. The performance of a single mailbox support was found to be marginally acceptable. Although the windshield of the impacting vehicle was completely shattered, high-speed film indicated that the mailbox assembly did not intrude or penetrate into the occupant compartment.

Subsequent to the crash testing, design modifications were made to the swing-away mailbox support by MINNCOR Industries. There was a need to evaluate these design changes through full-scale crash testing to determine whether or not they adversely influenced the crashworthiness of the mailbox system. The modified design was evaluated and crash tested by TTI in 2006 *(4)* in accordance with the guidelines outlined in *NCHRP Report 350 (2)* and the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (3)*. The performance of a single mailbox support was found to be marginally acceptable. Although contact with the mailbox caused a tear in the windshield, no pieces or components of the mailbox system penetrated the occupant compartment.

AASHTO recently published a second edition of the *Manual for Assessing Safety Hardware* (*MASH*) *(5)*. As part of this update process, AASHTO and the Federal Highway Administration (FHWA) developed and adopted a revised joint implementation agreement that establishes compliance dates for use of *MASH* hardware for new installations and full replacements on the National Highway System (NHS) that differ by hardware category.

Mailbox supports fall under breakaway hardware and, therefore, have a *MASH* implementation date of December 31, 2019. Many state DOTs are currently identifying and prioritizing their roadside safety devices that will require *MASH* testing. MnDOT has prioritized their swing-away mailbox support as a device requiring *MASH* testing and evaluation.

1.2. OBJECTIVE

No modifications to the MnDOT swing-away mailbox support have occurred since the 2006 testing. In the previous testing conducted on the original and modified swing-away mailbox designs *(1,4)*, substantial windshield damage was observed. Based on review of this previous testing and other recent mailbox tests, some modifications to the 2006 design may be needed for it to comply with MASH criteria. The modification under consideration is a vertical extension at the end of the cantilever support that can engage the front end of the vehicle, thereby reducing interaction of the mailbox with the vehicle windshield.

The objective of the study is to test and evaluate a modified swing-away mailbox support in accordance with *MASH* criteria.

1.3. WORK PLAN

The work plan for the project consisted of four tasks. Details of these four tasks are described below.

1.3.1. Task 1: Develop Design Modifications

Substantial windshield damage was observed during the previous testing conducted on the modified swing-away mailbox design *(4).* When the vehicle impacted the support post, the windshield was shattered and had an opening of 15.7 inches × 11.8 inches near the center. When the vehicle impacted the mailbox assembly independent of the support, the windshield was shattered over an area measuring 24.4 inches × 17.7 inches and sustained a cut measuring 5.5 inches × 0.6 inch near the right A-pillar. Under *MASH*, the windshield has a maximum deformation threshold of 3 inches and is not permitted to have a tear in the plastic safety liner (i.e., no holes, cuts, or tears through the windshield).

Under this task, the cantilever arm of the swing-away mailbox was modified to mitigate the mailbox contact and related windshield damage. The modification consisted of a vertical extension at the end of the cantilever support that can engage the front end of the vehicle, thereby accelerating the mailbox assembly and cantilever arm. This involved an extension of the tubular support that extended downward and then loops back to attach to the support to provide better strength. This would hopefully eliminate or reduce the severity of any interaction between the mailbox and vehicle windshield, and enable the swing-away mailbox to satisfy *MASH* impact performance criteria.

Test installation drawings for the modified support structure were prepared and submitted to the technical representative for review and approval. Upon approval of the test installation drawings, prototype supports were fabricated for testing and evaluation under Tasks 2 and 3.

1.3.2. Task 2: *MASH* Test 3-61 Impacting Vertical Mailbox Support

The recommended Test Level 3 (TL-3) *MASH* test matrix for evaluation of breakaway supports consists of three full-scale crash tests: test designations 3-60, 3-61, and 3-62. Test designation 3-60 involves a 2420-lb (1100 kg) passenger car impacting the support at a speed of 19 mph (30 km/h) and the critical impact angle (CIA) between zero and 25 degrees. Test designation 3-61 involves a 2420-lb (1100 kg) passenger car impacting the support at a speed of 62 mph (100 km/h) at the CIA. Test designation 3-62 involves a 5000-lb (2270 kg) pickup truck impacting the support at a speed of 62 mph (100 km/h) at the CIA.

Previous testing of the MnDOT swing-away mailbox under *NCHRP Report 350* with a 1800-lb (820 kg) passenger car demonstrated that the low-speed test (test designation 3-60) posed no problems or concerns *(1)*. In this test (Test No. 471470-11), the mailbox system readily released from its base and was propelled forward with only minor damage to the vehicle front end and without windshield contact. Consequently, the researchers do not feel that a repeat of this test is necessary on the modified design under *MASH*.

The small passenger car is considered the critical design vehicle based on the mailbox mounting height that is dictated by the United States Postal Service. As shown in Figure 1.1, the taller hood height and longer wrap-around distance (i.e., the distance from the ground, around the front end, and across the hood to the base of the windshield) of the pickup truck significantly decreases the probability of windshield impact and occupant compartment intrusion. Consequently, the researchers do not feel that test 3-62 is necessary on the modified swing-away mailbox design under *MASH*.

Figure 1.1. Vehicle-Mailbox Geometrics for 2270P *MASH* Pickup Truck.

Rather, it was proposed to conduct two high-speed tests (test designation 3-61) to evaluate two different impact scenarios associated with the cantilevered design of the swing-away mailbox. In the first test which was performed under this task, the left front quarter point of the 2420-lb (1100-kg) passenger car will be aligned with and impact the vertical mailbox support at a speed of 62 mi/h (100 km/h). The quarter point was selected as the point of impact to permit evaluation of the interaction between the cantilevered arm and mailbox assembly with the windshield after release of the support from its base.

TTI constructed, tested, and evaluated the modified swing-away mailbox support in accordance with *MASH* impact performance guidelines. The full-scale crash testing was performed at the TTI Proving Ground according to TTI Proving Ground quality procedures, and according to the *MASH* guidelines and standards. The TTI Proving Ground is an International

Standards Organization/International Electrotechnical Commission (ISO/IEC) 17025-accredited laboratory.

MnDOT was responsible for providing a swing-away mailbox support that conforms to the design changes previously developed by MINNCOR Industries for use in the test. The mailbox support was delivered to TTI Proving Ground at no cost to the project. TTI Proving Ground was responsible for modifying the mailbox support following the design details developed and approved under Task 1. TTI Proving Ground also provided all other parts, equipment, and facilities required to conduct the crash test.

1.3.3. Task 3. *MASH* Test 3-61 Impacting the Cantilever Arm and Mailbox Assembly

The cantilevered design of the MnDOT swing-away mailbox permits the mailbox assembly to engage the windshield of the vehicle without the front of the vehicle impacting the vertical support. In the second test, the centerline of the 2420-lb (1100 kg) passenger car was aligned with the centerline of the mailbox unit. The impact speed was 62 mi/h (100 km/h). This test condition evaluates whether or not the design change to the cantilever support prevents contact with and limits damage to the windshield of the impacting vehicle.

MnDOT was responsible for providing a swing-away mailbox support that conforms to the design changes previously developed by MINNCOR Industries for use in the test. The mailbox support was delivered to TTI Proving Ground at no cost to the project. TTI Proving Ground was responsible for modifying the mailbox support following the design details developed and approved under Task 1. TTI Proving Ground provided all other parts, equipment, and facilities required to conduct the crash test.

1.3.4. Task 4: Preparation and Submittal of Project Deliverables

TTI Proving Ground prepared this report documenting the testing performed on the updated swing-away mailbox support in a format suitable for submittal to FHWA. Additionally, TTI Proving Ground provided composite video and photographic documentation for each crash test.

The full-scale crash testing was successful, and it was concluded that the updated swing-away mailbox complies with *MASH* criteria. Therefore, the researchers prepared a draft request for FHWA eligibility that could be reviewed and submitted to FHWA by the project technical representative. Additionally, TTI Proving Ground provided documentation and required drawings for submission to the *Task Force 13 Online Guide to Standardized Small Sign Support Hardware*.

This report provides details on the modified swing-away mailbox, the crash tests and results, and the performance assessment of the mailbox for *MASH* TL-3 support structure evaluation criteria.

Chapter 2. SYSTEM DETAILS

2.1. TEST ARTICLE AND INSTALLATION DETAILS

The installation consisted of a mailbox and newspaper box mounted onto a swinging post assembly. The post assembly was anchored to the ground by being set inside a 2-inch square 12-gauge × 64-inch-long perforated steel tube, which was embedded 48 inches deep into the base. A collar was secured to the mailbox mounting tube with a ⅜ × 3-inch-long grade 5 hex bolt, washers, and nut. Additionally, a length of proof coil chain tethered the collar to the lower leg of the mount tubing to limit rotation. The swinging post assembly located the bottom of the mailbox 43 inches above the roadway.

Figure 2.1 presents the overall information on the Modified Minnesota Swing-Away Mailbox, and Figure 2.2 provides photographs of the installation. Appendix A provides further details on the Modified Minnesota Swing-Away Mailbox. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground, and construction was performed by TTI Proving Ground personnel.

2.2. DESIGN MODIFICATIONS DURING TESTS

No modification was made to the installation during the testing phase.

2.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the Modified Minnesota Swing-Away Mailbox.

2.4 SOIL CONDITIONS

The test installation was installed in standard soil meeting grading D of AASHTO standard specification M147-2017 “Materials for Aggregate and Soil-Aggregate Subbase, Base, and Surface Courses.”

In accordance with Appendix B of *MASH*, soil strength was measured the day of the crash test. During installation of the mailbox for full-scale crash testing, two 6-ft long W6×16 posts were installed in the immediate vicinity of the mailbox assembly using the same fill materials and installation procedures used in the test installation and the standard dynamic test. Table C.1 in Appendix C presents minimum soil strength properties established through the dynamic testing performed in accordance with *MASH* Appendix B.

As determined by the tests summarized in Appendix C, Table C.1, the minimum post loads required for deflections at 5 inches, 10 inches, and 15 inches, measured at a height of 25 inches, are 4420 lbf, 4981 lbf, and 5282 lbf (90 percent of static load for the initial standard installation). On the day of the test, June 24, 2021, loads on the post at deflections of 5 inches, 10 inches, and 15 inches were 5434 lbf, 6105 lbf, and 7024 lbf. Table C.2 in Appendix C shows the strength of the backfill material in which the Modified Minnesota Swing-Away Mailbox was installed met minimum *MASH* requirements for soil strength.

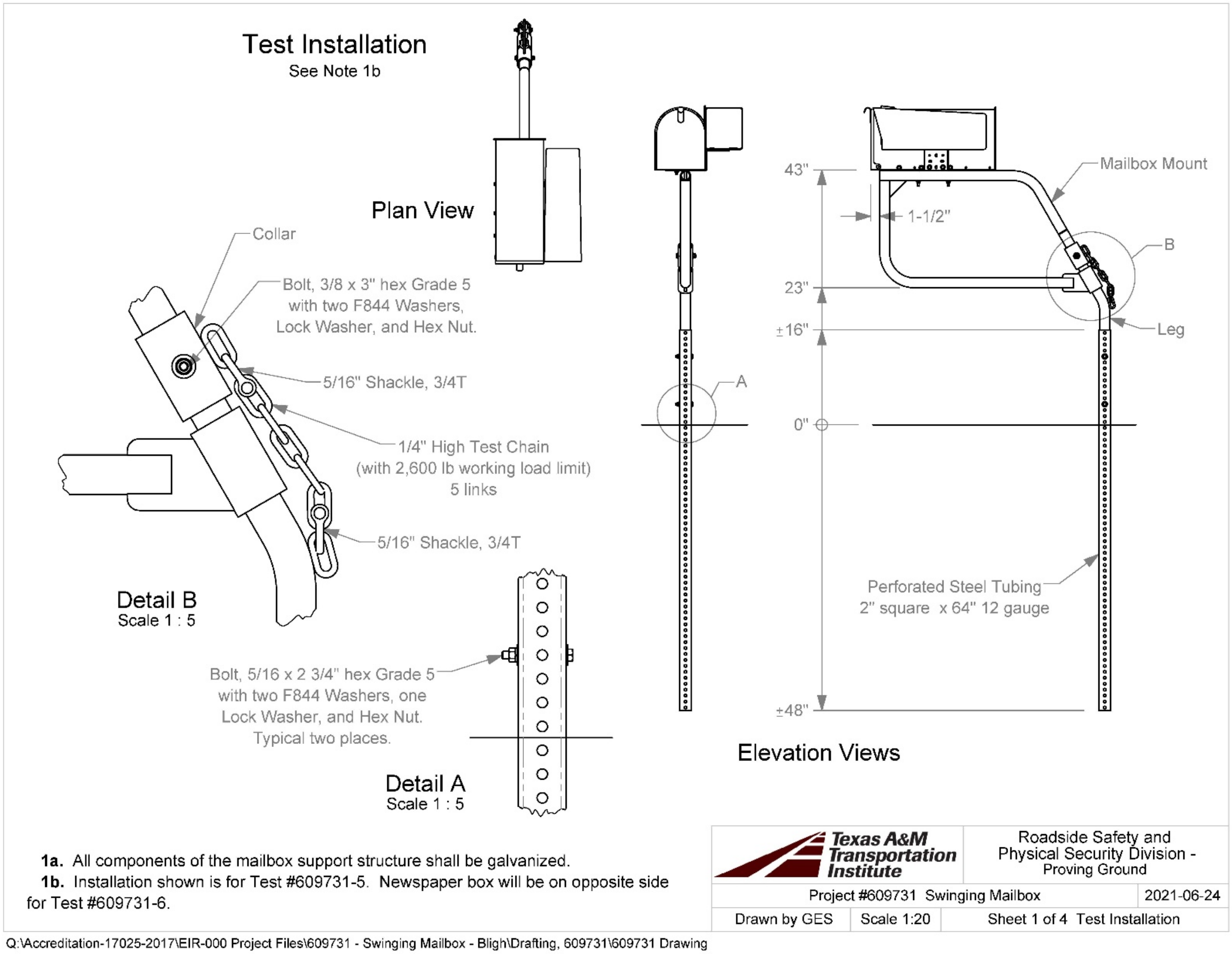


Figure 2.1. Details of Modified Minnesota Swing-Away Mailbox.

Figure 2.2. Modified Minnesota Swing-Away Mailbox prior to Testing.

Chapter 3. TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1. CRASH TEST PERFORMED/MATRIX

Table 3.1 shows the test conditions and evaluation criteria for *MASH* TL-3 for support structures. The target critical impact angle (CIA) was determined to using the information provided in *MASH* Section 2.2.4 and Figure 2-5. Figure 3.1 shows the CIA was the orientation the mailbox encountered as a vehicle traveled down the roadway (0 degree).

Table 3.1. Test Conditions and Evaluation Criteria Specified for | *MASH* TL-3 Support Structures.

Test Article	Test Designation	Test Vehicle	Impact Conditions			Evaluation Criteria
			Speed	Angle	Kinetic Energy	
Support Structures	3-60	1100C	19 mi/h	CIA	≤34 kip-ft	B, D, F, H, I, N
	3-61	1100C	62 mi/h	CIA	≥288 kip-ft	B, D, F, H, I, N
	3-62	2270P	62 mi/h	CIA	≥594 kip-ft	B, D, F, H, I, N

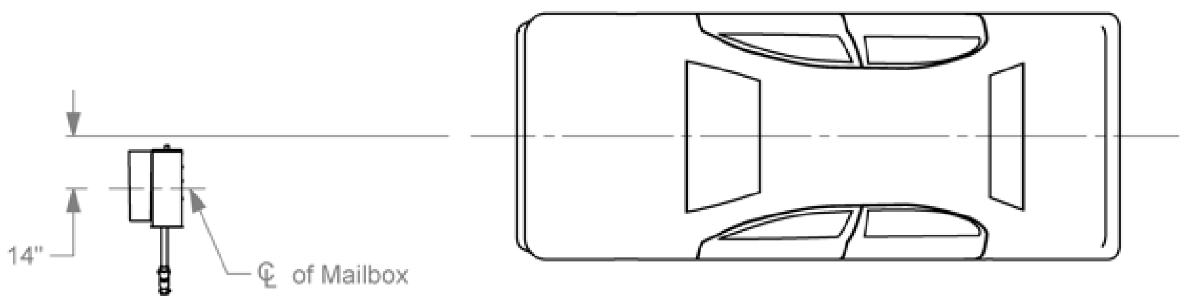


Figure 3.1. Target Impact for *MASH* Test 3-61 (Test No. 609731-5) on Modified Minnesota Swing-Away Mailbox Impacting Cantilever Arm and Mailbox Assembly.

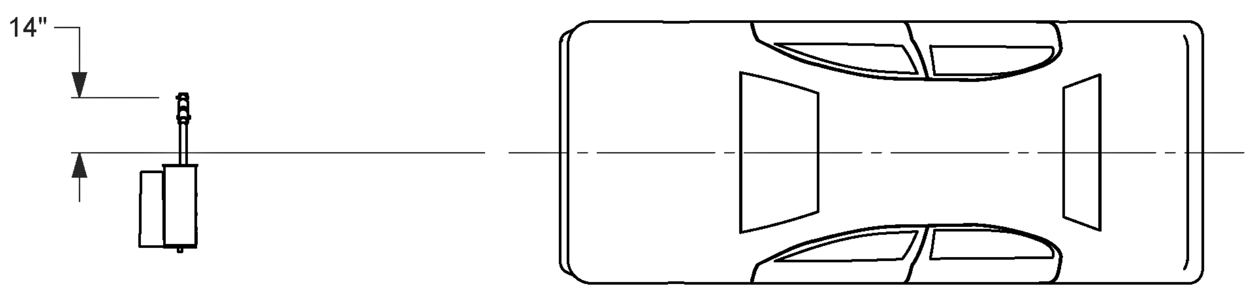


Figure 3.2. Target Impact for *MASH* Test 3-61 (Test No. 609731-6) on Modified Minnesota Swing-Away Mailbox Impacting Vertical Mailbox Support.

The crash tests and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 4 presents brief descriptions of these procedures.

3.2. EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2-5 and 5-1 of *MASH* were used to evaluate the crash tests reported herein. Figure 3.1 lists the test conditions and evaluation criteria required for *MASH* TL-3, and Table 3.2 provides detailed information on the evaluation criteria. An evaluation of the crash test results is presented in Chapter 8.

Table 3.2. Evaluation Criteria Required for *MASH* TL-3 Support Structures.

Evaluation Factors	Evaluation Criteria	*MASH* Test
	B. The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.	*3-60, 3-61, and 3-62*
Occupant Risk	*D. Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone.* *Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.*	*3-60, 3-61, and 3-62*
	F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	*3-60, 3-61, and 3-62*
	H. Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 10 ft/s, or maximum allowable value of 16 ft/s.	*3-60, 3-61, and 3-62*
	I. The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.	*3-60, 3-61, and 3-62*
Post-Impact Vehicular Response	*N. Vehicle trajectory behind the test article is acceptable.*	*3-60, 3-61, and 3-62*

Chapter 4. TEST CONDITIONS

4.1. TEST FACILITY

The full-scale crash tests reported herein were performed at the TTI Proving Ground, an International Standards Organization (ISO)/International Electrotechnical Commission (IEC) 17025-accredited laboratory with American Association for Laboratory Accreditation (A2LA) Mechanical Testing Certificate 2821.01. The full-scale crash tests were performed according to TTI Proving Ground quality procedures, as well as *MASH* guidelines and standards.

The test facilities of the TTI Proving Ground are located on The Texas A&M University System RELLIS Campus, which consists of a 2000-acre complex of research and training facilities situated 10 mi northwest of the flagship campus of Texas A&M University. The site, formerly a United States Army Air Corps base, has large expanses of concrete runways and parking aprons well suited for experimental research and testing in the areas of vehicle performance and handling, vehicle-roadway interaction, highway pavement durability and efficacy, and roadside safety hardware and perimeter protective device evaluation. The site selected for construction and testing of the mailbox was in soil within the surface of an out-of-service apron. The apron consists of an unreinforced jointed-concrete pavement in 12.5-ft × 15-ft blocks nominally 6 inches deep. The aprons were built in 1942, and the joints have some displacement but are otherwise flat and level.

4.2. VEHICLE TOW AND GUIDANCE SYSTEM

Each vehicle was towed into the test installation using a steel cable guidance and reverse tow system. A steel cable for guiding the test vehicle was tensioned along the path, anchored at each end, and threaded through an attachment to the front wheel of the test vehicle. An additional steel cable was connected to the test vehicle, passed around a pulley near the impact point and through a pulley on the tow vehicle, and then anchored to the ground such that the tow vehicle moved away from the test site. A 2:1 speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released and ran unrestrained. The vehicle remained freewheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site.

4.3. DATA ACQUISITION SYSTEMS

4.3.1. Vehicle Instrumentation and Data Processing

Each test vehicle was instrumented with a self-contained onboard data acquisition system. The signal conditioning and acquisition system is a 16-channel Tiny Data Acquisition System (TDAS) Pro produced by Diversified Technical Systems Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors, measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid-state units designed for crash test service. The TDAS Pro hardware and software conform to the latest SAE J211, Instrumentation for Impact Test. Each of the 16 channels is capable of providing precision amplification, scaling, and filtering based on transducer specifications and calibrations. During the test, data are recorded from each channel at a rate of 10,000 samples per second with a resolution of one part in 65,536. Once data are recorded, internal batteries back these up inside the unit in case the primary battery cable is severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the TDAS Pro unit into a laptop computer at the test site. The Test Risk Assessment Program (TRAP) software then processes the raw data to produce detailed reports of the test results.

Each of the TDAS Pro units is returned to the factory annually for complete recalibration and to ensure that all instrumentation used in the vehicle conforms to the specifications outlined by SAE J211. All accelerometers are calibrated annually by means of an ENDEVCO® 2901 precision primary vibration standard. This standard and its support instruments are checked annually and receive a National Institute of Standards Technology (NIST) traceable calibration. The rate transducers used in the data acquisition system receive calibration via a Genisco Rate-of-Turn table. The subsystems of each data channel are also evaluated annually, using instruments with current NIST traceability, and the results are factored into the accuracy of the total data channel per SAE J211. Calibrations and evaluations are also made anytime data are suspect. Acceleration data are measured with an expanded uncertainty of ±1.7 percent at a confidence factor of 95 percent (k = 2).

TRAP uses the data from the TDAS Pro to compute the occupant/compartment impact velocities, time of occupant/compartment impact after vehicle impact, and highest 10-millisecond (ms) average ridedown acceleration. TRAP calculates change in vehicle velocity at the end of a given impulse period. In addition, maximum average accelerations over 50-ms intervals in each of the three directions are computed. For reporting purposes, the data from the vehicle-mounted accelerometers are filtered with an SAE Class 180-Hz low-pass digital filter, and acceleration versus time curves for the longitudinal, lateral, and vertical directions are plotted using TRAP.

TRAP uses the data from the yaw, pitch, and roll rate transducers to compute angular displacement in degrees at 0.0001-s intervals, and then plots roll, pitch, and yaw versus time. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation being initial impact. Rate of rotation data is measured with an expanded uncertainty of ±0.7 percent at a confidence factor of 95 percent (k = 2).

4.3.2. Anthropomorphic Dummy Instrumentation

An Alderson Research Laboratories Hybrid II, 50th percentile male anthropomorphic dummy, restrained with lap and shoulder belts, was placed in the front seat on the opposite side of impact of the 1100C vehicle. The dummy was not instrumented.

4.3.3. Photographic Instrumentation Data Processing

Photographic coverage of each test included two digital high-speed cameras:

- One placed upstream from the installation at an angle.
- One placed with a field of view perpendicular to the installation/vehicle path.

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the mailbox. The flashbulb was visible from each camera. The video files from these digital high-speed cameras were analyzed to observe phenomena occurring during the collision and to obtain time-event, displacement, and angular data. A digital camera recorded and documented conditions of each test vehicle and the installation before and after the test.

Chapter 5. *MASH* TEST 3-61 (CRASH TEST NO. 609731-5) IMPACTING CANTILEVER ARM AND MAILBOX ASSEMBLY

5.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

MASH Test 3-61 involves a 1100C vehicle weighing 2420 lb ± 55 lb impacting the CIP of the support structure at an impact speed of 62 mi/h ± 2.5 mi/h and an angle of 0 degrees ± 1.5 degrees. Figure 3.1 and Figure 5.1 depict the target impact setup of the centerline of the mailbox aligned 14 inches to the left of the centerline, or quarter point, of the vehicle.

Figure 5.1. Mailbox/Test Vehicle Geometrics for Test No. 609731-5.

The 1100C vehicle weighed 2425 lb, and the actual impact speed and angle were 63.1 mi/h and 0 degrees. The actual impact point was as described above as shown in Figure 5.1. Minimum target kinetic energy (KE) was 288 kip-ft, and actual KE was 323 kip-ft.

5.2. WEATHER CONDITIONS

The test was performed on the morning of June 24, 2021. Weather conditions at the time of testing were as follows: wind speed: 9 mi/h; wind direction: 202 degrees (vehicle was traveling at a heading of 170 degrees); temperature: 89°F; relative humidity: 77 percent.

5.3. TEST VEHICLE

Figure 5.2 shows the 2016 Nissan Versa used for the crash test. The vehicle's test inertia weight was 2425 lb, and its gross static weight was 2590 lb. The height to the lower edge of the vehicle bumper was 7.0 inches, and the height to the upper edge of the bumper was 22.25 inches. Table C.1 in Appendix C.1 gives additional dimensions and information on the vehicle. The vehicle was directed into the installation using a cable reverse tow and guidance system, and was released to be freewheeling and unrestrained just prior to impact.


Figure 5.2. Test Vehicle before Test No. 609731-5.

5.4. TEST DESCRIPTION

Table 5.1 lists events that occurred during Test No. 609731-5. Figures C.1 and C.2 in Appendix C.2 present sequential photographs during the test.

Table 5.1. Events during Test No. 609731-5.

Time (s)	Events
0.0000	Vehicle impacts cantilever arm and mailbox assembly
0.0363	Upper post begins to separate from lower post above chain
0.0513	Soil begins to be disturbed at base of post
0.0788	Upper post completely separated from lower post
0.1487	Post pulled completely out of ground

Brakes on the vehicle were applied at 2.2 s after impact, the vehicle subsequently came to rest 315 ft downstream of the point of impact and 15 ft left of the vehicle impact path.

5.5. DAMAGE TO TEST INSTALLATION

Figure 5.3 shows the damage to the mailbox. The perforated steel tubing pulled completely out from the ground, and the entire mailbox assembly landed 319 ft downstream and 30 ft to the left of impact, except for the newspaper box, which disconnected from the mailbox at impact. The mailbox was deformed, and the top portion of the mailbox mount opened and separated from the leg.

Figure 5.3. Mailbox after Test No. 609731-5.

5.6. DAMAGE TO TEST VEHICLE

Figure 5.4 shows the damage sustained by the vehicle. The front bumper, hood, grill, radiator and support, left front fender, and left front door were damaged. The windshield was cracked over an area 16 inches × 11 inches and 0.25 inch deep, however there were no holes, cuts, or tears in the laminate. No fuel tank damage was observed. Maximum exterior crush to the vehicle was 8.0 inches in the front plane at the left front corner at bumper height. Maximum occupant compartment deformation was 0.25 inches in the windshield with no other deformation or intrusion. Figure 5.5 shows the interior of the vehicle. Tables C.2 and C.3 in Appendix C.1 provide exterior crush and occupant compartment measurements.

Figure 5.4. Test Vehicle after Test No. 609731-5.

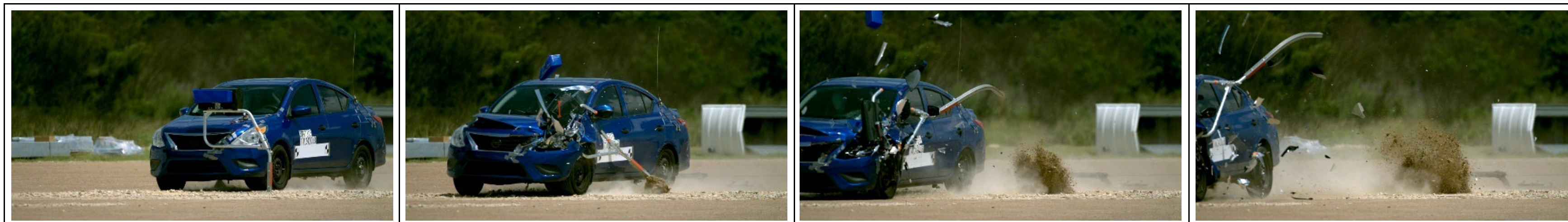
Figure 5.5. Interior of Test Vehicle after Test No. 609731-5.

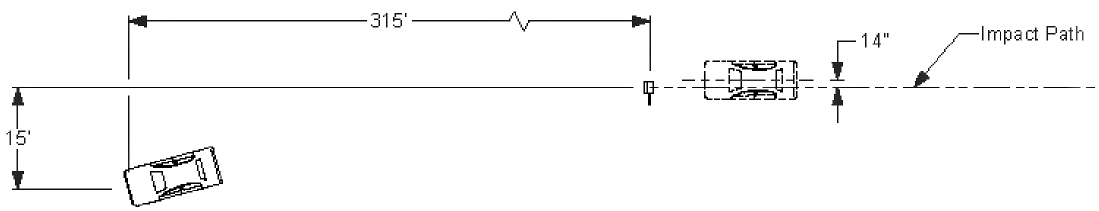
5.7. OCCUPANT RISK FACTORS

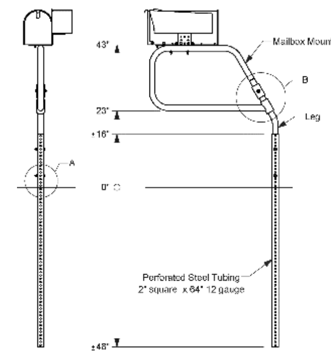
Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 5.2. Figure C.3 in Appendix C.3 shows the vehicle angular displacements, and Figures C.4 through C.6 in Appendix C.4 show acceleration versus time traces. Figure 5.6 summarizes pertinent information from the test.

Table 5.2. Occupant Risk Factors for Test No. 609731-5.

Occupant Risk Factor	Value	Time
Occupant Impact Velocity (OIV)		
Longitudinal	5.2 ft/s	at 0.4469 s on right side of interior
Lateral	4.8 ft/s	
Occupant Ridedown Accelerations		
Longitudinal	0.6 g	0.6294 - 0.6394 s
Lateral	0.9 g	1.0410 - 1.0510 s
Theoretical Head Impact Velocity (THIV)	2.2 m/s	at 0.3770 s on right side of interior
Acceleration Severity Index (ASI)	0.2	0.0767 - 0.1267 s
Maximum 50-ms Moving Average		
Longitudinal	−1.7 g	0.0682 - 0.1182 s
Lateral	−1.0 g	0.1652 - 0.2152 s
Vertical	1.2 g	0.0311 - 0.0811 s
Maximum Yaw, Pitch, and Roll Angles		
Roll	6°	0.3438 s
Pitch	2°	0.2837 s
Yaw	15°	0.5381 s







General Information

Test Agency	Texas A&M Transportation Institute (TTI)
Test Standard Test No.	*MASH* Test 3-61
TTI Test No.	609731-5
Test Date	2021-06-24

Test Article

Type	Support Structure—Mailbox
Name	Modified Minnesota Swing-Away Mailbox
Installation Height	43 inches from bottom to roadway
Material or Key Elements	

Soil Type and Condition ..... AASHTO M147-2017, grading D Soil (crushed concrete), damp

Test Vehicle

Type/Designation	1100C
Make and Model	2016 Nissan Versa
Curb	2382 lb
Test Inertial	2425 lb
Dummy	165 lb
Gross Static	2590 lb

Impact Conditions

Speed	63.1 mi/h
Angle	0°
Location/Orientation	Impacting Arm and Mailbox Assembly

Kinetic Energy ..... 323 kip-ft

Exit Conditions

Speed	56.9 mi/h

Occupant Risk Values

Longitudinal OIV	5.2 ft/s
Lateral OIV	4.8 ft/s
Longitudinal Ridedown	0.6 g
Lateral Ridedown	0.9 g
THIV	2.2 m/s
ASI	0.2
Max. 0.050-s Average	
Longitudinal	−1.7 g
Lateral	−1.0 g
Vertical	1.2 g

Post-Impact Trajectory

Stopping Distance	315 ft downstream 15 ft left of center

Vehicle Stability

Maximum Roll Angle	6°
Maximum Pitch Angle	2°
Maximum Yaw Angle	15°

Test Article Scatter

Longitudinal	319 ft downstream
Lateral	30 ft to the left

Vehicle Damage

VDS	12LFQ3
CDC	12FLEN3
Max. Exterior Deformation	8.0 inches
OCDI	LF0000000
Max. Occupant Compartment Deformation	0.25 inch

Figure 5.6. Summary of Results for *MASH* Test 3-61 on Modified Minnesota Swing-Away Mailbox Impacting Cantilever Arm and Mailbox Assembly.

Chapter 6. *MASH* TEST 3-61 (CRASH TEST NO. 609731-6) IMPACTING VERTICAL MAILBOX SUPPORT

6.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

MASH Test 3-61 involves a 1100C vehicle weighing 2420 lb ± 55 lb impacting the CIP of the support structure at an impact speed of 62 mi/h ± 2.5 mi/h and an angle of 0 degrees ± 1.5 degrees. Figure 3.2 and Figure 6.1 depict the target impact setup of the centerline of the support post aligned 14 inches to the right of the centerline, or quarter point, of the vehicle.

Figure 6.1. Mailbox/Test Vehicle Geometrics for Test No. 609731-6.

The 1100C vehicle weighed 2422 lb, and the actual impact speed and angle were 62.8 mi/h and 0 degrees. The actual impact point was as described above and shown in Figure 6.1. Minimum target KE was 288 kip-ft, and actual KE was 320 kip-ft.

6.2. WEATHER CONDITIONS

The test was performed on the afternoon of June 24, 2021. Weather conditions at the time of testing were as follows: wind speed: 10 mi/h; wind direction: 186 degrees (vehicle was traveling at a heading of 170 degrees); temperature: 94°F; relative humidity: 66 percent.

6.3. TEST VEHICLE

Figure 6.1 shows the 2015 Nissan Versa used for the crash test. The vehicle's test inertia weight was 2422 lb, and its gross static weight was 2587 lb. The height to the lower edge of the vehicle bumper was 7.0 inches, and height to the upper edge of the bumper was 22.25 inches. Table D.1 in Appendix D.1 gives additional dimensions and information on the vehicle. The vehicle was directed into the installation using a cable reverse tow and guidance system and was released to be freewheeling and unrestrained just prior to impact.

6.4. TEST DESCRIPTION

Table 6.1 lists events that occurred during Test No. 609731-6. Figures D.1 and D.2 in Appendix D.2 present sequential photographs during the test.

Table 6.1. Events during Test No. 609731-6.

Time (s)	Events
0.0000	Vehicle impacted the installation
0.0190	Soil begins to be disturbed at base of post
0.0540	Lower tube section breaks from main post

Brakes on the vehicle were applied at 2.2 s after impact, the vehicle subsequently came to rest 328 ft downstream of the point of impact along the vehicle impact path.

6.5. DAMAGE TO TEST INSTALLATION

Figure 6.2 shows the damage to the mailbox. The perforated post pulled out of the ground and laid over at the impact area. The lower gusset plate, connecting the post and the lower horizontal pipe broke. The mailbox landed 155 ft downstream and 29 ft to the right of impact, and the mailbox pipe landed 400 ft downstream and 52 ft to the right.

6.6. DAMAGE TO TEST VEHICLE

Figure 6.3 shows the damage sustained by the vehicle. The front bumper, hood, and grill were damaged. The hood sustained two deformation areas; one 4 inches × 6 inches × 1.25 inches deep to the right of centerline, and another 8 inches × 8 inches × 2.5 inches deep 19 inches to the left of centerline. The windshield was not cracked, shattered, or torn. No fuel tank damage was observed. Maximum exterior crush to the vehicle was 4.0 inches in the front plane at the front at bumper height. No occupant compartment deformation or intrusion was observed. Figure 6.4 shows the interior of the vehicle. Tables D.3 and D.4 in Appendix D.1 provide exterior crush and occupant compartment measurements.

6.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 6.2. Figure D.3 in Appendix D.3 shows the vehicle angular displacements, and Figures D.4 through D.6 in Appendix D.4 show acceleration versus time traces. Figure 6.5 summarizes pertinent information from the test.

Figure 6.2. Mailbox after Test No. 609731-6.

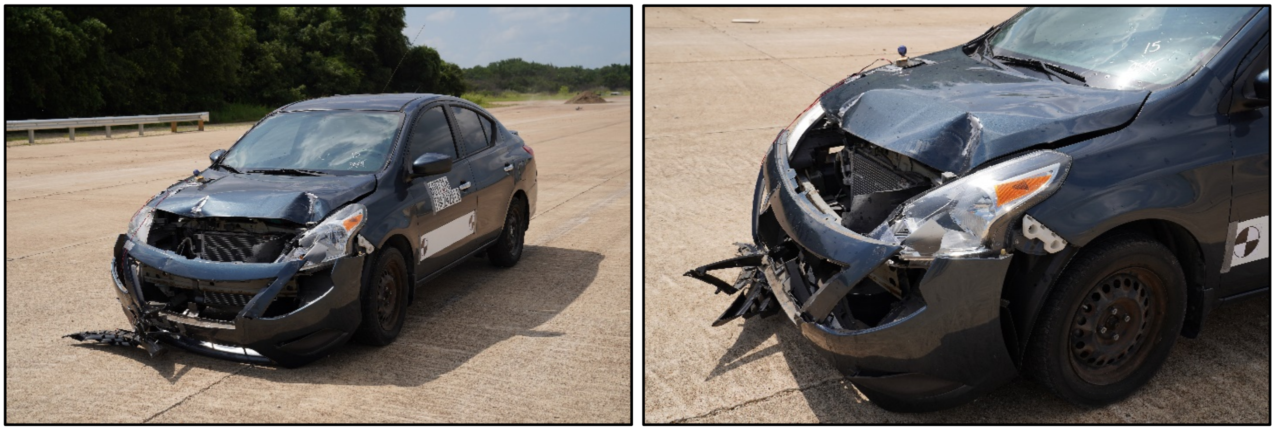
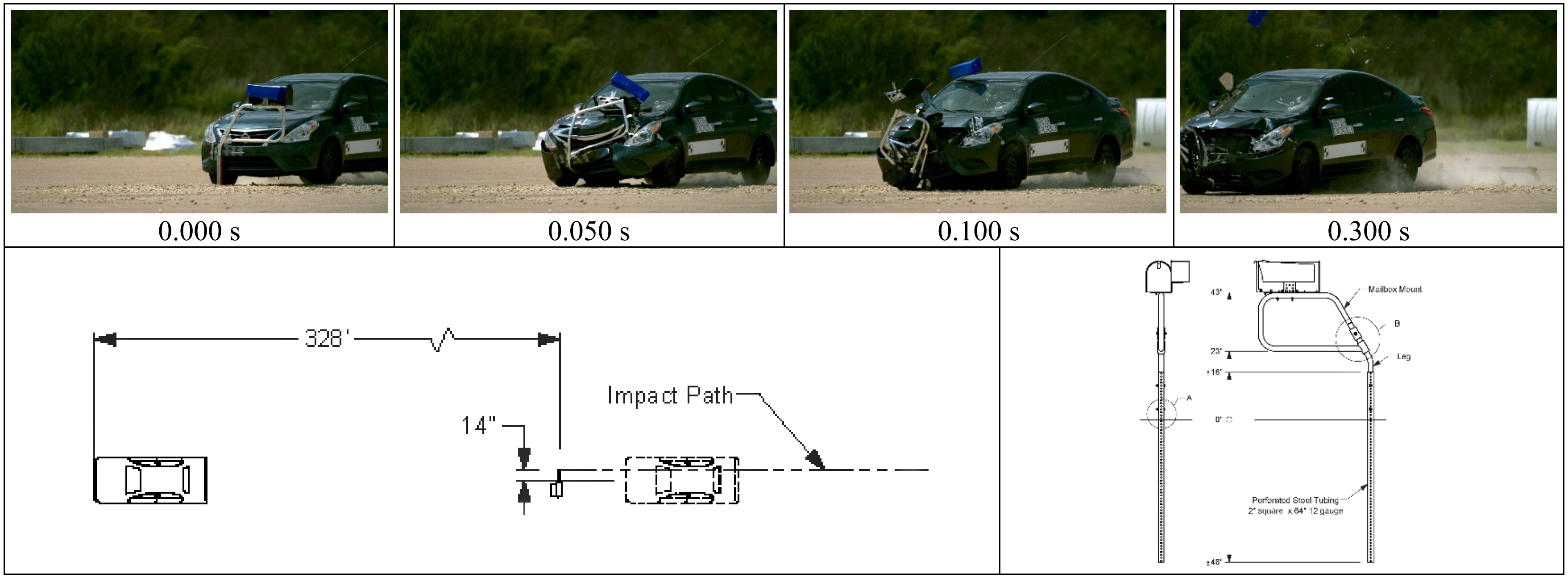


Figure 6.3. Test Vehicle after Test No. 609731-6.

Figure 6.4. Interior of Test Vehicle after Test No. 609731-6.

Table 6.2. Occupant Risk Factors for Test No. 609731-6.

Occupant Risk Factor	Value	Time
Occupant Impact Velocity (OIV)		
Longitudinal	5.8 ft/s	at 0.3729 s on front of interior
Lateral	0.1 ft/s	
Occupant Ridedown Accelerations		
Longitudinal	0.5 g	0.7620 - 0.7720 s
Lateral	0.7 g	0.8096 - 0.8196 s
Theoretical Head Impact Velocity (THIV)	1.8 m/s	at 0.3722 s on front of interior
Acceleration Severity Index (ASI)	0.3	0.0231 - 0.0731 s
Maximum 50-ms Moving Average		
Longitudinal	−3.1 g	0.0043 - 0.0543 s
Lateral	−0.5 g	0.0518 - 0.1018 s
Vertical	1.2 g	0.1102 - 0.1602 s
Maximum Yaw, Pitch, and Roll Angles		
Roll	3°	2.0000 s
Pitch	2°	0.2044 s
Yaw	3°	0.3719 s



General Information
- Test Agency: Texas A&M Transportation Institute (TTI)
- Test Standard Test No.: *MASH* Test 3-61
- TTI Test No.: 609731-6
- Test Date: 2021-06-24

Test Article
- Type: Support Structure—Mailbox
- Name: Modified Minnesota Swing-Away Mailbox
- Installation Length: 43 inches from bottom to roadway
- Material or Key Elements:

Soil Type and Condition: AASHTO M147-2017, grading D Soil (crushed concrete), damp

Test Vehicle
- Type/Designation: 1100C
- Make and Model: 2015 Nissan Versa
- Curb: 2431 lb
- Test Inertial: 2422 lb
- Dummy: 165 lb
- Gross Static: 2587 lb

Impact Conditions
- Speed: 62.8 mi/h
- Angle: 0°
- Location/Orientation: Impacting Vertical Mailbox Support

Kinetic Energy: 320 kip-ft

Exit Conditions
- Speed: 56.9 mi/h

Occupant Risk Values
- Longitudinal OIV: 5.8 ft/s
- Lateral OIV: 0.1 ft/s
- Longitudinal Ridedown: 0.5 g
- Lateral Ridedown: 0.7 g
- THIV: 1.8 m/s
- ASI: 0.3

Max. 0.050-s Average
- Longitudinal: −3.1 g
- Lateral: −0.5 g
- Vertical: 1.2 g

Post-Impact Trajectory
- Stopping Distance: 328 ft downstream In-line

Vehicle Stability
- Maximum Roll Angle: 3°
- Maximum Pitch Angle: 2°
- Maximum Yaw Angle: 3°

Test Article Scatter
- Longitudinal: 400 ft downstream
- Lateral: 52 ft right of center

Vehicle Damage
- VDS: 12FC2
- CDC: 12FCEN2
- Max. Exterior Deformation: 4.0 inches
- OCDI: FS0000000
- Max. Occupant Compartment Deformation: None

Figure 6.5. Summary of Results for *MASH* Test 3-61 on Modified Minnesota Swing-Away Mailbox Impacting Vertical Mailbox Support.

Chapter 7. SUMMARY AND CONCLUSIONS

7.1. ASSESSMENT OF TEST RESULTS

The crash tests reported herein was/were performed in accordance with *MASH* TL-3 on the Modified Minnesota Swing-Away Mailbox. Table 7.1 and Table 7.2 provide an assessment of each test based on the applicable safety evaluation criteria for *MASH* TL-3 support structures.

7.2. CONCLUSIONS

The Modified Minnesota Swing-Away Mailbox met the performance criteria for *MASH* Test 3-61 when impacting the cantilever arm and mailbox assembly and Test 3-61 when impacting the vertical mailbox support.

Table 7.1. Performance Evaluation Summary for *MASH* Test 3-61 on Modified Minnesota Swing-Away Mailbox Impacting Cantilever Arm and Mailbox Assembly.

Test Agency: Texas A&M Transportation Institute | Test No.: 609731-5 | Test Date: 2021-06-24

***MASH* Test 3-61 Evaluation Criteria**	**Test Results**	**Assessment**
Structural Adequacy *B. The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.*	The mailbox readily activated by yielding to the 1100C vehicle.	Pass
Occupant Risk *D. Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.*	The detached elements of the mailbox assembly did not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to others in the area.	Pass
Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.	Maximum occupant compartment deformation was 0.25 inches in the windshield.	
F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	The 1100C vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 6° and 2°.	Pass
H. Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 10 ft/s, or maximum allowable value of 16 ft/s.	Longitudinal OIV was 5.2 ft/s, and lateral OIV was 4.8 ft/s.	Pass
I. The occupant ridedown accelerations should satisfy the following limits: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.	Longitudinal occupant ridedown acceleration was 0.6 g, and lateral occupant ridedown acceleration was 0.9 g.	Pass
Vehicle Trajectory *N. Vehicle trajectory behind the test article is acceptable.*	The 1100C vehicle came to rest 315 ft downstream of the point of impact and 15 ft left of the vehicle impact path	Pass

Table 7.2. Performance Evaluation Summary for *MASH* Test 3-61 on Modified Minnesota Swing-Away Mailbox Impacting Vertical Mailbox Support.

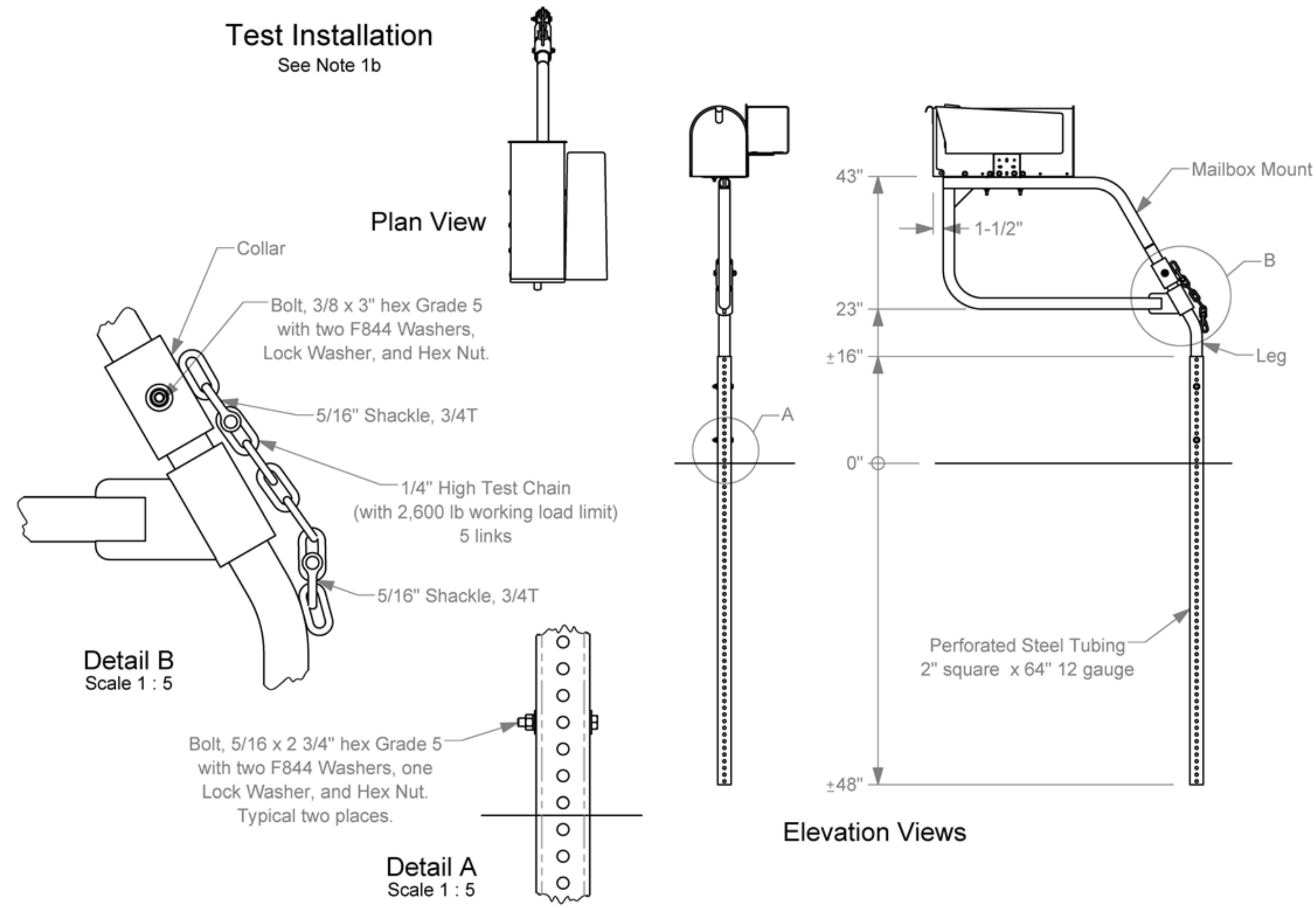
Test Agency: Texas A&M Transportation Institute — Test No.: 609731-6 — Test Date: 2021-06-24

***MASH* Test 3-61 Evaluation Criteria**	**Test Results**	**Assessment**
Structural Adequacy		
B. *The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.*	The mailbox readily activated by yielding to the 1100C vehicle.	Pass
Occupant Risk		
D. *Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone.*	The detached elements of the mailbox assembly did not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to others in the area.	Pass
Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of MASH.	No occupant compartment deformation or intrusion was observed.	
F. *The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.*	The 1100C vehicle remained upright during and after the collision event. Maximum roll and pitch angles were 3° and 2°.	Pass
H. *Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 10 ft/s, or maximum allowable value of 16 ft/s.*	Longitudinal OIV was 5.8 ft/s, and lateral OIV was 0.1 ft/s.	Pass
I. *The occupant ridedown accelerations should satisfy the following limits: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.*	Longitudinal occupant ridedown acceleration was 0.5 g, and lateral occupant ridedown acceleration was 0.7 g.	Pass
Vehicle Trajectory		
N. *Vehicle trajectory behind the test article is acceptable.*	The 1100C vehicle came to rest 328 ft downstream of the point of impact.	Pass

REFERENCES

1. Mak, K. K. and Menges, W. L., "Crash Testing and Evaluation of the Minnesota Swing-Away Mailbox Support," Report No. FHWA-RD-98-042, Federal Highway Administration, Washington, D.C., 1996.
2. Ross, H. E., Jr., Sicking, D.L., Zimmer, R.A., and Michie, J.D., "Recommended Procedures for the Safety Performance Evaluation of Highway Features," *National Cooperative Highway Research Program Report 350*, Transportation Research Board, National Research Council, Washington, D.C., 1993.
3. "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," AASHTO, 1985.
4. Bligh, R. P., Bullard, L. D., Jr., Haug, R. R., and Menges, W. L., "Impact Performance Evaluation of Modified Minnesota Swing-Away Mailbox Support," Research Report 405160-6-1, Texas A&M Transportation Institute, College Station, TX, September 2006.
5. American Association of State Highway and Transportation Officials, *Manual for Assessing Safety Hardware*, Second Edition, AASHTO, Washington, D.C., 2016.

APPENDIX A. DETAILS OF MODIFIED MINNESOTA SWING-AWAY MAILBOX

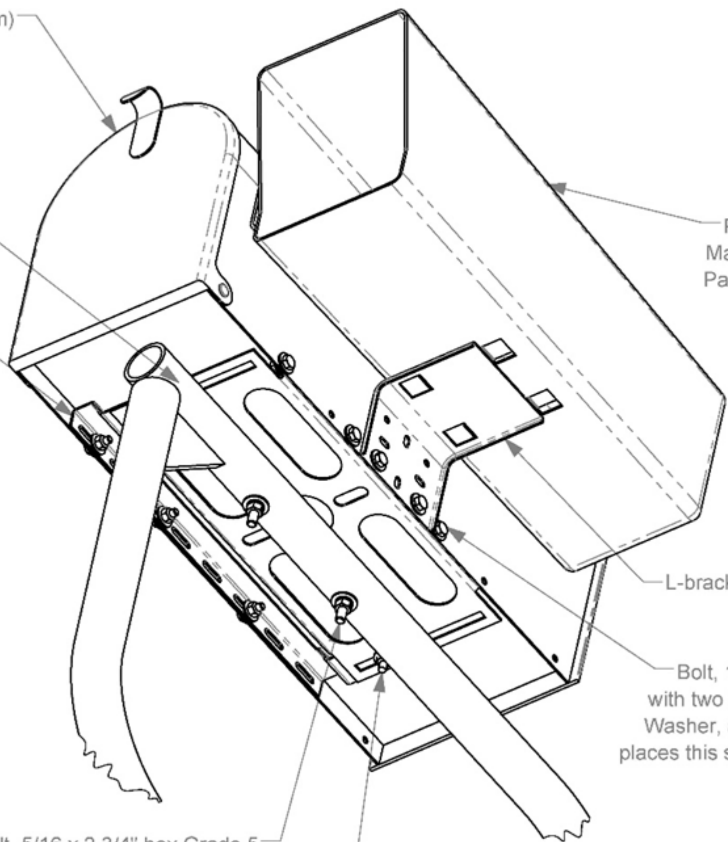


1a. All components of the mailbox support structure shall be galvanized.
1b. Installation shown is for Test #609731-5. Newspaper box will be on opposite side for Test #609731-6.

Texas A&M Transportation Institute		Roadside Safety and Physical Security Division - Proving Ground	
Project #609731 Swinging Mailbox			2021-06-24
Drawn by GES	Scale 1:20	Sheet 1 of 4 Test Installation	

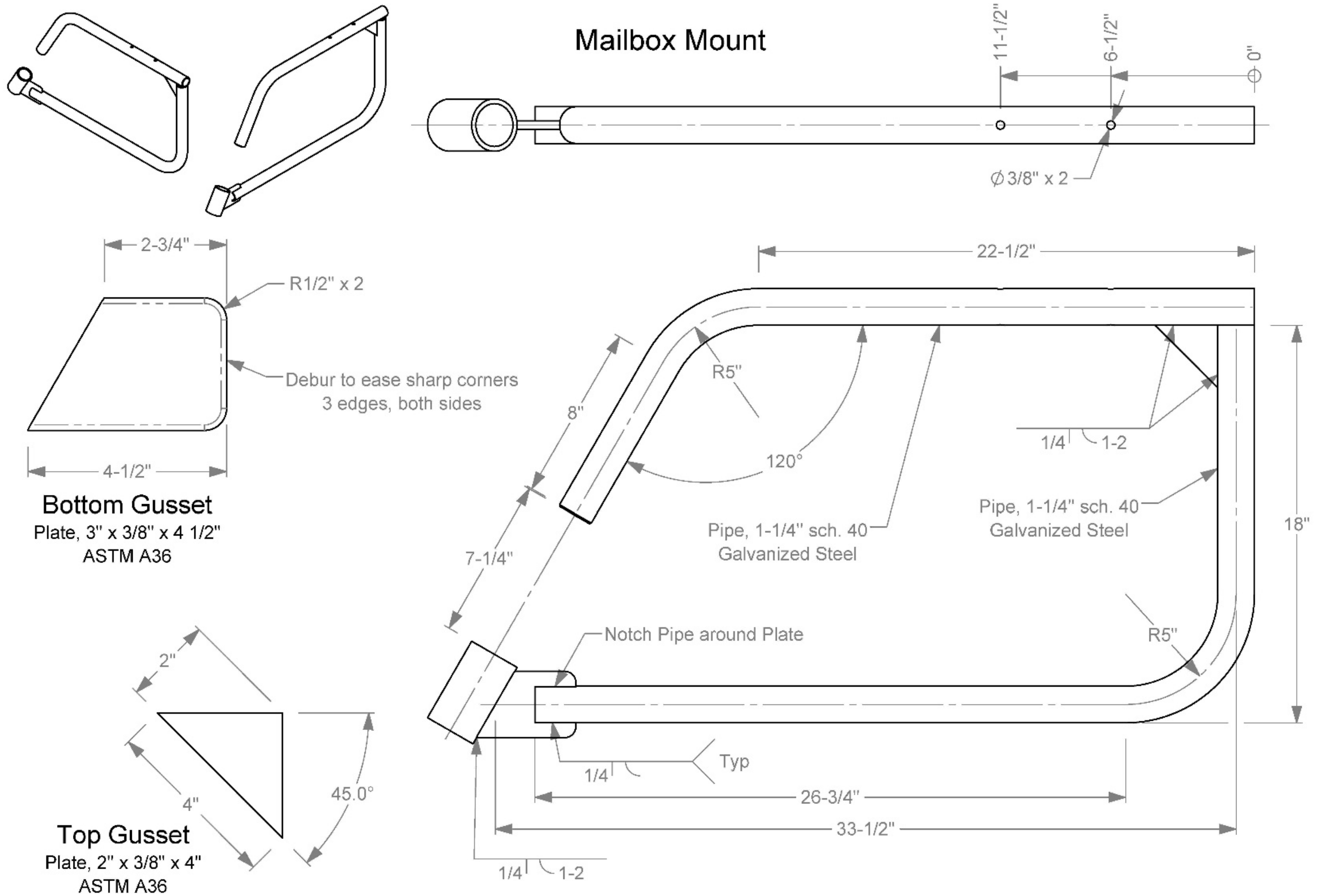
Q:\Accreditation-17025-2017\EIR-000 Project Files\609731 - Swinging Mailbox - Bligh\Drafting, 609731\609731 Drawing

Mailbox Connections



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #609731 Swinging Mailbox		2021-06-24
Drawn by GES	Scale 1:5	Sheet 2 of 4 Mailbox Connections

Q:\Accreditation-17025-2017\EIR-000 Project Files\609731 - Swinging Mailbox - Bligh\Drafting, 609731\609731 Drawing

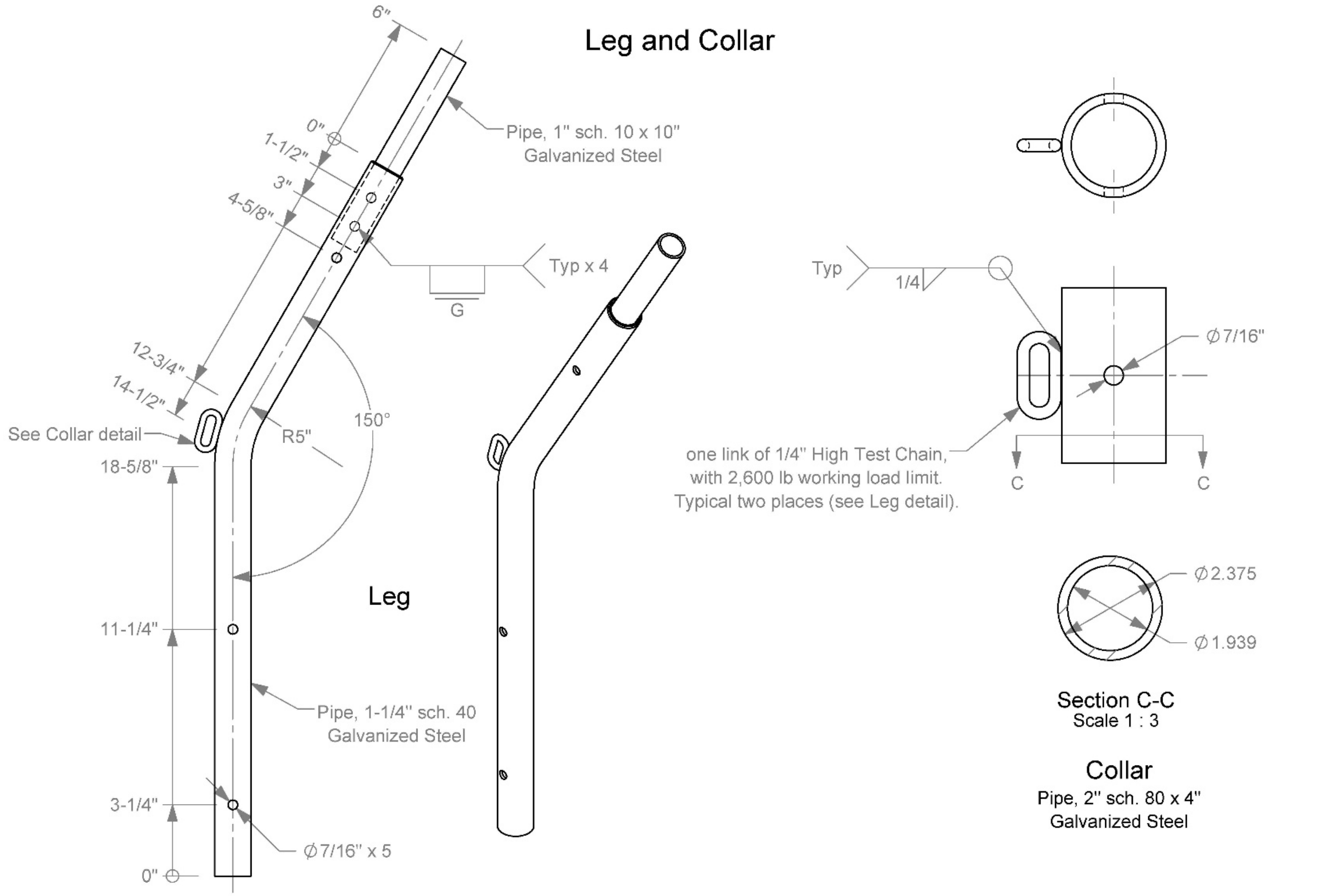


3a. All welding must be performed by certified welders using industry standard practices.
3b. Galvanize all components after fabrication is complete.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #609731 Swinging Mailbox		2021-06-24
Drawn by GES	Scale 1:6	Sheet 3 of 4 Mailbox Mount

Q:\Accreditation-17025-2017\EIR-000 Project Files\609731 - Swinging Mailbox - Bligh\Drafting, 609731\609731 Drawing

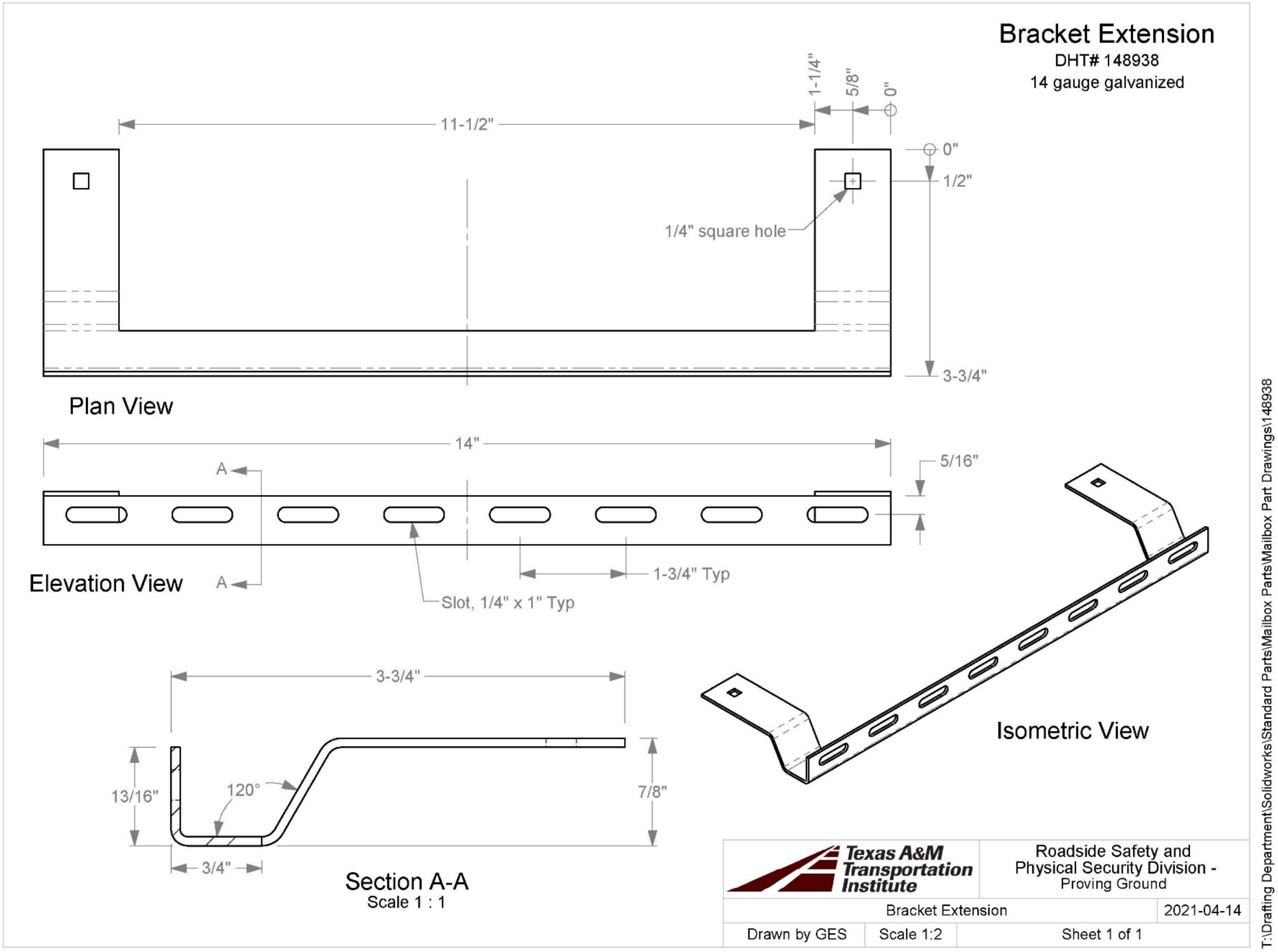
Leg and Collar

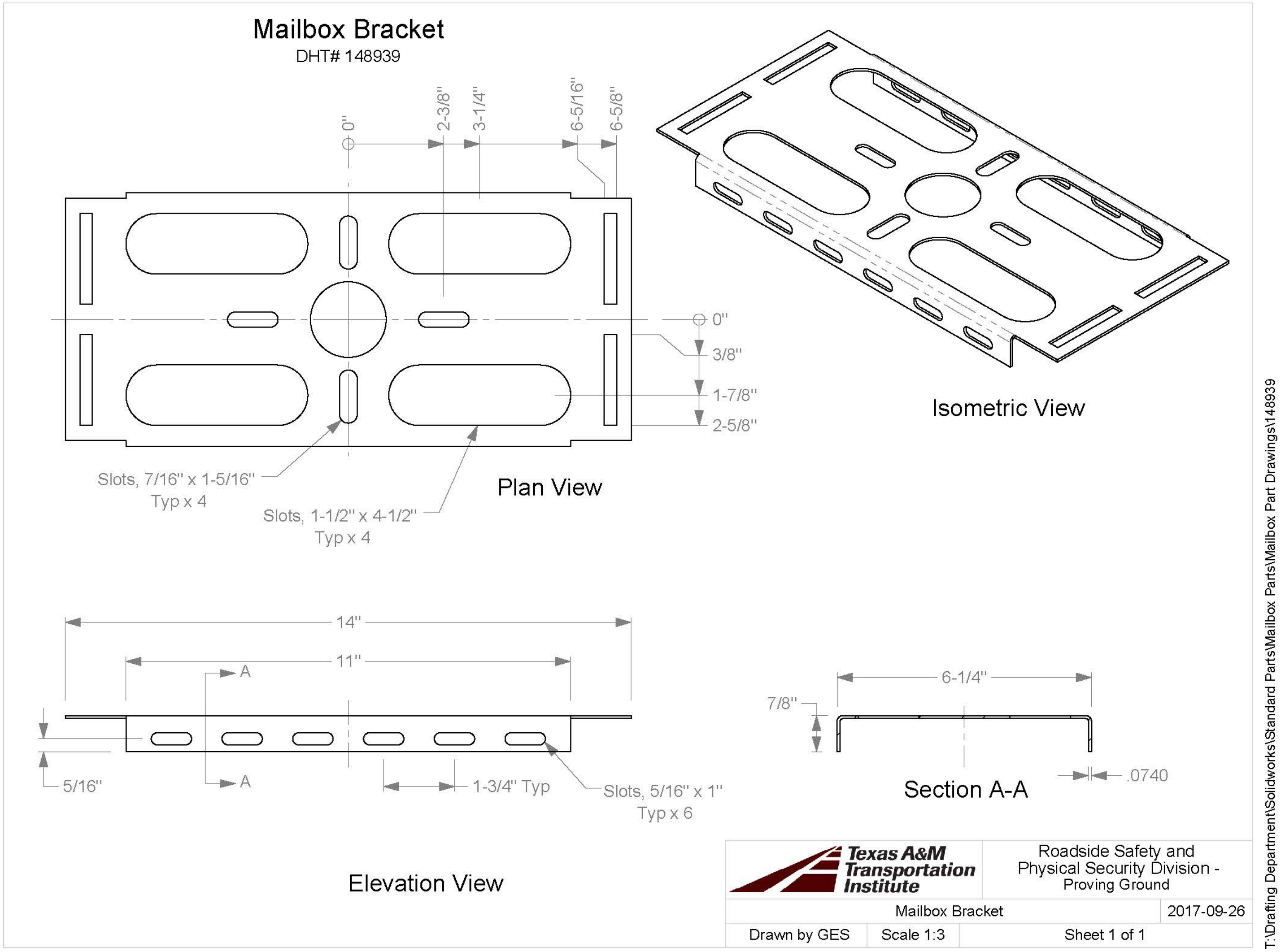


4a. All welding must be performed by certified welders using industry standard practices.
4b. Galvanize all components after fabrication is complete.

Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #609731 Swinging Mailbox		2021-06-24
Drawn by GES	Scale 1:6	Sheet 4 of 4 Leg and Collar

Q:\Accreditation-17025-2017\EIR-000 Project Files\609731 - Swinging Mailbox - Bligh\Drafting, 609731\609731 Drawing


Bracket Extension
DHT# 148938
14 gauge galvanized
11-1/2"
1-1/4"
5/8"
0"
0"
1/2"
1/4" square hole
3-3/4"
Plan View
14"
5/16"
A
A
Elevation View
Slot, 1/4" x 1" Typ
1-3/4" Typ
3-3/4"
13/16"
120°
7/8"
3/4"
Section A-A
Scale 1 : 1
Isometric View
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Bracket Extension
2021-04-14
Drawn by GES
Scale 1:2
Sheet 1 of 1
T:\Drafting Department\Solidworks\Standard Parts\Mailbox Parts\Mailbox Part Drawings\148938


Mailbox Bracket
DHT# 148939
0"
2-3/8"
3-1/4"
6-5/16"
6-5/8"
0"
3/8"
1-7/8"
2-5/8"
Slots, 7/16" x 1-5/16"
Typ x 4
Slots, 1-1/2" x 4-1/2"
Typ x 4
Plan View
Isometric View
14"
11"
A
A
5/16"
1-3/4" Typ
Slots, 5/16" x 1"
Typ x 6
Elevation View
6-1/4"
7/8"
.0740
Section A-A
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Mailbox Bracket
2017-09-26
Drawn by GES
Scale 1:3
Sheet 1 of 1
T:\Drafting Department\Solidworks\Standard Parts\Mailbox Parts\Mailbox Part Drawings\148939

APPENDIX B. SUPPORTING CERTIFICATION DOCUMENTS

NEED CERTIFICATION DOCUMENTS

APPENDIX C. SOIL PROPERTIES

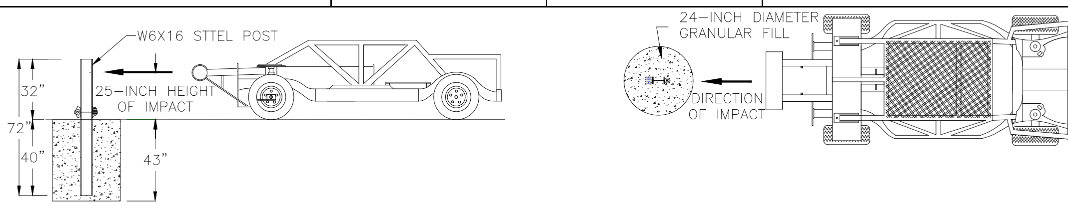
Table C.1. Summary of Strong Soil Test Results for Establishing Installation Procedure.

Dynamic Test Setup

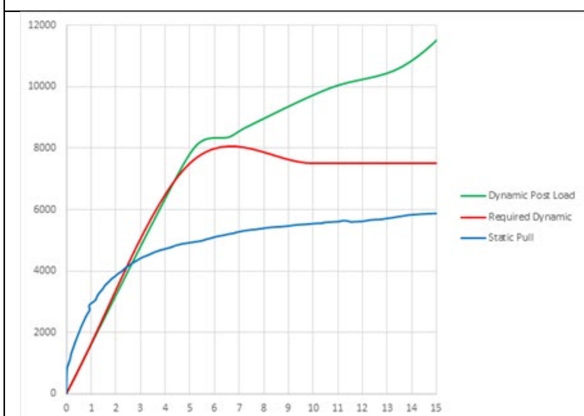
Post-Test Photo of post

Static Load Test

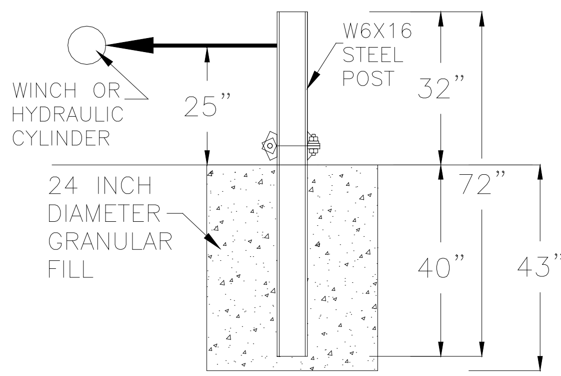
Post-Test Photo



Dynamic Test Installation Details



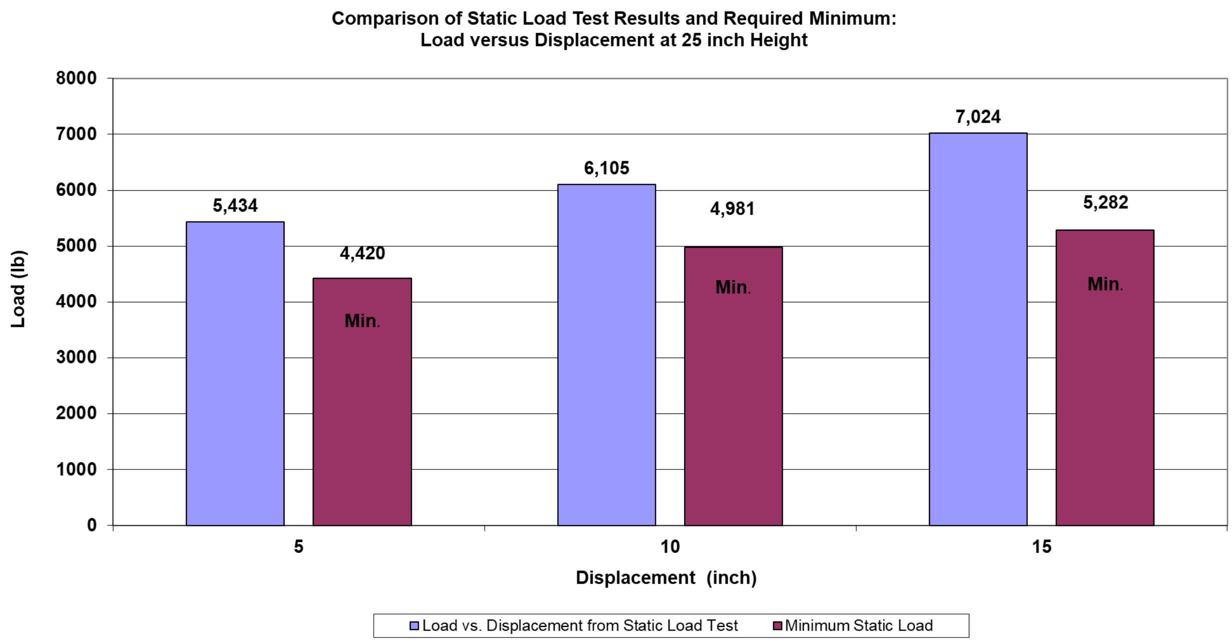
Comparison of Load vs. Displacement



Static Load Test Installation Details

Date	2020-02-02
Test Facility and Site Location	TTI Proving Ground, 1254 Avenue A, Bryan, TX 77807
In Situ Soil Description (ASTM D2487)	Sandy gravel with silty fines
Fill Material Description (ASTM D2487) and sieve analysis	AASHTO M147 Grade D or Type D Crushed Concrete Road Base
Description of Fill Placement Procedure	12-inch lifts tamped with a pneumatic compactor for 20 sec
Bogie Weight	2020 lb
Impact Velocity	19.2 mph

Table C.2. Test Day Static Soil Strength Documentation for Test No. 609731-5 and 6.



Date	2021-06-24 – Test No. 609731-5 and 6
Test Facility and Site Location	TTI Proving Ground, 1254 Avenue A, Bryan, TX 77807
In Situ Soil Description (ASTM D2487)	Sandy gravel with silty fines
Fill Material Description (ASTM D2487) and sieve analysis	AASHTO M147 Grade D or Type D Crushed Concrete Road Base
Description of Fill Placement Procedure	12-inch lifts tamped with pneumatic compactor for 20 s

APPENDIX C. *MASH* TEST 3-61 (CRASH TEST NO. 609731-5)

C.1. VEHICLE PROPERTIES AND INFORMATION

Table C.1. Vehicle Properties for Test No. 609731-5.

Date: 2021-06-24 Test No.: 609731-5 VIN No.: 3N1CN7AP7GL841624

Year: 2016 Make: NISSAN Model: VERSA

Tire Inflation Pressure: 36 PSI Odometer: 99080 Tire Size: P185/65R15

Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

NOTES: None

Engine Type: 4 CYL

Engine CID: 1.6 L

Transmission Type:

☑ Auto or ☐ Manual

☑ FWD ☐ RWD ☐ 4WD

Optional Equipment:

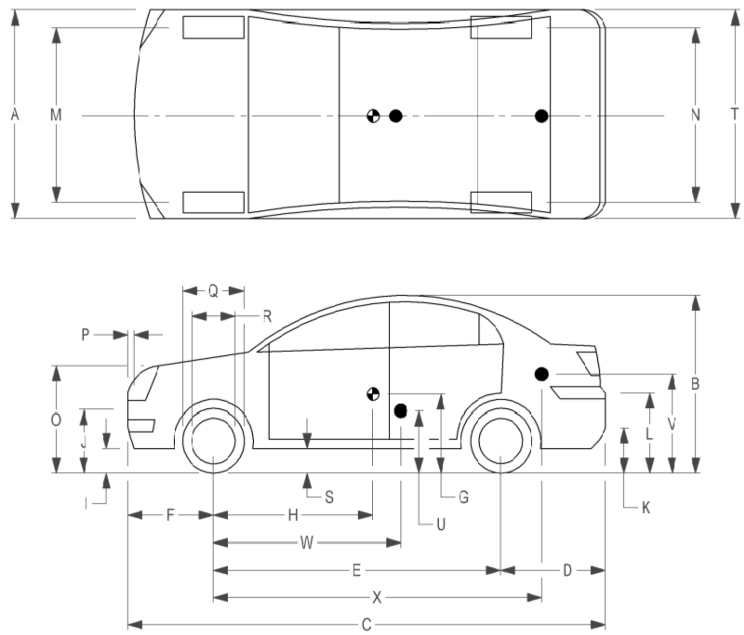
None

Dummy Data:

Type: 50th Percentile Male

Mass: 165 lb

Seat Position: OPPOSITE IMPACT



Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G		L	26.00	Q	24.00	V	21.25
C	175.40	H	41.25	M	58.30	R	16.25	W	41.25
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.25	O	30.50	T	64.50		

Wheel Center Ht Front 11.50 Wheel Center Ht Rear 11.50 W-H 0.00

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches (M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1750	M_{front}	1434	1448	1533
Back	1687	M_{rear}	948	977	1057
Total	3389	M_{Total}	2382	2425	2590

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:

lb LF: 736 RF: 712 LR: 478 RR: 499

Table C.2. Exterior Crush Measurements for Test No. 609731-5.

Date:	2021-6-24	Test No.:	609731-5	VIN No.:	3N1CN7AP7GL841624
Year:	2016	Make:	NISSAN	Model:	VERSA

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width ________	Bowing: B1 _____ X1 _____
Corner shift: A1 ________	B2 _____ X2 _____
A2 ________	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _______
< 4 inches ________	
≥ 4 inches ________	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
1	Front plane at bumper ht	12	8	24	-	-	-	-	-	-	-23
	Measurements recorded										
	☑ **inches** or ☐ **mm**										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

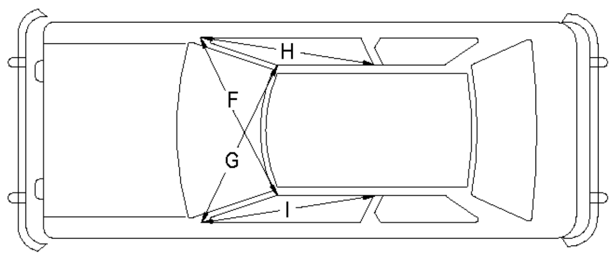
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

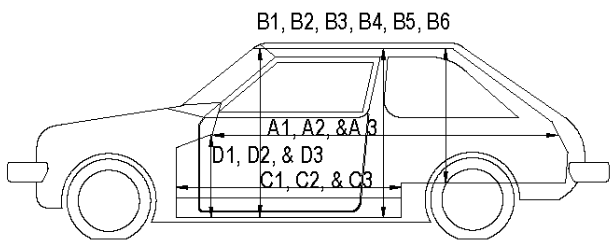
***Measure and document on the vehicle diagram the location of the maximum crush.

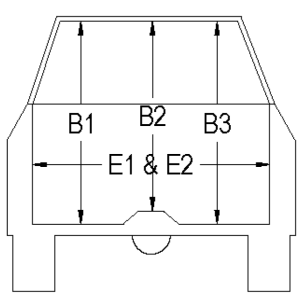
Note: Use as many lines/columns as necessary to describe each damage profile.

Table C.3. Occupant Compartment Measurements for Test No. 609731-5.

Date:	2021-6-24	Test No.:	609731-5	VIN No.:	3N1CN7AP7GL841624
Year:	2016	Make:	NISSAN	Model:	VERSA







*Lateral area across the cab from
driver's side kick panel to passenger's side kick panel.

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	75.00	75.00	0.00
A2	74.00	74.00	0.00
A3	74.00	74.00	0.00
B1	43.00	43.00	0.00
B2	37.00	37.00	0.00
B3	43.00	43.00	0.00
B4	46.50	46.50	0.00
B5	42.50	42.50	0.00
B6	46.50	46.50	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	12.50	12.50	0.00
D2	0.00	0.00	0.00
D3	10.00	10.00	0.00
E1	45.00	45.00	0.00
E2	48.75	48.75	0.00
F	47.50	47.50	0.00
G	47.50	47.50	0.00
H	39.00	39.00	0.00
I	39.00	39.00	0.00
J*	48.50	48.50	0.00

C.2. SEQUENTIAL PHOTOGRAPHS

0.000 s

0.050 s

0.100 s

0.150 s

Figure C.1. Sequential Photographs for Test No. 609731-5 (Oblique and Perpendicular Views).

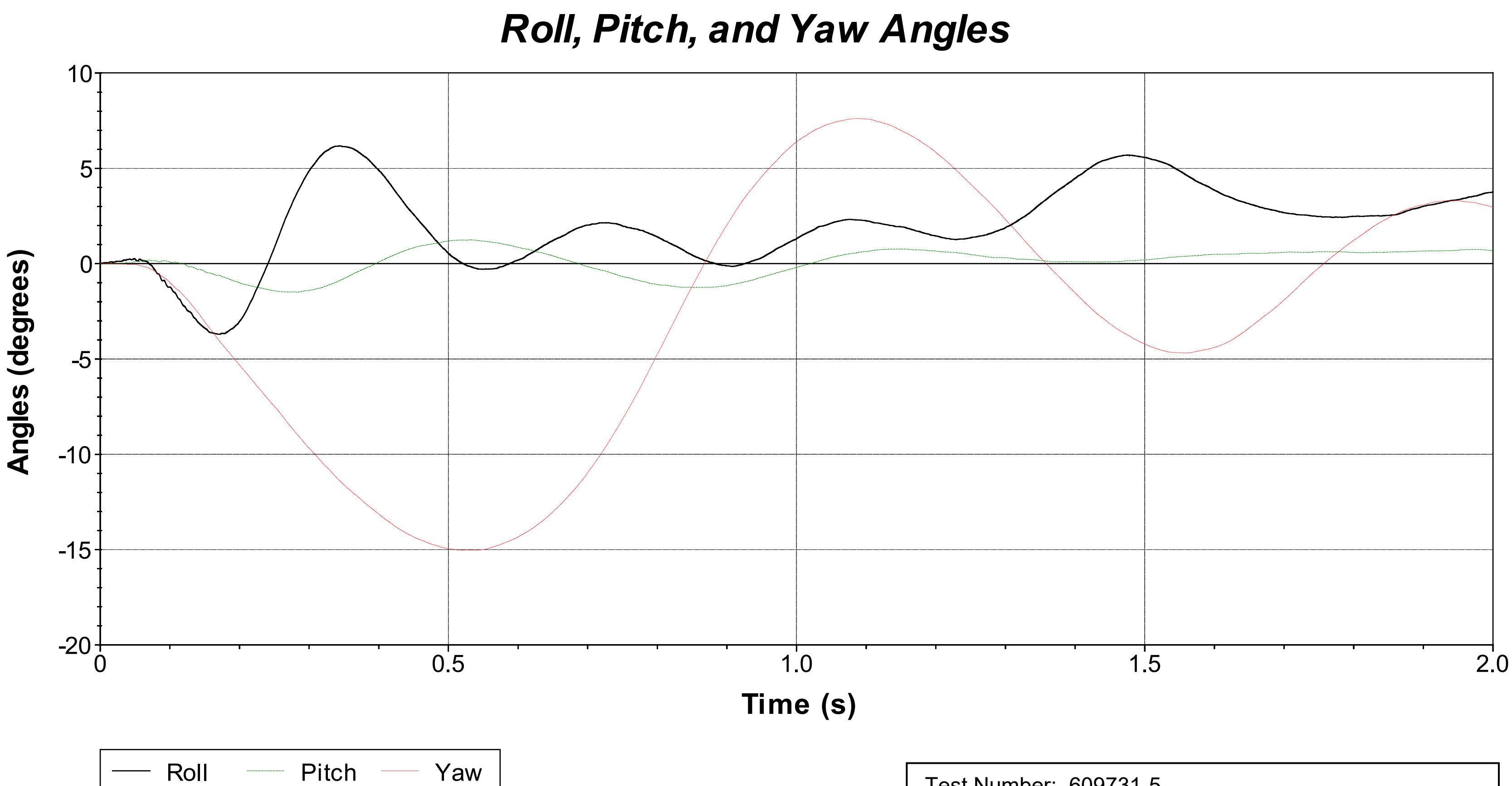
0.200 s

0.250 s

0.300 s

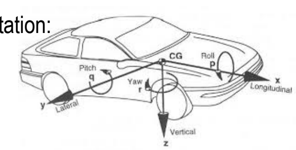
0.350 s

Figure C.1. Sequential Photographs for Test No. 609731-5 (Oblique and Perpendicular Views) (Continued).



Axes are vehicle-fixed.
Sequence for determining orientation:

1. Yaw.
2. Pitch.
3. Roll.



Test Number: 609731-5
Test Standard Test Number: *MASH* Test 3-61 Impacting Cantilever Arm and Mailbox Assembly
Test Article: Modified Minnesota Swing-Away Mailbox
Test Vehicle: 2016 Nissan Versa
Inertial Mass: 2425 lb
Gross Mass: 2590 lb
Impact Speed: 63.1 mi/h
Impact Angle: 0°

Figure C.2. Vehicle Angular Displacements for Test No. 609731-5.

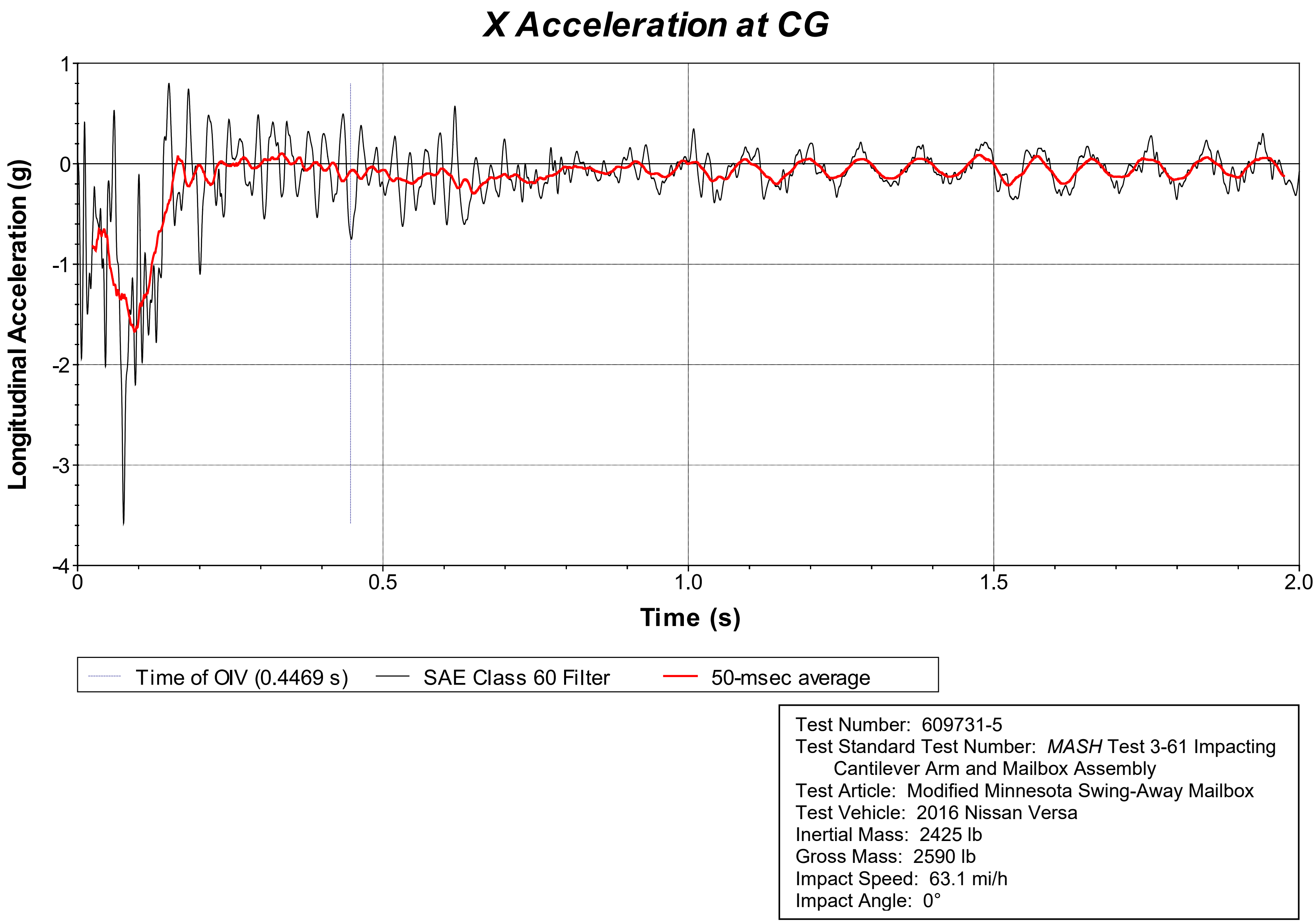


Figure C.3. Vehicle Longitudinal Accelerometer Trace for Test No. 609731-5 (Accelerometer Located at Center of Gravity).

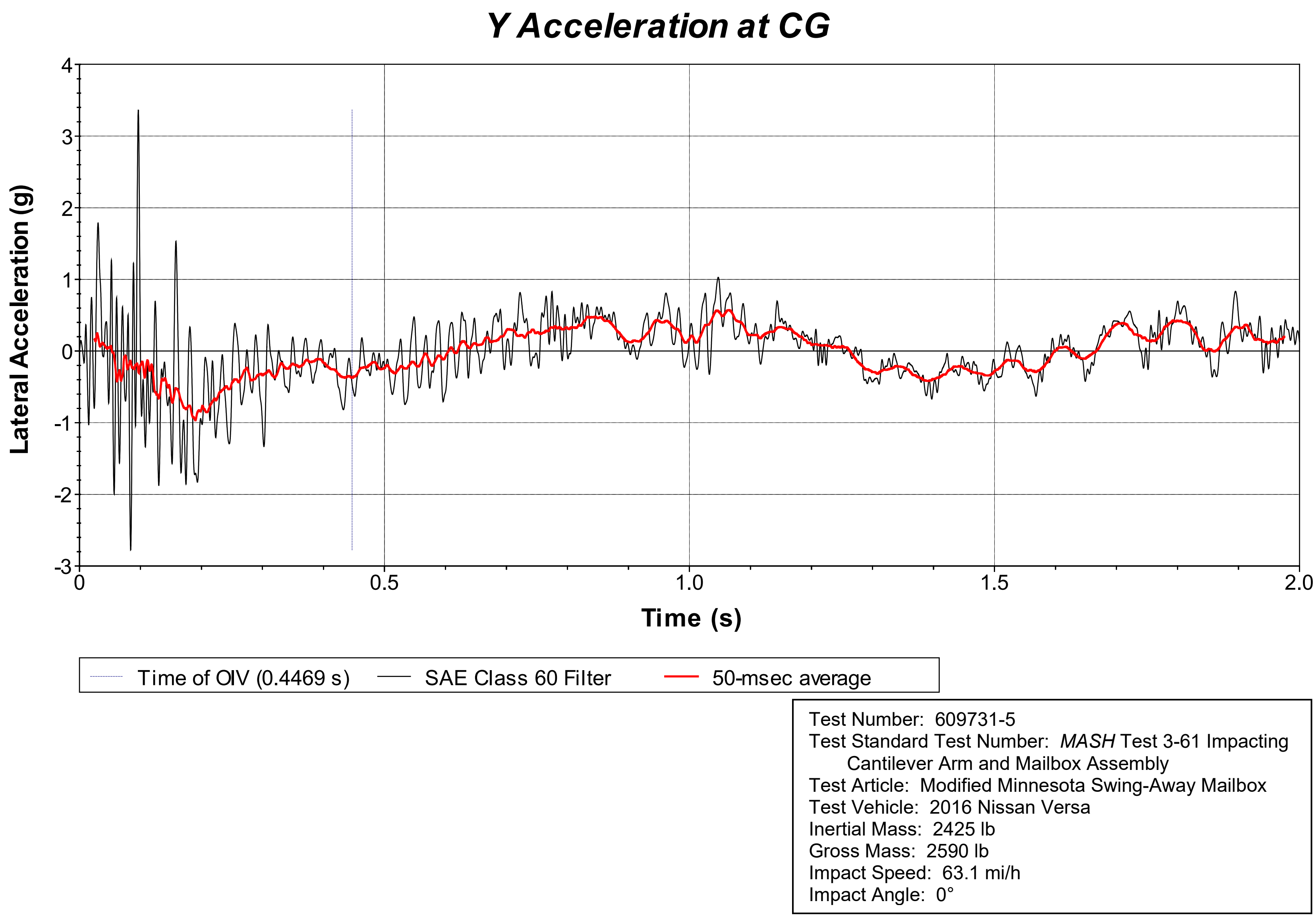


Figure C.4. Vehicle Lateral Accelerometer Trace for Test No. 609731-5 (Accelerometer Located at Center of Gravity).

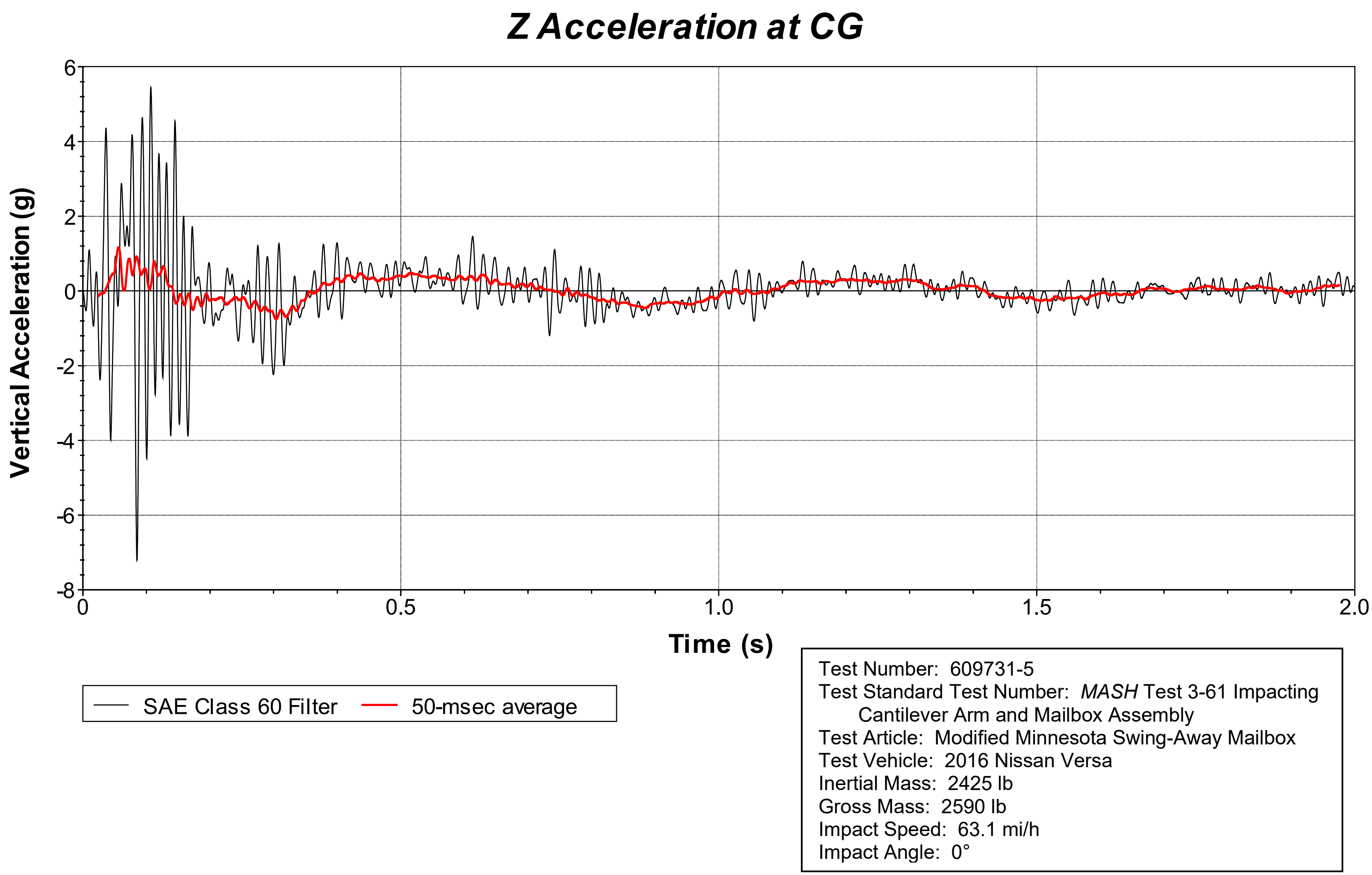


Figure C.5. Vehicle Vertical Accelerometer Trace for Test No. 609731-5 (Accelerometer Located at Center of Gravity).

APPENDIX D. *MASH* TEST 3-61 (CRASH TEST NO. 609731-6)

D.1. VEHICLE PROPERTIES AND INFORMATION

Table D.1. Vehicle Properties for Test No. 609731-6.

Date: 2021-06-24 Test No.: 609731-6 VIN No.: 3N1CN7APXFL808213

Year: 2015 Make: NISSAN Model: VERSA

Tire Inflation Pressure: 36 PSI Odometer: 83961 Tire Size: P185/65R15

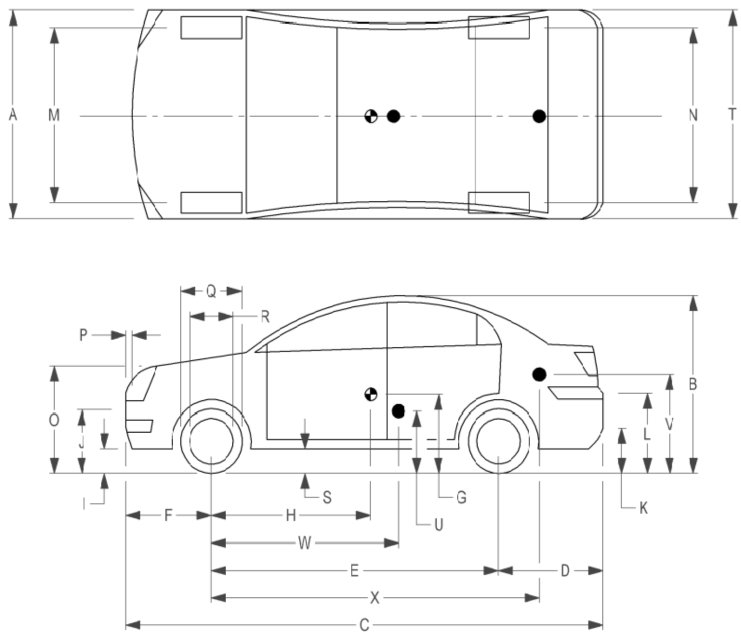
Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

NOTES: None

Engine Type: 4 CYL
Engine CID: 1.6 L
Transmission Type:
☑ Auto or ☐ Manual
☑ FWD ☐ RWD ☐ 4WD
Optional Equipment:
None

Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: OPPOSITE



Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G		L	26.00	Q	24.00	V	21.25
C	175.40	H	41.13	M	58.30	R	16.25	W	41.10
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.25	O	30.50	T	64.50		

Wheel Center Ht Front 11.50 Wheel Center Ht Rear 11.50 W-H -0.03

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches
(M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1750	M_{front}	1458	1449	1534
Back	1687	M_{rear}	973	973	1053
Total	3389	M_{Total}	2431	2422	2587

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:
lb LF: 737 RF: 712 LR: 491 RR: 482

Table D.2. Exterior Crush Measurements for Test No. 609731-6.

Date:	2021-6-24	Test No.:	609731-6	VIN No.:	3N1CN7APXFL808213
Year:	2015	Make:	NISSAN	Model:	VERSA

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width ________	Bowing: B1 _____ X1 _____
Corner shift: A1 ________	B2 _____ X2 _____
A2 ________	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _______
< 4 inches ________	
≥ 4 inches ________	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
1	Front plane at bmp ht	4	4	20	-	-	-	-	-	-	14.5
	Measurements recorded										
	☑ **inches or** ☐ **mm**										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

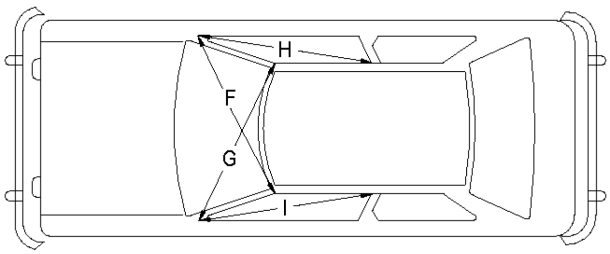
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

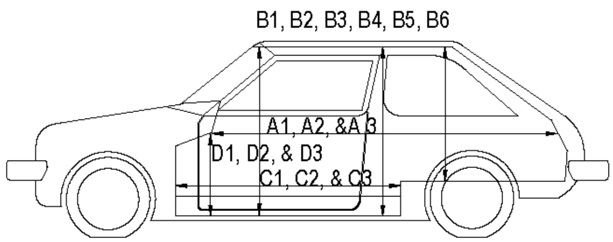
***Measure and document on the vehicle diagram the location of the maximum crush.

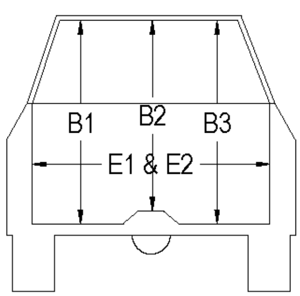
Note: Use as many lines/columns as necessary to describe each damage profile.

Table D.3. Occupant Compartment Measurements for Test No. 609731-6.

Date:	2021-6-24	Test No.:	609731-6	VIN No.:	3N1CN7APXFL808213
Year:	2015	Make:	NISSAN	Model:	VERSA





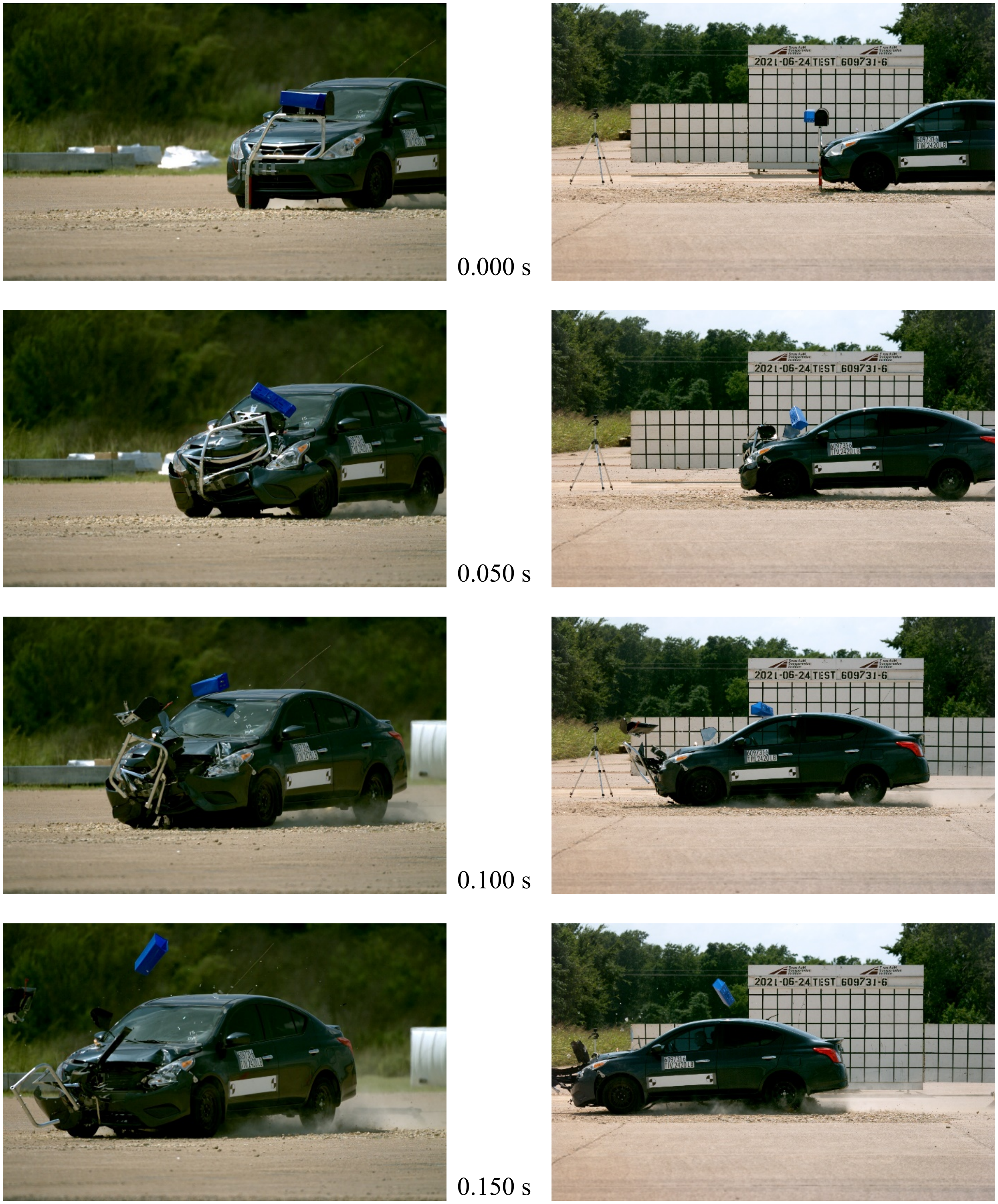


*Lateral area across the cab from driver's side kick panel to passenger's side kick panel.

OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	75.00	75.00	0.00
A2	74.00	74.00	0.00
A3	74.00	74.00	0.00
B1	43.00	43.00	0.00
B2	37.00	37.00	0.00
B3	43.00	43.00	0.00
B4	46.50	46.50	0.00
B5	42.50	42.50	0.00
B6	46.50	46.50	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	12.50	12.50	0.00
D2	0.00	0.00	0.00
D3	10.00	10.00	0.00
E1	45.00	45.00	0.00
E2	48.75	48.75	0.00
F	47.50	47.50	0.00
G	47.50	47.50	0.00
H	39.00	39.00	0.00
I	39.00	39.00	0.00
J*	48.50	48.50	0.00

D.2. SEQUENTIAL PHOTOGRAPHS



0.000 s

0.050 s

0.100 s

0.150 s

Figure D.1. Sequential Photographs for Test No. 609731-6 (Oblique and Perpendicular Views).


0.200 s



0.250 s

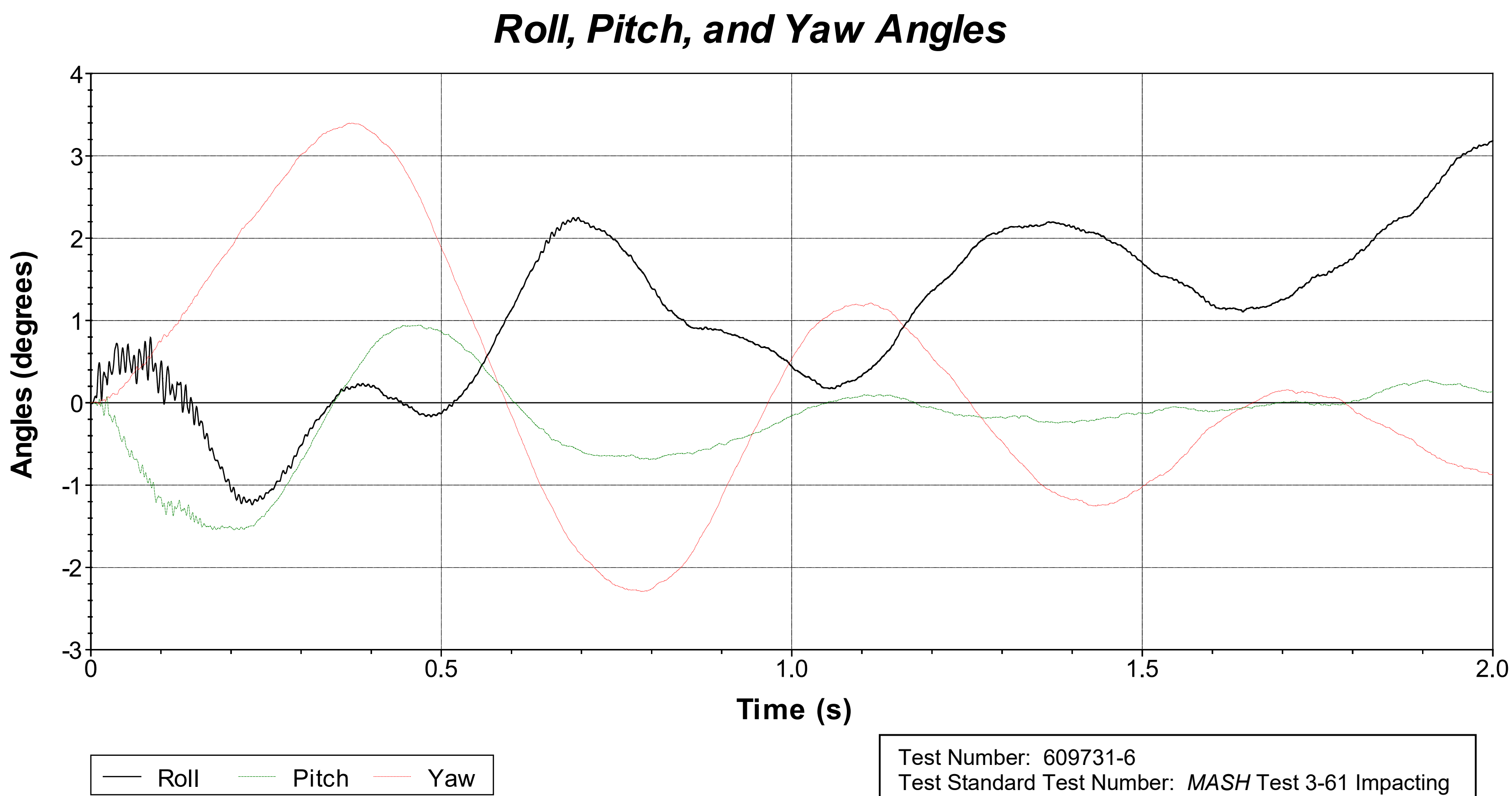


0.300 s



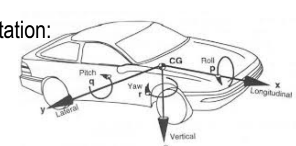
0.350 s


Figure D.1. Sequential Photographs for Test No. 609731-6 (Oblique and Perpendicular Views) (Continued).



Axes are vehicle-fixed.
Sequence for
determining orientation:

1. Yaw.
2. Pitch.
3. Roll.



Test Number: 609731-6
Test Standard Test Number: *MASH* Test 3-61 Impacting Vertical Mailbox Support
Test Article: Modified Minnesota Swing-Away Mailbox
Test Vehicle: 2015 Nissan Versa
Inertial Mass: 2422 lb
Gross Mass: 2587 lb
Impact Speed: 62.8 mi/h
Impact Angle: 0°

Figure D.2. Vehicle Angular Displacements for Test No. 609731-6.

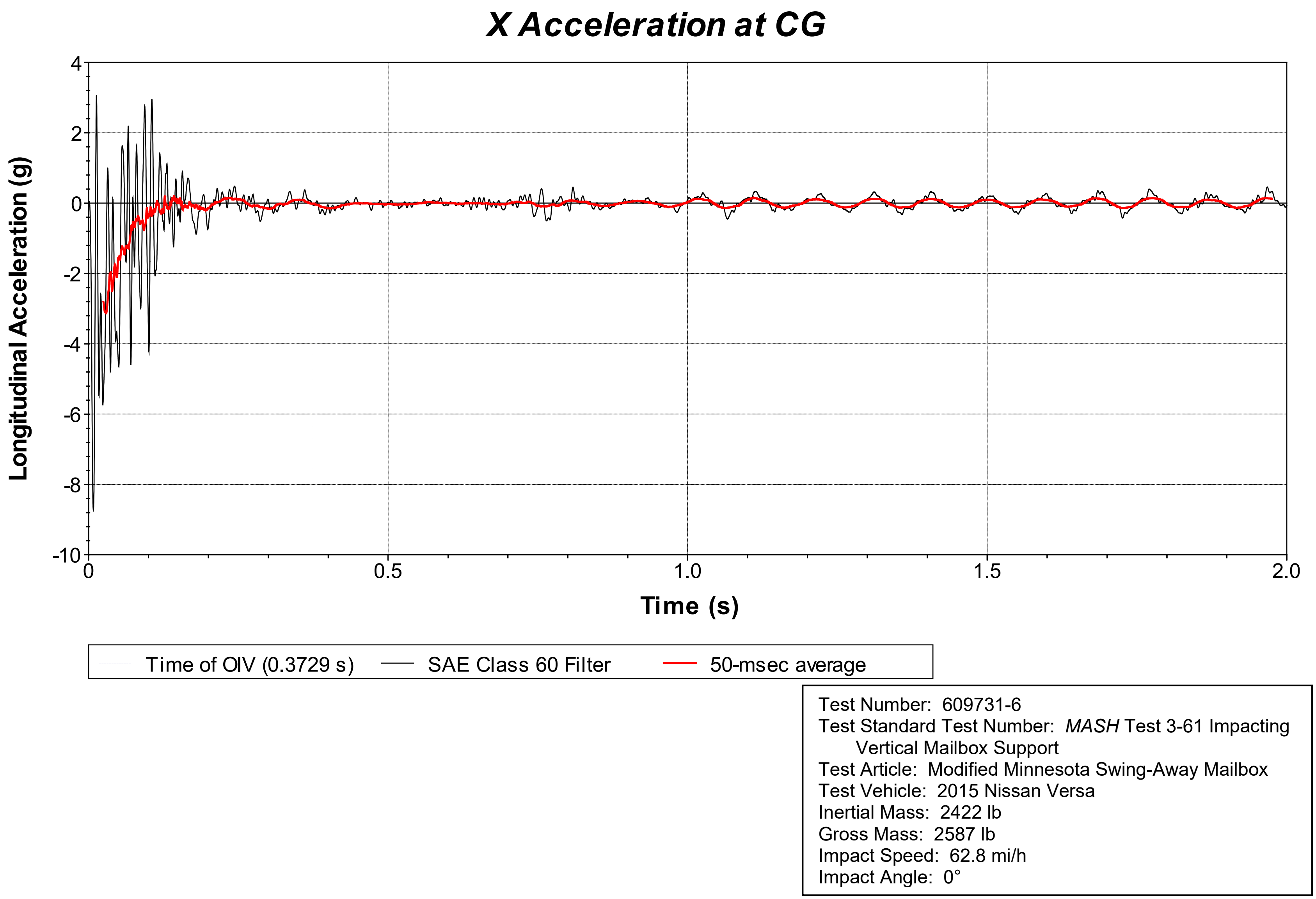
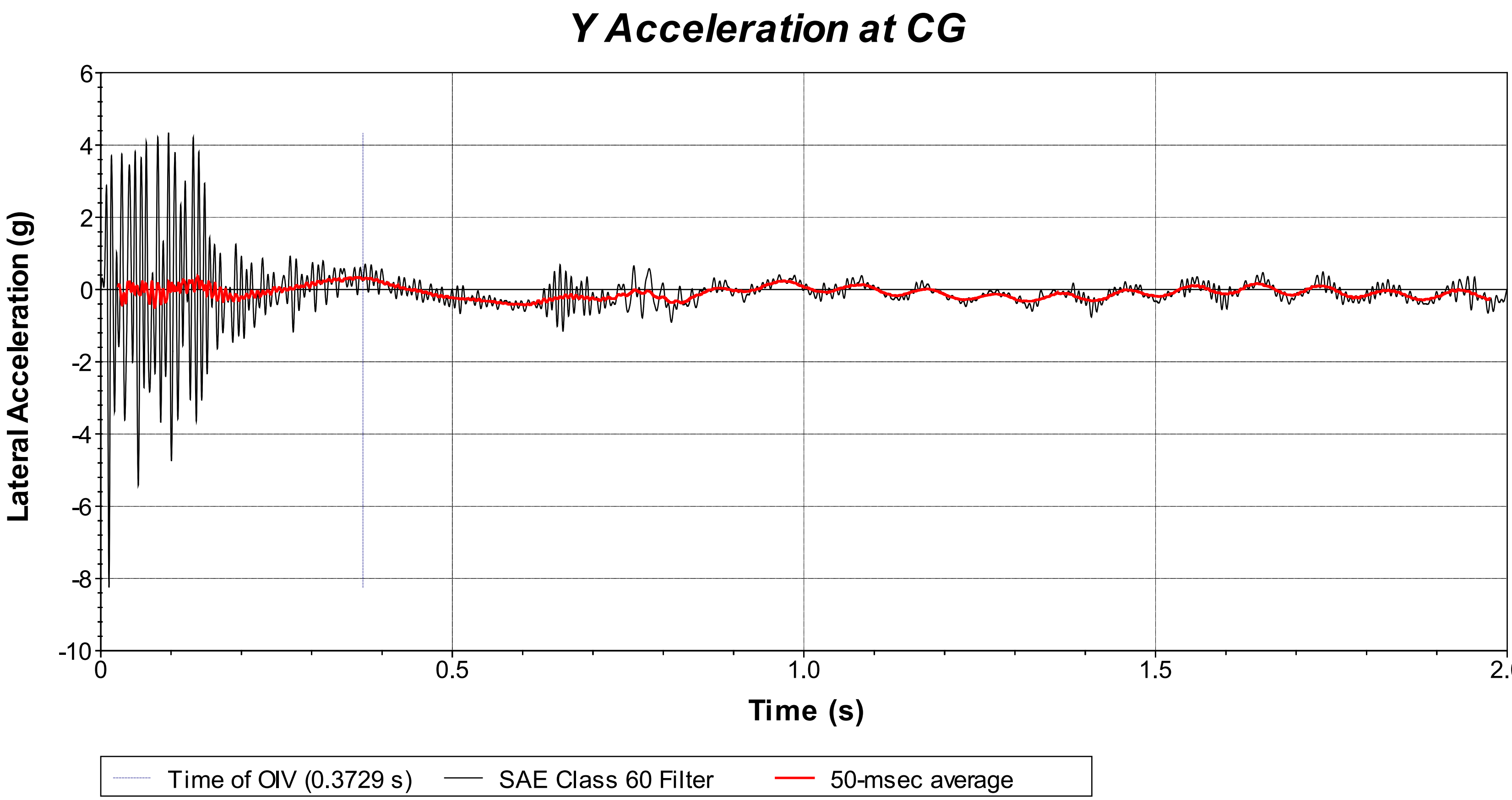


Figure D.3. Vehicle Longitudinal Accelerometer Trace for Test No. 609731-6 (Accelerometer Located at Center of Gravity).



Test Number: 609731-6
Test Standard Test Number: *MASH* Test 3-61 Impacting Vertical Mailbox Support
Test Article: Modified Minnesota Swing-Away Mailbox
Test Vehicle: 2015 Nissan Versa
Inertial Mass: 2422 lb
Gross Mass: 2587 lb
Impact Speed: 62.8 mi/h
Impact Angle: 0°

Figure D.4. Vehicle Lateral Accelerometer Trace for Test No. 609731-6 (Accelerometer Located at Center of Gravity).

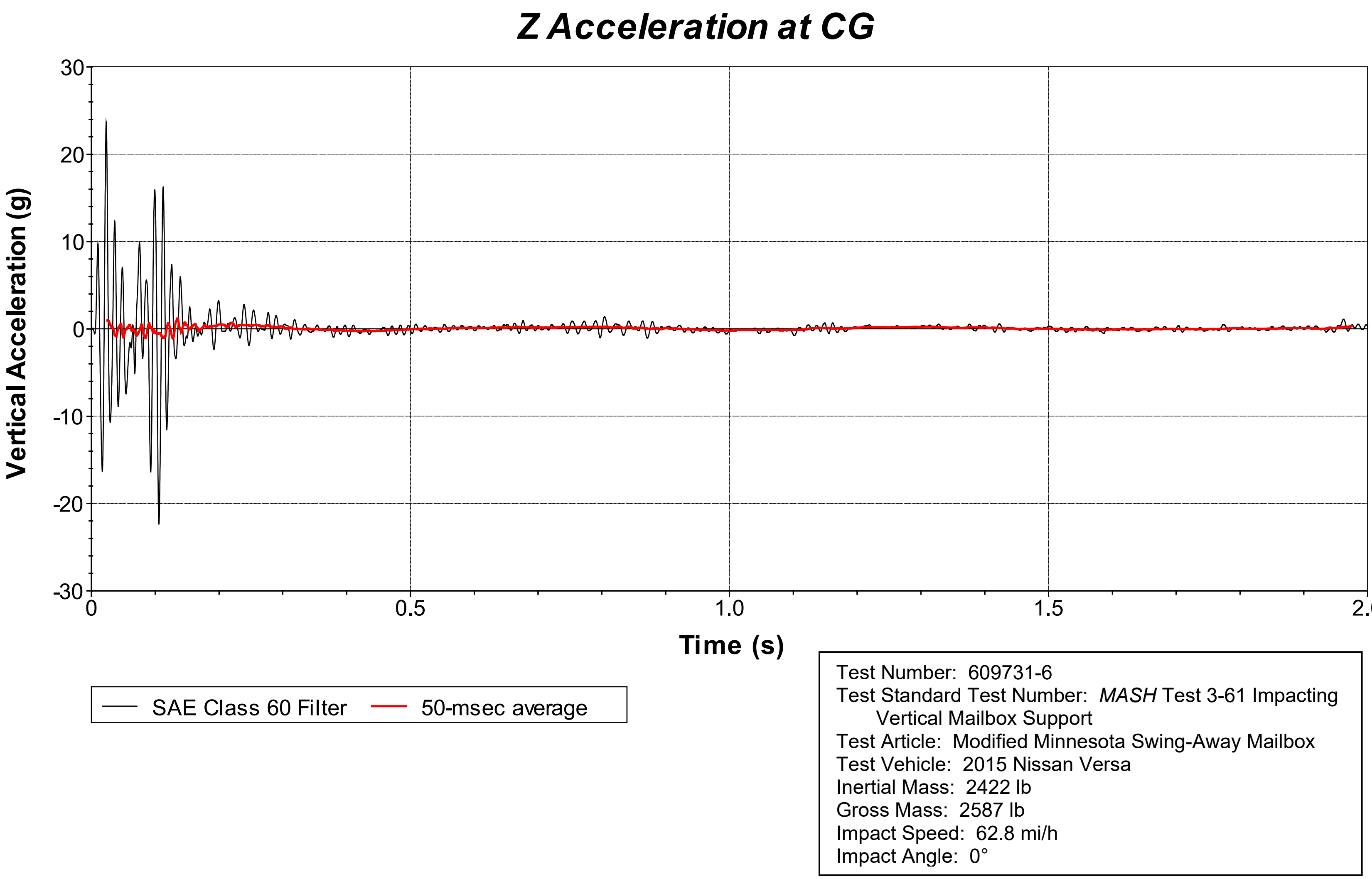


Figure D.5. Vehicle Vertical Accelerometer Trace for Test No. 609731-6 (Accelerometer Located at Center of Gravity).