MoDOT

105 West Capitol Avenue
P.O. Box 270
Jefferson City, Missouri 65102

Missouri Department of Transportation
Patrick K. McKenna, Director

1.888.ASK MODOT (275.6636)

December 22, 2021

Dear Consultant:

The Missouri Highways and Transportation Commission is requesting the services of a consulting engineering firm to perform the described professional services for the project included on the attached list.

If your firm would like to be considered for these consulting services, you may express your interest by responding to the appropriate office, which is indicated on the attachments. Limit your letter of interest to no more than three pages. This letter should include a statement to indicate your firm's understanding of the project. It should also include any other information which might help us in the selection process, including key personnel you would assign to the project and the backgrounds of those individuals, and any sub-consultants you would propose to use, and an indication of your firm's approach to promoting and developing a diverse workforce. MoDOT is committed to reflecting the diversity of the communities we serve and we expect our partners to do the same. We will utilize the consultant information already on file so we will not need a lengthy submittal of other general company information. In addition, please attach one page with detailed information on similar projects that your key personnel have worked on. Indicate the role your key personnel played in the projects and include reference contact information.

DBE firms must be certified by the Missouri Department of Transportation in order to be counted as participation towards an established DBE Goal. We encourage DBE firms to submit letters of interest as prime consultants for any projects they feel can be managed by their firm. We also encourage both DBE firms and non-DBE firms to consider joining MoDOT's Mentor/Protégé program whenever possible as part of a MoDOT project.

MoDOT will evaluate firms based on: Project Understanding & Innovation, Past Performance, Qualifications of Personnel Assigned, General Experience of Firm, Familiarity/Capability, Accessibility of Firm & Staff. Firm's not providing a response on approach to workforce diversity will be considered non-responsive to this solicitation. Firm's that are not current on all of the required prequalification categories found in MoDOT's Approved Consultant Prequalification List at the date of the solicitation expiration will be considered non-responsive.

We request all letters be received by 3:00 pm, January 5, 2022 at the appropriate office.

Sincerely,

DocuSigned by:

7235401C396454...

Travis Koestner, P.E.
State Design Engineer

Attachment

DISTRICT OFFICES

District NW
Marty Liles – District Engineer
Missouri Department of Transportation
3604 North Belt Highway
St. Joseph, MO 64506

Contact
Joyce Reynolds, P.M.
816-387-2411
joyce.reynolds@modot.mo.gov
Email responses are encouraged

District NW

Buchanan County, Route 752, 59 & U	
Job No:	J1P3452
Location:	MO 752, US 59, and Rte. U in Saint Joseph
Proposed Improvement:	Intersection improvements
Length:	0.24 mile
Approximate Construction Cost:	$4,000,000
DBE Goal (if applicable)	8%
Consultant Services Required:	The consultant will provide professional, technical, and other personnel, equipment, material, and all other things necessary for setting project control, remote sensing acquisition, mapping, boundary surveying, and conventional surveying of the project area. More information can be found on the subsequent pages
Other Comments:	Interviews or presentation will not be required for the consultant selection. Tentative Date of Consultant Selection - 1/12/2022

Rating Criteria w/Weighted Values

Project Understanding & Innovation	25 Points Max
Past Performance	25 Points Max
Qualifications of Personnel Assigned	20 Points Max
General Experience of Firm	10 Points Max
Familiarity/Capability	10 Points Max
Accessibility of Firm & Staff	10 Points Max
	100 Points Max Total

SCOPE OF SERVICES

The work covered by this Agreement shall include furnishing equipment, materials, professional, technical, and personnel resources necessary for the performance of airborne and terrestrial LiDAR, airborne photography, mobile imaging, and conventional surveying services for design and development of the specified highway project. Terrestrial LiDAR is defined as either a mobile or static system. The following information will explain and define the items of importance relating to this project. All the elements of work that are necessary to satisfactorily complete the airborne and terrestrial LiDAR, photography, imagery, and conventional surveying services of this project may not be listed. The lack of a specific listing of an element or item of work does not; in itself constitute a basis for additional services or work supplement, and/or adjustment in compensation.

I. PROJECT

Remote sensing services for the specified project area. These services shall include the analytics, compilation, planimetry, and topography (terrain modeling) in addition to orthophoto imaging, ground targeting, airborne photography, Light Detection and Ranging (LiDAR) acquisition, and project control surveying.

Conventional surveying services collecting topography and planimetric of obscure areas, utilities, and drainage, etc., for both airborne and terrestrial lidar acquisition for a full topographic service.

Boundary surveys establishing existing Missouri Highways and Transportation Commission (MHTC) boundaries (right of ways), adjoining government and private property boundaries and will be required on this project.

II. SERVICES AND DATA PROVIDED BY THE COMMISSION

The COMMISSION will provide available information of record to the CONSULTANT as well as:

1) Project location and limit for acquisition and mapping shall be provided using a .kmz (Google Earth) file format or MicroStation .dgn file format.

2) Access to the MoDOT Real Time Network (RTN) and 1 second data for post process flight data.

3) Access to the MoDOT Engineering Policy Guide 238.1 Aerial Mapping and LIDAR Surveys.

   http://epg.modot.mo.gov/index.php?title=238.1_Aerial_Mapping_and_LiDAR_Surveys

4) Access to the NCHRP (National Cooperative Highway Research Program, No 748, Guidelines for the Use of Mobile LiDAR in Transportation Applications.

   http://www.trb.org/main/blurbs/169111.aspx

5) As-built roadway plans for each project corridor to serve as an aid to the CONSULTANT for locating drainage structures.

III. SCOPE OF WORK

Work covered in this document shall include furnishing the professional, technical, and other personnel necessary to provide the following services:

1) **Project Control Surveying.** CONSULTANT shall be responsible for marker placement, field observations, field notes, adjustments, and reporting of all horizontal and vertical control on all projects, unless control is provided by the COMMISSION.

2) **Remote Sensing Acquisition.** The CONSULTANT shall be responsible for providing airborne and terrestrial photography and lidar services on all

projects.

a. **Planning**. The CONSULTANT is responsible for project planning as it relates to coordinating the airborne and terrestrial ground control targeting prior to the mission.

b. **Mission Planning.** The CONSULTANT shall be responsible for the final mission plans and shall make the necessary adjustments to meet ALL required specifications herein.

c. **Standards**. The CONSULTANT shall comply with the most recent and applicable State and Federal Laws. Procedures shall be performed in a manner that supports airborne and terrestrial LiDAR compilation in accordance with the United States National Map Accuracy Standards and any applicable portion of the Missouri Department of Transportation Engineering Policy Guide section 238.1 Aerial Mapping and LiDAR Surveys and 238.3 Route Surveying

3) **Mapping.** CONSULTANT shall be responsible for extracting planimetric features and topography in accordance with the accuracy requirements outlined for each of the acquisition types listed in this scope of service.

4) **Boundary Surveying.** CONSULTANT shall be responsible for providing boundary surveying services on specific projects outlined within this document.

5) **Conventional Surveying.** CONSULTANT shall be responsible for providing conventional surveying services necessary to obtain topographic and planimetric data for all obscured areas, underground utilities, and drainage structures within the project limits.

IV. SPECIFICATIONS AND REQUIREMENTS FOR PROJECT CONTROL SURVEY

1) **Project Control Survey**. The CONSULTANT shall perform a control survey for the project. This survey will ensure precise positions of GNSS network stations throughout the project.

   The survey shall comply with the following specifications. If any portion of the survey does not comply with these specifications, a written report substantiating the material variances for the specification with the responsible surveyor's signature is required. The COMMISSION reserves the right to disallow variation.

   a. **Primary Project Control** shall be referenced and adjusted to the Missouri Department of Transportation CORS network and/or the National Spatial Refence System (NSRS) using a minimum dual frequency GNSS receiver. The quality of this control shall be based on a Network Accuracy with respects to the CORS Network at the 95% confidence level using the NAD83 (NSRS2011), Epoch 2010 datum.

   b. **Secondary Project Control** shall be referenced to the Primary Project Control using a minimum dual frequency GNSS receiver. The quality of this control shall be based on a Local Network Accuracy with respects to the Primary Control Network at a 95% confidence level using the NAD83 (NSRS2011), Epoch 2010 datum.

   c. **Benchmarks** shall be referenced to the North American Vertical Datum of 1988 (NAVD88). Project reference benchmark shall be established using nearby NOAA's National Geodetic Survey passive vertical control monumentation or primary project control. If primary project control is utilized as the basis of vertical control, then NOAA's National Geodetic Survey (NGS) Geoid 18 model shall be applied to the ellipsoid model to derive the orthometric height for the project.

2) **Types of Project Control:**

a. **Primary Project Control**. Primary project control point shall be a minimum of a #5 rebar, 24" long (5/8" x 24") with an aluminum cap. Aluminum cap shall have a datum point stamped into cap for coordinate reference.

- Primary project control points should be conveniently located and easily accessible within the public right-of-way. Safety and preservation of control should also be considered when selecting a location.

- Control point shall be placed a minimum of 6 inches below the grounds surface.

- Primary project control points shall be located outside the project area; with a pair at each end of the project and alternating each side of the project at an interval of 5 miles throughout project limits. The control shall be located 1000 feet (± 250 ft) outside the project area. These control points should serve as network reference points for secondary project control, as well as calibration points for GNSS surveying activities.

- Horizontal (XY) position may be established using a static GNSS or Real-Time Kinematic (RTK) method.

- Static GNSS method shall have a minimum of two (2) four (4) hour observations with a minimum of a one (1) hour time differential is required.

- Real-Time Kinematic (RTK) method shall have an average of four (4) five (5) minute (300 epoch) observations with a minimum of a one (1) hour time differential is required.

- Control shall meet a network accuracy of (H) ≤ 0.05 ft (1.5cm) and vertical (V) ≤ 0.098ft (3cm) at a 95% confidence level.

- Primary Project Control may be used as a reference benchmark for the differential level loop(s) or section(s). For projects less than 10 miles only one (1) primary control may be used as a reference benchmark. Projects 10 miles or greater, a primary control on each end may be used to begin and terminate the level section. If the required misclosure is not met using the level section method, then the leveling operation shall loop back to the beginning reference point and be re-calculated. Both the level loop or section method will require a misclosure accuracy of 3rd order or better.

- A minimum of three (3) reference ties to recoverable accessories will be made for each control station. The control station is to be described in such manner as to facilitate navigation and recovery of its location.

b. **Secondary Project Control**. Secondary project control points shall be a minimum of a #5 rebar, 24” long (5/8” x 24”) with an aluminum cap. Aluminum cap shall have a datum point stamped into cap for coordinate reference.

- Secondary Project control points shall be conveniently located and easily accessible within the public right-of-way. Safety and preservation of control should also be considered when selecting a location.

- Control point shall be placed a minimum of 6 inches below the grounds surface.

- A pair of inter-visible secondary control points shall be placed at a 1-mile interval throughout the corridor. The distance between inter-visible points should be 1500 feet (± 200 ft) apart along corridor.

- Horizontal (XY) position may be established using a static GNSS or Real-Time Kinematic (RTK) methods.

- Static GNSS method shall have a minimum of two (2) one (1) hour observations with a minimum of a 1-hour time differential is required.

- Real-Time Kinematic (RTK) method shall have four (4) five (5) minute (300 epochs) observations with a minimum of a thirty (30) minute time differential is required.

- Control shall meet a local network accuracy of horizontal (H) ≤ 0.05 ft (1.5cm) and vertical (V) ≤ 0.098 ft (3cm) at a 95% confidence level.

- Elevation (Z) on these control points shall be established using differential leveling. These control points should be included in the benchmark leveling operation and adjusted with benchmarks.

- A minimum of three (3) reference ties to recoverable accessories will be made for each control station. The control station is to be described in such manner as to facilitate navigation and recovery of its location.

c. **Vertical Control (benchmarks)**. Benchmarks should be of a stable, permanent nature; e.g., aluminum or brass disk epoxied into a drilled hole in rock or concrete, 1/4-inch-deep cut or chiseled “square” in a concrete object. A minimum of a 2-inch MAG nail epoxied into a drilled hole in a concrete object, e.g., concrete headwalls, retaining walls, signal base, or concrete pads. No benchmark shall be placed in the top of curbing or sidewalks along streets or highways. If previous conditions are unavailable, then the use of a minimum 8 inch long spike driven in the root or base of a tree within public right-of- way or 5/8” x 24” long rebar with 2” aluminum cap buried a minimum of 12 inch below the ground’s surface in a safe area free of disturbance within public right-of-way.

- Benchmarks shall be conveniently located and easily accessible.

- Spacing shall be at an interval of 1000 feet.
- Level loop or section misclosure shall meet a Third (3rd) Order differential level accuracy
- XY coordinates and a minimum of three (3) reference ties to recoverable accessories will be made for each benchmark. The benchmark is to be described in such manner as to facilitate navigation and recovery of its location.

Table IV-1 – Third Order Differential Leveling Specification

Operation/Specification	Compensator-Level Three-Wire Observation	Compensator-Level Single-Wire Observation	Electronic/Digital Bar Code Level
Difference in length between fore and back sites not to exceed per setup	33 feet	33 feet	33 feet
Cumulative difference in length between fore and back sights, not to exceed per loop or section	33 feet	33 feet	33 feet
Maximum site lengths	300 feet	300 feet	300 feet
Minimum ground clearance or sight line	1.6 feet	1.6 feet	1.6 feet
Maximum section misclosure	0.05 feet x (√D) *(See Note 2)*	0.05 feet x (√D) *(See Note 2)*	0.05 feet x (√D) *(See Note 2)*
Maximum loop misclosure	0.05 feet x (√E) *(See Note 3)*	0.05 feet x (√E) *(See Note 3)*	0.05 feet x (√E) *(See Note 3)*
Difference between top and bottom intervals not to exceed:	0.30 of rod unit	N/A	N/A
Collimation (Two-Peg) Test	Daily (not to exceed 0.007 feet) *(See Note 4)*	Daily	Daily

Minimum number of readings. (use repeat measure option for each observation)	N/A	N/A	3 *(See Note 5)*

Notes:

1. *Leveling staff in backlit conditions may decrease maximum sight distance.*
2. *D = Shortest one-way length of section in miles (section in defined as a series of setups between two permanent control points).*
3. *E = Length of loop in miles (loop is defined as a series of setups closing on a starting point).*
4. *Readjust level if 0.007 feet in 200 feet is exceeded.*
5. *If the standard error of the mean exceeds 0.0003 feet, continue repeat measurements until standard error of the mean is less than 0.0003 feet.*

d. **TML Project Base Station Control**. Base Station control shall be used to post-process the TML GNSS data. These points shall be placed at intervals to ensure that no processed baseline exceeds the survey type requirements listed in Table VII-1 Terrestrial Mobile LiDAR Scanning and VIII-1 Airborne and Mobile LiDAR Scanning Integration.

- Base station control shall be tied to the project's primary control network.
- Horizontal (XY) position shall be established using a static or real-time kinematic (RTK) GNSS methods. Static GNSS shall require a minimum of two (2) two (1) hour observations with a minimum one (1) hour time differential is required. Real-Time Kinematic (RTK) shall require a minimum of four (4) five (5) minute (300 epochs) observations with a minimum of thirty (30) minute time differential is required.
- Required surveyed accuracy for this control shall meet or exceed a

horizontal (H) ≤ 0.03 foot and vertical (V) ≤ 3rd Order.

e. **Local Transformation and Validation Points**. Local transformation (target location) points shall serve as control for adjustment of the point clouds. Validation (check) points shall serve as an independent quality control checks of the adjusted scan data. Local transformation and validation points may be targeted control points, recognized features, or coordinate position within the scans.

- Local transformation and validation points shall be tied to the project's primary control network using a GNSS Real-Time Kinematic (RTK) base and rover method.
- Minimum of three (3) averaged positions having a 300 epochs per session with a 1-hour time interval between sessions.
- Type "AL-A" survey requires local transformation and validation points to have a surveyed local positional accuracy of H ≤ 0.06 foot and Z ≤ 0.04 foot or better.
- Type "AL-B" survey requires local transformation and validation points to have a surveyed local positional accuracy of H*z* ≤ 0.10 foot and Z ≤ 0.10 foot or better.
- Type "TML-A" survey requires local transformation and validation points to have a surveyed local positional accuracy of H*z* ≤ 0.06 foot and Z ≤ 0.04 foot or better.
- Type "ATLI-A" survey requires local transformation and validation points to have a surveyed local positional accuracy that corresponds to the airborne and mobile standards required for the project.

3) **Linear measures**. Linear measurements will be made in the English System. The base unit will be the U.S. Survey Foot (and decimal parts thereof).

4) **Coordinate System**. All coordinates shall be based on the Missouri State Plane Coordinate System in the appropriate zone.

5) **Horizontal Datum.** The horizontal positions shall be based on the North American Datum of 1983 (NAD83) (NSRS2011) Epoch 2010.

6) **Vertical Datum**. The orthometric elevations shall be referenced to the North American Vertical Datum of 1988 (NAVD 88).

7) **Global Navigation Satellite System (GNSS)**. CONSULTANT will use GNSS survey technology to establish the ground control. The orthometric elevations shall be based upon ellipsoidal heights that have been modified by the NOAA's National Geodetic Survey (NGS) Geoid 18 model

8) **Project Coordinate.** All project coordinates shall be Modified State Plane Coordinate System (ground) using the project's Projection Factor (reciprocal average grid factor). Projecting of coordinates shall be about the 0.00,0.00 origin and not a central point of the project.

9) **Projection Factor**. The CONSULTANT is responsible for developing a project projection factor based on the Missouri Coordinate System of 1983 Manual for Land Surveyors, unless provided by the COMMISSION.

   a. Scale Factor. Using the most easterly and westerly control points within the project to develop a centroid point for a project. Use the converted English easting of the centroid point in the correct zone formula below.

East Zone =
(easting – 820,208.3333) *0.00000000045 * (easting – 820,208.3333) + 0.9999333 =
393,700

Central Zone =
(easting – 1,640,416.6665) *0.00000000045 * (easting – 1,640,416.6665) + 0.9999333 =
393,700

West Zone =

(easting – 2,788,708.3331) *0.00000000045 * (easting – 2,788,708.3331) + 0.9999412 = 393,700

b. Elevation Factor is determined by dividing the ellipsoid radius by the ellipsoid radius plus the mean elevation for the project.

$$\text{Elevation Factor} = \frac{20{,}909{,}689}{[20{,}909{,}689 + (\text{elevation in feet} - 100.065)]}$$

c. Grid Factor is the result of multiplying the Elevation Factor by the Scale Factor of the centroid point of the project.

Grid Factor = Elevation factor * Scale factor

d. Projection Factor is the reciprocal of the grid factor.

Projection Factor = 1 / Grid factor

V. SPECIFICATIONS AND REQUIREMENTS FOR REMOTE SENSING ACQUISITION

The following specifications set forth the minimum requirements that must be met by the CONSULTANT when providing all remote sensing (photography or lidar) data.

1) **Acquisition Conditions**

a. No work shall be done without MoDOT notification that work may begin.
b. Ground surface shall be free of snow coverage within acquisition limits
c. Shall take place when deciduous trees are free of foliage
d. Shall not take place when the ground is obscured by haze, smoke or dust and in the case of airborne when clouds are present below the flight path.
e. Shall be performed between March 1 and April 15, when the deciduous trees are bare, ground is free of snow, and undergrowth is at its closest level to the ground surface from winter weather.

2) **Photography.** The CONSULTANT shall provide the necessary airborne

photographic coverage for the project. Specifications and instructions for delivery for airborne photography are contained in the Missouri Department of Transportation Specifications for Vertical Airborne Photography.

a. Digital Camera Requirements

- Digital image data will be captured of selected sites using a high precision digital aerial mapping metric camera.

b. Camera Location Data

c. An electronic file is to be delivered for each project containing the photo centers of exposures.

d. The file name must contain the MoDOT project number.

e. Coordinate units must be in the datum/coordinate system of the project.

f. Photo shall be collected using a 3-inch pixel size

g. Flight Conditions. Spring flying season photography shall be taken during the hours of mid-day (3 hours after sunrise to 3 hours before sunset).

3) **Light Detection and Ranging (LiDAR)**. The following specifications set forth the minimum requirements that must be met by the CONSULTANT when providing airborne and terrestrial LiDAR to the MoDOT.

a. **Technical Specifications**. The CONSULTANT shall provide the necessary LiDAR coverage for the project. Specifications and instructions for delivery of LiDAR are contained in each of the acquisition categories outline in this document.

b. LiDAR Sensor Calibration Reports.

- LiDAR sensor, the CONSULTANT shall provide the calibration report and/or the manufacture's recommended equivalent

procedure. If a manufacturer recommended procedure is provided, a Statement of Compliance on company letterhead shall be submitted. The statement of compliance shall:

i. Certify that the manufacture's recommended procedure; was completed at the recommended intervals as required.

ii. Identify the date the procedure was last accomplished before the project data was collected.

iii. Be signed by an authorized representative of the company submitting the Statement of Compliance.

- If requested, the CONSULTANT shall submit a statement certifying that the LiDAR sensor has not been disturbed, repaired or modified in any fashion since the submitted calibration report or statement of compliance as made.

- If at any time after award of the contract, the LiDAR sensor is disturbed, repaired or modified in any fashion, the CONSULTANT shall submit to MoDOT a new calibration report or statement of compliance.

- MoDOT reserves the right to restrict the use of any LiDAR sensor based upon the data contained in the calibration report or based upon operational results.

VI. SPECIFICATIONS AND REQUIREMENTS FOR AIRBORNE LIDAR (AL)

1) **Airborne LiDAR Equipment.** All the equipment used to collect, process, and adjust data must be of sufficient precision to meet the accuracy requirements of the project.

   a. Aircraft will be equipped with an Aerial Sensor Management System (ASMS) for guidance, positioning and flight management.

   b. Airborne Global Positioning System (ABGPS) survey and Inertial

Measurement Unit (IMU) measurement technology will be employed, estimating the imagery capture control stations. Consultant shall use static logging information from base stations within MoDOT's GNSS Reference Station Network for all post processing of ABGPS data. A user ID will be provided by MoDOT to access MoDOT's GNSS Reference Station Network web site for the purpose of downloading the necessary GNSS data accentual to post processing. GNSS static data must be downloaded from GNSS Reference Station Network web site within 15 days of flight.

2) **Post-Processing of Airborne LiDAR (AL) Data**. The Consultant shall be responsible for all post-processing of the LiDAR to meet the following specifications.

Table VI-1 – Airborne LiDAR (AL) Tolerance and Accuracy

Operation/Specification	Type of Surveys	
	AL - A	AL - B
Hard Surfaces	± 0.10 ft	± 0.20 ft
Non-Vegetative Surfaces	± 0.20 ft	± 0.20 ft
Vegetative Surfaces	± 0.30 ft	± 0.30 ft
Minimum order of accuracy for GNSS Base Station horizontal (H) and vertical (V) project control	H ≤ 0.07 ft V = 3rd Order	
Local Transformation Point and Validation Point surveyed positional accuracy requirement	H ≤ 0.06 ft V ≤ 0.04 ft	H ≤ 0.10 ft V ≤ 0.10 ft
Local transformation points maximum stationing spacing throughout the project	Must support surface accuracy requirements	
Validation point maximum stationing spacing throughout the project	Must support surface accuracy requirements	
Point Density	≤ 5 points/feet^2	

VII. SPECIFICATIONS AND REQUIREMENTS FOR TERRESTRIAL MOBILE LIDAR (TML)

1) **Post-Processing**. The Consultant shall be responsible for all post-processing of the TML data to meet the following specifications.

2) **Mission Planning.** Mission planning session should be conducted to assure adequate GNSS satellite availability during the data collection especially for GNSS-challenged locations.

3) **Inertial Measuring Unit (IMU) and Distance Measuring Instrument (DMI) Sensors.** The use of IMU and DMI sensor are required during data acquisition.

4) **Collection Rate (Epoch).** MLS sensors must be sufficient to meet project accuracy and point density requirements.

5) **GNSS Base Station(s) and Rover Units.** Refers to the GNSS System utilized during the Mobile LiDAR acquisition.

   a. GNSS base station shall be at a minimum of a dual frequency receiver capable of logging data at a 1 Hz or faster.

   b. Simultaneous GNSS signals from a minimum constellation of 6 satellites shall be maintained between at least one GNSS base station receiver and the GNSS roving receiver(s).

   c. The GNSS PDOP shall be 5 or less at the base and roving units during data acquisition.

   d. GNSS baselines shall not exceed 5 miles in length.

   e. Dual redundant GNSS base stations are highly recommended.

6) **Scan Pass.** Refers to mobile data associated with individual driven trajectories along the corridor.

a. Mobile LiDAR data collection shall be conducted with a minimum of two (2) passes along each corridor ensure data redundancy and sufficient point density to model objects. Additional passes may be required.

b. Allow sufficient time between overlapping collection passes to ensure change in satellite constellation. Recommend a minimum time differential of 15 minutes.

c. The minimum amount of overlap along the sides of the scan passes shall be 25%.

d. Maximum vertical separation between overlapping area shall be 0.05 feet.

e. Random Noise level shall not exceed a peak-to-peak value of *0.04 foot (+/- 0.02 foot)*.

7) **Camera.** Camera manufacture and model shall be provided.

8) **Image Quality.** Images will exhibit appropriate clarity and resolution as would be expected when using appropriate aperture, shutter speed, or equivalent operating parameters.

a. The images shall be sufficiently calibrated in such a manner as to ensure image alignment with the point cloud data.

b. Digital video and photo files with data files supported by TopoDOT.

c. A calibration file supported by TopoDOT shall be provided.

9) **Types of TML Surveys.**

a. Type A – High Accuracy Surveys:

- Design engineering topographic
- As-built
- Structures and bridge clearances

- Pavement analysis
- ADA compliance

Table VII-1 – Terrestrial Mobile LiDAR (TML) Tolerances and Accuracy

Operation/Specification	Type of Surveys
	TML - A
Hard Surfaces	± 0.06 ft
Non-Vegetative Surfaces	± 0.12 ft
Vegetative Surfaces	± 0.20 ft
Minimum order of accuracy for GNSS Base Station horizontal (H) and vertical (V) project control	H ≤ 0.07 ft V = 3rd Order
Local Transformation Point and Validation Point surveyed positional accuracy requirement	H ≤ 0.06 ft V ≤ 0.04 ft
Local transformation points maximum stationing spacing throughout the project	Must support surface accuracy requirements
Validation point maximum stationing spacing throughout the project	Must support surface accuracy requirements
Point Density	≤ 20 points/feet^2

VIII. SPECIFICATIONS AND REQUIREMENTS FOR AIRBORNE AND TERRESTRIAL LIDAR INTERGRATION (ATLI)

Airborne and Terrestrial LiDAR Integration (ATLI) combines multiple acquisition methods (e.g. airborne, mobile, and static) through an integration (data fusion) process that yield a single point cloud with multiple levels of accuracy. This application is generally used when a higher degree of accuracy and detail is needed on hard surfaces along the roadway corridor and a lesser accuracy out to the extense of the acquisition corridor.

The following specifications set forth the minimum requirements that must be

met by the CONSULTANT when providing airborne and terrestrial lidar integration.

1) **Accuracy Requirements.** LiDAR integration shall maintain accuracies in accordance with the required Survey Type listed for AL and TML requirements and specifications.

Table VIII-1 – Airborne and Terrestrial LiDAR Integration (ATLI)
Tolerances and Accuracy

Operation/Specification	Type of Surveys
	ATLI - A
Hard Surfaces	± 0.06 ft
Non-Vegetative Surfaces	± 0.20 ft
Vegetative Surfaces	± 0.30 ft
Minimum order of accuracy for GNSS Base Station horizontal (H) and vertical (V) project control	H ≤ 0.07 ft V = 3rd Order
Local Transformation Point and Validation Point surveyed positional accuracy requirement	H ≤ 0.06 ft V ≤ 0.04 ft
Local transformation points maximum stationing spacing throughout the project	Must support surface accuracy requirements
Validation point maximum stationing spacing throughout the project	Must support surface accuracy requirements
Point Density	Airborne = ≤ 5 points/feet^2 Mobile = ≤ 20 points/feet^2

IX. SPECIFICATIONS AND REQUIREMENTS FOR MAPPING

Work covered in this document shall include furnishing the professional, technical, and other personnel necessary to perform photogrammetric services for the project. The services shall address the following:

1) **Project Limits.** The mapping will be performed within the limits that are graphically marked and indicated on the COMMISSION provided Google Earth *.kmz file(s).

2) **Topography.** The mapping data shall include natural positions on the earth's surface within the project limits that determine the configuration of the terrain. The positions will be in the form of points and strings that locate vertical and horizontal transitions.

3) **Planimetry.** The mapping data shall include the positions of all natural and all man-made features within the project limits. The positions will be in the form of points and strings that define the shape, size and position of the features.

4) **Position Definition.** All positions mapped shall be defined by their unique identifier, coordinate value and feature code. These values are referenced to the aforementioned systems and datum. These are expressed in the format of:

   - Identifier = Point number
   - Coordinate value = X (easting), Y (northing), Z (elev.)
   - Feature code = Number

5) **Feature Codes.** Position description will be derived from the *MoDOT Surveying Feature Codes*. These codes shall be used on all mapped positions.

6) **Standards.** The CONSULTANT shall comply with the most recent and applicable State and Federal Laws. Procedures and criteria shall be determined in accordance with any applicable portions of the Missouri Department of Transportation Engineering Policy Guide, Section 238.1 "*Aerial Mapping and LiDAR Surveys*."

7) **Deliverables.** The CONSULTANT shall provide mapping data in the digital formats set forth in this document's Specifications for Deliverables and its associated appendix.

8) **Data Quality**. The CONSULTANT shall be responsible for the professional quality, technical precision and the coordination of data, documents and other services furnished for this project. The CONSULTANT shall, without additional compensation, correct or revise any errors or deficiencies in the delivered services and information.

9) **Additional Services.** The COMMISSION reserves the right to request additional work beyond the scope of services addressed in this document. In this event, a supplemental agreement shall be executed and approved prior to the performance of additional services. Changes in compensation will be addressed in the supplemental agreement.

10) **Documentation.** The CONSULTANT shall provide any documentation necessary to explain, support and clarify the procedures used for data development. After map compilation has been completed, the CONSULTANT shall be available to the COMMISSION to discuss and interpret provided data.

11) **Data Ownership.** All data and documents prepared in performance of this Scope of Services shall be delivered to and become the property of the COMMISSION upon suspension, abandonment, cancellation, termination, or completion of the CONSULTANT'S services.

X. SPECIFICATIONS AND REQUIREMENTS FOR BOUNDARY SURVEYING

1) The CONSULTANT shall be responsible for all the following boundary surveying services within the project limits for the following projects:

   a. CONSULTANT shall be responsible for collection and verification of all land corners, registered or non-registered with the Department of Agriculture's Land Survey Program within the project corridor.

b. CONSULTANT shall be responsible for establishing a certified land corner at a minimum of one per mile within the project limits.

c. CONSULTANT shall be responsible for establishing all existing horizontal alignments owned or maintained by state, county and local municipalities within limits shown.

d. CONSULTANT shall be responsible for establishing all existing boundaries (right of way and permanent easements) owned or maintained by state, county or local municipalities within project limits.

e. CONSULTANT shall be responsible for establishing all existing property boundaries adjoining the highway corridor.

f. CONSUTLANT shall be responsible for establishing all USPLSS lines within the project limits.

g. CONSULTANT shall be responsible for establishing a tie station to the right of way centerline at the beginning of the project and an established section corner, and label all Section, ¼ and ¼ ¼ lines within the new right of way.

h. CONSULTANT shall be responsible for obtaining deeds and title work as needed.

i. CONSULTANT shall provide to the COMMISSION all adjoining property owner's information along adjacent State Route within the project limits.

j. CONSULTANT shall be responsible for preparing legal descriptions for property acquisition based on design plans.

k. CONSULTANT shall be responsible for preparing, signing and sealing all legal description 'Exhibit A' used in the acquisition deeds.

l. CONSULTANT shall be responsible for preparing a Location Survey Plan for the project corridor.

m. CONSULTANT shall provide temporary staking of COMMISSION boundaries (right of way and permanent easement) for negotiation purposes and utility movement.

n. CONSULTANT shall monument the COMMISSION's final boundaries (right of way and permanent easement) within four weeks of request from MoDOT.

o. CONSULTANT shall monument the final COMMISSION'S boundary breaks at each project location with a 5/8-inch (#5) rebar having a length of 24 inches. Rebar shall contain a 2-inch aluminum cap with the following designation stamped on cap MODOT, PLS number of the responsible surveyor, and a define datum point. See MoDOT EPG Category 238.2 Land Surveying for further additional.

p. CONSULTANT shall be responsible for the acquisition and installation of white 6 ft carsonite post witness to be installed at each monument location. Carsonite post shall contain a Boundary Marker decal. See MoDOT EPG Category 238.2 Land Surveying for further additional.

q. CONSULTANT shall prepare the final Location Survey Plan for each project site and submit to MoDOT for review prior to filing with the County Recorder of Deeds Office. Upon the completion of MoDOT's review and any corrections the consultant shall have four weeks to record a certified copy with the County Recorder of Deeds Office.

2) The CONSULTANT shall be responsible for all the following boundary surveying services within the project limits for the following projects:

   a. CONSULTANT shall be responsible for establishing all existing horizontal alignments owned or maintained by state, county and local municipalities within limits shown.

   b. CONSULTANT shall be responsible for establishing all existing boundaries (right of way and permanent easements) owned or maintained by state, county or local municipalities within project

limits.

The aforementioned Boundary Surveying services shall comply with the most recent Missouri Standards for Property Boundary Surveys set forth in the Missouri Revised Statues Chapter 327 and Chapter 60, Code of State Regulations - 20 CSR 2030, and any applicable portions of the Missouri Department of Transportation's Engineering Policy Guide (EPG) Category 238 Surveying Activities. Property descriptions and title work shall be in accordance with MoDOT EPG Category 236.4 Property Descriptions and Titles.

XI. SPECIFICATIONS AND REQUIREMENTS FOR CONVENTIONAL COLLECTION OF TOPOGRAPHY, PLANIMETRY, AND UTILITIES

1) The CONSULTANT shall provide the COMMISSION this additional data in modified state plane coordinates using the projection factor for the project as described in section *IV. Specifications and Requirements for Project Control Survey*, subsection *(9) Projection Factor.*

2) The CONSULTANT shall provide the COMMISSION this additional data in accordance with section *X. Specifications and Requirements for Mapping,* subsections *(2), (3), (4), and (5).*

3) The CONSULTANT shall provide the COMMISSION this additional data in accordance to MoDOT's EPG 238.3 Route Surveying Policy.

4) The CONSULTANT shall include this additional data in the final terrain model and graphics (mapping) development.

http://epg.modot.mo.gov/index.php?title=238.3_Route_Surveying

XII. SPECIFICATIONS AND REQUIRMENTS FOR PROJECT CONTROL DELIVERABLES

The CONSULTANT shall provide to the COMMISSION the following items:

1) ASCII or CSV coordinate files containing the following information: (1) primary and secondary control, (2) vertical control, (3) local transformation

control, (4) validation control, (5) geodetic control, (6) boundary survey, and (7) topography and planimetric data for the project survey. These files are:

a. Primary & Secondary Control File. A file listing control positions by point number, X, Y, and Z values in project units referenced to the Missouri Coordinate System of 1983, Zone Name. This ASCII formatted file shall be named **JobNumber_Control_Pt.ctl** with specifications for file setup in Appendix A, Item 1.

b. Vertical Control (benchmark) File. A file listing the benchmark position by point number, X Y values in project units referenced to the Missouri Coordinate System of 1983, Zone Name. This ASCII formatted file shall be named **JobNumber_Vertical _Pt.ctl**

c. Local Transformation (target) Control File. A file listing control positions by point number, X, Y, and Z values in project units referenced to the Missouri Coordinate System of 1983, Zone Name. This ASCII formatted file shall be named **JobNumber_Local-Transformation_Pt.txt** with specifications for file setup in Appendix A, Item 2.

d. Validation (check) Point File. A file listing verification of control positions by point number X, Y, and Z values in project units referenced to the Missouri Coordinate System of 1983, Zone Name. This ASCII formatted file shall be named **JobNumber_Validation_Pt.txt** with specifications for file setup in Appendix A, Item 3

e. Geodetic Control File. A file containing latitude and longitude information for all control points named **JobNumber_Geodetic.txt** with file format listed in Appendix A, Item, 4.

f. Boundary Survey File. A file containing all the existing field evidence collected.

2) All OPUS solution sheets and/or data sheets from post processed static GNSS sessions, calculations for grid and projection factor including the centroid point, mean elevation and the final grid and projection factor will also be listed in this file. An example of this file is shown in Appendix A, Item 5.

3) Field Notes and Sketches. Description of monumentation and a sketch of each point shall be provided showing the relative location of field ties to the point being referenced.

4) Surveying Records. CONSULTANT shall provide the following surveying information on each project.

5) GNSS (static, fast static, RTK) control network records, raw data adjustment reports.

   a. Vertical control (leveling) records, raw data files (if applicable), and adjustment reports

   b. Statistical analysis reporting for all project control.

   c. All survey controller files (Trimble ##.job, Topcon ##.mjf, Carlson ##.crd, Carlson ##.raw, etc.) and any other RAW data files.

6) MoDOT Survey Report. A survey report for each project certified by a Professional Land Surveyor that all required surveying specifications have been achieved for this project.

   a. Scanned documents and facsimile copies are not considered legal documents, and therefore will not be permitted as a deliverable for this report. An original copy of the report shall be signed and sealed using an ink seal, rather than an embossing seal. The signature must go through the seal and must be dated. The Consultant may submit an electronic version of this report provided it meets all the requirements for digital signatures in accordance with state statute 20 CSR 2030-3.010. An example of a digitally signed and sealed document is

provided in Appendix D.

http://www.sos.mo.gov/adrules/csr/current/20csr/20c2030-3.pdf.

7) A MicroStation Design (*.dgn) file with all survey control points plotted and labeled.

XIII. SPECIFICATIONS AND REQUIRMENTS FOR AIRBORNE PHOTOGRAPHY DELIVERABLES

The following materials shall be delivered to and shall become the property of MoDOT:

1) A copy of the camera calibration report or a statement of compliance.

2) An orthomosaic captured simultaneously with LiDAR or separate aerial sensor, meeting the following requirements:

   a. Shall have a resolution of 3 inch per pixel.

   b. Shall encompass the area requested for mapping.

   c. Shall include a shape file indicating the locations of the orthomosaic tiles.

   d. Shall be delivered in both Missouri State Plane NAD83(NSRS2011), Epoch 2010 and Modified State Plane (project projection applied).

   e. Missouri State Plane projected orthomosaic geotiff files shall contain the appropriate geospatial header information. *(Missouri State Plane NAD83 (NSRS2011), Epoch 2010 horizontal datum and the NAVD88 vertical datum in US survey feet.)*

XIV. SPECIFICATIONS AND REQUIRMENTS FOR AIRBORNE AND TERRESTRIAL LIDAR DELIVERABLES

The following materials shall be delivered to and shall become the property of MoDOT:

1) For any LiDAR project, the following shall be delivered:

   a. Data will be delivered in LAZ version 1.2 format or newer with the following information.

      i. Record return

      ii. Intensity

      iii. GPS time

      iv. Swath line number designation

      v. Classification values after trimming (without data voids between swath lines) per the American Society for Photogrammetry and Remote Sensing (ASPRS) standards for LAS format 1.2.

      https://www.asprs.org/a/society/committees/standards/asprs_las_format_v12.pdf

      0 = raw, never classified

      1 = unclassified

      2 = ground (i.e. bare earth)

      3 = low vegetation

      4 = medium vegetation

      5 = high vegetation

      6 = building

      7 = low point

      9 = water

      10 = bridge

      12 = overlap

b. LiDAR Processing Report.

c. Vertical Accuracy Report.

d. A shape file containing numbered LAZ tiles.

e. LAZ file size shall not exceed 100 MB.

f. Each LAZ file shall be named to include the MoDOT required information. The text shall be placed from left to right in the following order.

   i. Project number (i.e. J1P3452).

   ii. The unique tile number (tiles are numbered in sequence). The first tile shall be labeled as number one (1), with each succeeding tile having a number one greater than the tile before it.

g. Each LAZ files shall be delivered in both Missouri State Plane NAD83(NSRS2011), Epoch 2010 and Modified State Plane (projection factor applied)

h. Each LAZ file projected to the Missouri State Plane coordinate system shall contain the appropriate geospatial header information. *(Missouri State Plane NAD83(NSRS2011), Epoch 2010 horizontal datum and the NAVD88 vertical datum in US survey feet.)*

2) **Terrestrial Photographic Imagery**. All photo imagery shall be delivered in .jpeg format.

3) **Terrestrial Mobile LiDAR Quality Control (QC) Report.** The QC report shall list the results of the TML including but not limited to the following documentation:

   a. The GNSS/IMU post-processing accuracy report should contain the following from the GNSS/IMU post-processing software:

i. The location coordinates, datum, vertical datum, and epoch data of the GNSS base station used for GNSS/IMU post-processing.

ii. Number of satellites

iii. Solution status plot

iv. GNSS baseline distance plot

v. Best estimate post-processed position and orientation error estimate plot

vi. Forward/Reverse Separation plot. Separation of forward and reverse solutions (difference between forward and reverse post-processed XYZ positions solution). Forward and reverse refers to time: processing from beginning-to-end and end-to beginning.

vii. Narrative on location(s) with large error and migration if applicable.

b. Registration Report

i. Adjustments (horizontal and vertical) made to the TML point cloud

ii. If cloud-to-cloud registration was performed, the reference cloud and the adjustments made should be provided.

iii. Average magnitude and standard deviation errors of ground controls and adjustment if available.

c. QC report on the registered point clouds

The Control report should contain the following:

i. Table showing the delta Z and/or delta XY differences between validation target points and TML registered point cloud

ii. Comparison of elevation data from overlapping (side-lap) runs

iii. Comparison of points at the area of overlap (end-lap) if more than

one GNSS base station is used for the project.

iv. Statistical comparison of registered point cloud data and validation points from conventional survey. The ground truth survey shall be independent of the target control survey and utilize the same horizontal and vertical constraints.

v. Average, minimum and maximum dZ for each run (optional)

vi. Narrative of QC methods employed and their results.

XV. SPECIFICATIONS AND REQUIRMENTS FOR COMPILATION DELIVERABLES

The CONSULTANT shall provide to the COMMISSION the following items:

1) Provide a **JobNumber_SurveyGraphics.dgn** (3D MicroStation design file) of all the topographic survey data collected.

   a. All MicroStation design (*.dgn) files will be based on modified state plane coordinates, using the projection factor for the project as described in section *IV. Specifications and Requirements for ProjectControl Survey*, subsection *(9) Projection Factor.*

   b. Working units: U.S. Survey Foot

   c. Features shall be annotation aware according to MoDOT CADD Standards. Standards are available in the *MoDOT_Workspace\Standards\Dgnlib* which is made available through the department's internet web site at:

      https://www.modot.org/cadd-environment

2) The CONSULTANT shall provide the COMMISSION the following additional items in modified state plane coordinates.

   a. PowerGEOPAK SS4 or SS10 Existing Terrain model and geometry.

   b. PowerGEOPAK SS4 or SS10 Existing Terrain model for the entire

project within the .dgn file containing the existing geometry. Any merging of terrain models shall be checked for ambiguities and corrected to ensure accurate merging of the terrain models.

c. A file containing all the geometry and features extracted from the aerial and terrestrial LiDAR and photogrammetry. This ASCII formatted file shall be named ***JobNumber_Topo.txt***

3) **Map Files.** All map files shall conform to the department's standards as specified in the MoDOT Engineering Policy Guide and the MoDOT MicroStation® CADD Standards, which are available from the department's internet site as a download package at:

https://www.modot.org/cadd-environment

XVI. SPECIFICATIONS AND REQUIRMENTS FOR BOUNDARY DELIVERABLES

The CONSULTANT shall provide to the COMMISSION the following items:

1) Provided a design file named **JobNumber_Boundary.dgn** (2D MicroStation design file) containing the existing right of ways, permanent easements, adjoining property boundaries, and all USPLS boundaries (section, ¼ section, ¼ ¼ section, etc.) within the project limits.

2) Provide information on all certified land corner found or established within the project limits.

3) Provide a signed and sealed copies of an Exhibit A legal description for each tract of land being acquired by the COMMISSION.

4) Provide an Acrobat Adobe electronic version (.pdf) of the Location Survey Plan.

5) Provide an original recorded copy of the Location Survey Plan from the County Recorder of Deeds Office.

6) Copies of all documentation (deeds, sub-sequent surveys, field notes, etc.) and field survey controller (data collector) files related to executing the boundary survey.

XVII. ACCEPTANCE OF COMPLETED WORK

1) The CONSULTANT shall submit all completed work promptly to allow time for proper review. Work reviewed and found in accordance with the specifications shall be considered to constitute “satisfactorily completed and accepted work”.

2) The Missouri Department of Transportation will determine which photography work is in accordance with these specifications and represents acceptable work. Failure to produce acceptable work as specified, and after the CONSULTANT has exercised the right to verify the quality of the work will cause the following:

3) The Missouri Department of Transportation may reject that portion of the work and the CONSULTANT will accept a hundred (100) percent reduction in payment, at the agreement price, for the affected portions of work.

4) In the event that some work is found to be unacceptable in accordance with the specifications, and reworking is deemed necessary, the CONSULTANT agrees that it shall re-collect such work without expense to the Missouri Department of Transportation, even though final payment may have been received. The CONSULTANT shall give immediate attention to these changes so there will be a minimum delay. The above and foregoing is not to be construed as a limitation of the Missouri Department of Transportation right to seek recovery of damages for negligence on the part of the CONSULTANT.

5) **Return of Source Data**: The CONSULTANT shall return to the COMMISSION all the provided source data, including, all airborne photographs and maps.

6) **Data Quality**. The CONSULTANT shall be responsible for the professional quality, technical accuracy and the coordination of data, documents and other services furnished for this project.

7) **Additional Services**. The COMMISSION reserves the right to request additional work beyond the scope of services addressed in this document. In this event, a supplemental agreement shall be executed and approved prior to the performance of additional services. Changes in compensation will be addressed in the supplemental agreement.

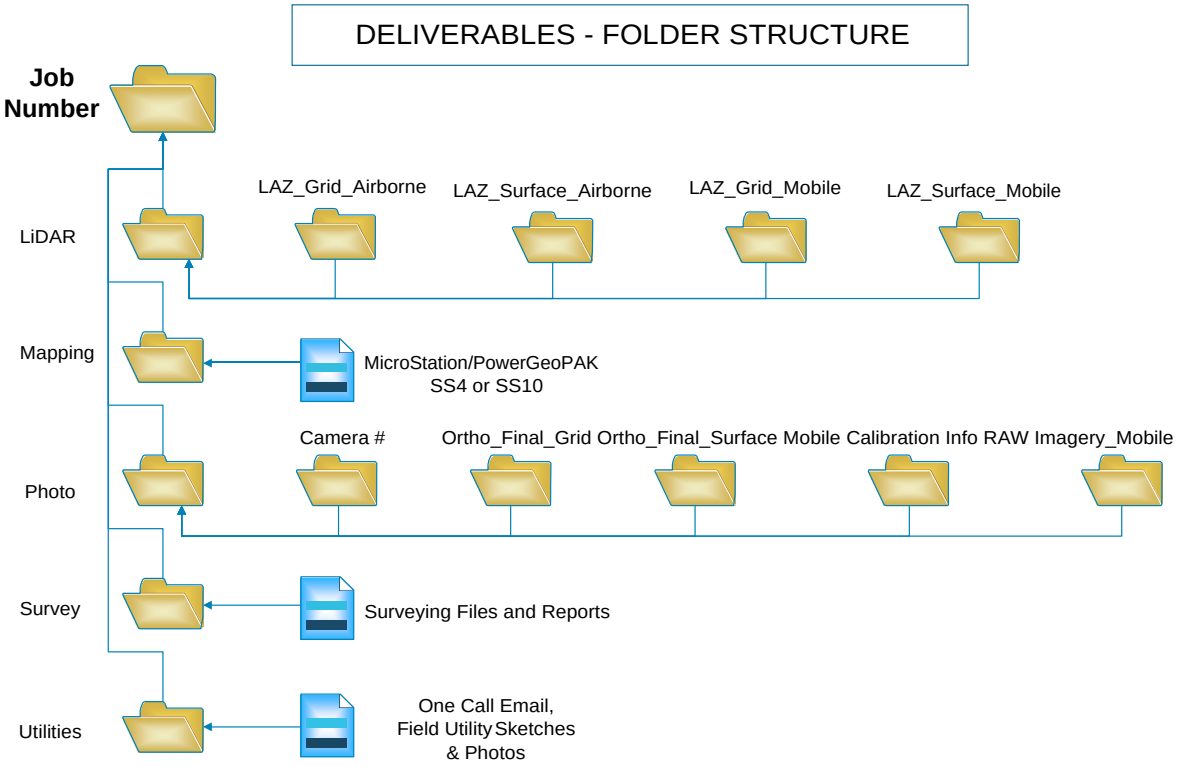
8) **Documentation**. The CONSULTANT shall provide any documentation necessary to explain, support and clarify the procedures used for data development. The CONSULTANT shall be available to the COMMISSION to discuss and interpret provided data.

9) **Data Ownership**. All data and documents prepared in performance of this Scope of Services shall be delivered to and become the property of the COMMISSION upon suspension, abandonment, cancellation, termination, or completion of the CONSULTANT'S services.

10) **Invoices and Payments.** Payment to the CONSULTANT for the photogrammetric surveying and engineering deliverables shall not be made until all the map files for the project have met the satisfaction of the department.

XVIII. DELIVERABLES AND FILE MANAGEMENT

The CONSULTANT shall furnish all the project files on an external hard-drive media. Each job (project) number shall include a read-only submittal form in Adobe Acrobat (PDF) file format describing the contents including project name, survey deliverables, photography deliverables, LIDAR deliverables, and all mapping files. This file shall be named ***JobNumber_Submittal.pdf*** and be in the project subfolder. For the CONSULTANT convenience, a submittal form has been provided in *Appendix C.*


DELIVERABLES - FOLDER STRUCTURE
Job Number
LiDAR
LAZ_Grid_Airborne
LAZ_Surface_Airborne
LAZ_Grid_Mobile
LAZ_Surface_Mobile
Mapping
MicroStation/PowerGeoPAK SS4 or SS10
Photo
Camera #
Ortho_Final_Grid
Ortho_Final_Surface Mobile
Calibration Info
RAW Imagery_Mobile
Survey
Surveying Files and Reports
Utilities
One Call Email, Field Utility Sketches & Photos

XIX. SCHEDULE AND DELIVERY

1) All mapping, including flow lines for all storm sewers shall be received no later than March 8, 2022.

2) All property ownership information and property lines April 18, 2022.

3) Boundary Deliverables starting October 1, 2022.

4) **Extensions.** The COMMISSION will grant time extensions for unavoidable delays beyond the control of the CONSULTANT. Requests for extensions of time shall be in writing by the CONSULTANT, before deliverables are due stating fully the reasons for the request.

SERVICES PROVIDED BY THE COMMISSION

The COMMISSION will provide available information of record to the CONSULTANT as well as:

1. Project location and limit for acquisition and mapping shall be provided using a .kmz (Google Earth) file format or MicroStation .dgn file format.
2. Access to the MoDOT Real Time Network (RTN) and 1 second data for post process flight data.
3. Access to the MoDOT Engineering Policy Guide 238.1 Aerial Mapping and LIDAR Surveys.

   http://epg.modot.mo.gov/index.php?title=238.1_Aerial_Mapping_and_LiDAR_Surveys
4. Access to the NCHRP (National Cooperative Highway Research Program, No 748, Guidelines for the Use of Mobile LiDAR in Transportation Applications.

   http://www.trb.org/main/blurbs/169111.aspx
5. As-built roadway plans for the project corridor to serve as an aid to the consultant for locating drainage structures.