AASHTO

American Association of State Highway and Transportation Officials













AASHTO GUIDELINES FOR UNMANNED AIRCRAFT SYSTEMS (UAS)

Applications for Bridge Inspections: Element-Level Data Collection



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AASHTO

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DISCLAIMER

All recommendations and guidelines set forth in this document are not intended to replace, recommend changes to, or provide exemption or exclusion to the federal requirements pertaining to any inspection type or description in the National Bridge Inspection Standards (NBIS) Title 23 CFR § 650 Subpart C (23 CFR 650C) (NBIS, 2023) and the referenced materials therein.

These Guidelines are intended as a supplement to safely and effectively operate UAS for the purposes of collecting element-level data in accordance with NBIS bridge inspections. Recommended UAS techniques and procedures are included as a resource for bridge inspection personnel. Other methods and means of access may exist that are more suitable for an inspection to evaluate the bridge condition. Information in these Guidelines is not intended to promote one access method over another, only to describe means of UAS access, if applicable. In accordance with NBIS, a qualified team leader is required on site at all times to oversee a bridge inspection per 23 CFR 650.313(J). Per 23 CFR 650.305, a team leader is, "in charge of an inspection team and responsible for planning, preparing, performing, and reporting on bridge field inspections" (NBIS, 2023). Therefore, the team leader is responsible for the evaluation of the bridge condition regardless of the data collection method or means of access, including UAS.

UAS Implementation Essential Information

- 23 CFR 650 Subpart C National Bridge Inspection Standards (NBIS) governs all bridge inspection activities on the National Highway System. The *Manual for Bridge Evaluation* further defines bridge inspection requirements as referenced by NBIS (AASHTO, 2022). The *Manual for Bridge Element Inspection* (AASHTO, 2022) and the *Bridge Inspector's Reference Manual* (Ryan et al., 2022) further define recommended element-level condition states and inspection procedures, respectively.
- A qualified team leader is required to always be on site for a bridge inspection.
- Element data collected during a bridge inspection must be reviewed by a qualified inspector.
- UAS are intended to supplement an inspection access plan and additional investigation at arm's length may be required to obtain condition states and measurements.
- All commercial pilots are required to have an FAA Part 107 Certification and comply with current FAA regulations.
- Flying UAS near bridges is hazardous and should be performed by proficient pilots.
- Many UAS are commercially available, however, certain airframes may be more suitable for bridge inspections. Remote pilots should be aware of the limitations and operational parameters of their UAS before conducting a bridge inspection. The safety of a UAS mission is the responsibility of the Part 107-certified remote pilot.

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ACRONYMS & ABBREVIATIONS

AASHTO = American Association of State Highway and Transportation Officials
AGL = Above Ground Level
ATC = Air Traffic Control
AOI = Area of Interest
ATC = Air Traffic Control
AUVSI = Association for Uncrewed Vehicle Systems International
BIRM = *Bridge Inspector's Reference Manual* (FHWA)
BVLOS = Beyond Visual Line of Sight
COA = Certificate of Authorization
CFR = Code of Federal Regulations
DIU = Defense Innovation Unit
DOT = Department of Transportation
FAA = Federal Aviation Administration
FAR = Federal Aviation Regulations
FF1 = Form Factor 1 UAS
FF2 = Form Factor 2 UAS
FHWA = Federal Highway Administration
FLIR = Forward-Looking Infrared
GPS = Global Positioning System
LAANC = Low Altitude Authorization and Notification Capability
MBE = *Manual for Bridge Evaluation* (AASHTO)
MBEI = *Manual for Bridge Element Inspection* (AASHTO)
METAR = Meteorological Aerodrome Reports
MOT = Maintenance of Traffic
NAS = National Airspace System
NBI = National Bridge Inventory
NBIS = *National Bridge Inspection Standards* (FHWA)
NDAA = National Defense Authorization Act
NM = Nautical Mile
NOTAM = Notice to Airmen
NM = Nautical Mile
NPRM = Notice of Proposed Rulemaking
NSTM = Non-Redundant Steel Tension Member
OEM = Original Equipment Manufacturer
Remote pilot = Remote Pilot in Command (as defined by FAA)
RA = Risk Assessment
RTH = Return to Home

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Section 1:
INTRODUCTION

1.1—BACKGROUND AND INTENT OF THE GUIDELINES

Unmanned aircraft systems (UAS) are an ideal tool for supplementing bridge inspections for their ability to collect visual information in areas that are challenging to safely and economically access. The continued technological advances and adaptation for a wide range of applications has positioned this technology as an incredible asset to the inspection industry. As with most new technology, adoption rates, standards for use, and operational procedures vary widely across the nation. Guidelines that address the specific application of UAS implementation for collecting element-level bridge data are necessary to ensure the quality of data collection and consistency among bridge owners. In combination with the AASHTO *Manual for Bridge Element Inspection* (AASHTO, 2019), these Guidelines provide direction for the standardization of UAS in the bridge inspection industry while ensuring that the data fidelity meets acceptance criteria.

These Guidelines are intended to be used by Departments of Transportation (DOTs), bridge Owner agencies, and other organizations for applying UAS to inspections to assess bridges using element-level condition states. The techniques and examples provided in these Guidelines will help remote pilots and inspectors perform visual inspection of a bridge using the UAS. UAS can be a powerful tool when used safely and effectively, as described in these Guidelines. The Guidelines are intended to serve as a roadmap for the effectual implementation of current and future UAS technologies during inspections to supplement data collection to be compliant with NBIS, given in Title 23 CFR § 650.301-317 (NBIS, 2023; see Section 7).

1.2—USING UAS AS A TOOL TO SUPPLEMENT CURRENT BRIDGE INSPECTION TECHNIQUES

Current practice for bridge inspections under AASHTO's *Manual for Bridge Evaluation,* Third Edition (MBE) (AASHTO, 2018) and the *Bridge Inspector's Reference Manual,* Second Edition, Chapter 2, specifies procedures for seven types of inspections (Ryan et al., 2022). Of these, routine and non-redundant steel tension member (NSTM) inspections are most common and are usually performed on a 24-month cycle unless specified more frequently. Per the Moving Ahead for Progress in the 21st Century Act (MAP-21), element-level data is cataloged throughout the structure while inspectors conduct these types of inspections (Moving Ahead for Progress in the 21st Century Act, 2012) (see Section 7 for all references).

The MBE states for routine inspections, "these inspections are generally conducted from the deck, from ground level and/or water level, and from permanent work platforms and walkways if present" (AASHTO, 2018). An NSTM (formerly fracture-critical member) inspection consists of "perform[ing] a hands-on inspection (inspection within arm's length of the component using visual or nondestructive techniques as required) of all NSTMs" (AASHTO, 2018). Due to these distinctions in requirements, UAS are **not permitted** to be used during a code-specified NSTM inspection. A possible exception could be the use of UAS to perform an off-cycle routine inspection of NSTMs between the mandatory NSTM inspection cycle. The use of UAS as a tool to access and inspect during routine inspections, or non-NSTMs, has many proven advantages and can be applied by these standards.

Ultimately, it is the team leader's responsibility to ensure quality data is obtained to satisfy the federal, state, and Owner requirements for safe operation of the bridge. Per CFR 650.313 (J), a team leader is required on site during inspection procedures, stating "provide at least one team leader at the bridge who meets the minimum qualifications stated in § 650.309 and actively participates in the inspection at all times during each initial, routine, in-depth, NSTM, underwater inspection, and special inspection…" (CFR 650.313 (J), 2022). The use of UAS must follow these regulations for safe application.

1.3—IMPLEMENTING AND SCALING THE USE OF UAS

UAS are steadily integrating into engineering and industry practices for DOTs. Implementation of the technology into existing workflows can improve efficiency, quality, and safety. Initial program considerations should include a phased approach to deployment versus immediate widespread adoption.

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Training and development should include thorough onboarding of new remote pilots (referenced as the remote pilot in command by the Federal Aviation Administration), visual observers (VO), and sensor operators (SO). The skills gained from operational experience can then be shared with new teams and the program scaled to meet the needs of the organization and workflows required for successful implementation.

These Guidelines present organizations with a framework for UAS implementation in bridge inspections. The intent is not to replace the inspector, but rather to enhance the inspector's capabilities with new tools and technology to improve access and reduce safety risks when used appropriately and responsibly. There are a multitude of practical applications where UAS can be used to gather data for an inspector's consideration. The team leader is ultimately responsible for a quality inspection meeting the Code of Federal Regulations requirements. The following Sections demonstrate a framework adhering to these requirements while also providing practical approaches for inspectors using UAS to consider.

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