EFCOG Best Practice # 266

Facility: Nuclear & Waste Management, Argonne National Laboratory

Best Practice Title: Unmanned Aerial Vehicles Unmanned Aircraft Systems Processes for U.S. Department of Energy Nuclear Facilities.

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Brief Description of Best Practice: Research conducted in coordination with Argonne National Laboratory, the U.S. Department of Energy Office of Aviation Management, and the Federal Aviation Administration confirm use of small Unmanned Aerial Vehicles and Unmanned Aerial Systems (small drones) and unmanned free balloons can be screened from Hazard Analysis and therefore excluded from Accident Analysis scenarios within the Documented Safety Analyses for Nuclear Facilities.

Why the best practice was used: The use of small Unmanned Aerial Vehicles and Unmanned Aerial Systems (small drones) is on the rise for both recreation and countless commercial applications in the public and private sector. Drones can provide a unique cost-effective means for conducting research, while minimizing personnel, and maximizing safety. In the public sector, this can translate to a significant savings for the taxpayer. Included in these applications are the operation of small Unmanned Aerial Vehicles and Unmanned Aerial Systems (small drones) operations in the proximity and in collocation with U.S. Department of Energy Nuclear Facilities. Argonne National Laboratory has elected to use small drones to conduct environmental research and infrastructure inspection over the site. A systemic evaluation was conducted to ensure operation of small drones and unmanned free balloons in proximity to Nuclear Facilities would not negatively impact the Safety Basis of existing Nuclear Facilities.

What are the benefits of the best practice: Small drone and unmanned free balloon operation at Argonne National Laboratory is now considered a routine operation for the laboratory constituting no measurable hazard to a Nuclear Facility. Thus, such operation does not represent a hazard that would impact existing Documented Safety Analysis assumptions regarding hazardous materials or parameters affecting rates of release of hazardous materials from a nuclear facility event or operation.

What problems/issues were associated with the best practice: Size, weight, height, and speed of drones and unmanned free balloons can vary and may be challenging to regulate. Size may be bounded by DOE restrictions and implemented by procedures at a site. The use of drones at DOE sites is regulated by the Federal Aviation Administration (FAA), the Department of Energy (DOE) Aviation Management (OAM), and site policies and procedures.

How the success of the Best Practice was measured: Argonne National Laboratory analyzed small drone and unmanned free balloons operations to demonstrate that specific activities, such as environmental research and infrastructure inspection over the site could be screened from Hazard Analysis and therefore excluded from Accident Analysis scenarios within the Documented Safety Analyses for existing Nuclear Facilities.

Description of process experience using the Best Practice: See Attached.

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– Attachment – D. Bush

Introduction

DOE sites may include civil and public operations of UAS and UAVs, aka drones. Operation of drones in public airspace is governed by 14 Code of Federal Regulations (CFR) Part 107 for civil operations and by the Certificate of Authorization and Waiver (COA) 2019-AHQ-907-COA-REVISED (Blanket Public COA) for public operations. 14 CFR Part 107, like any regulation, may be revised or interpreted by the FAA at any time by rulemaking, advisory circulars, or other clarifications. Modifications of the Blanket Public COA require approval by the FAA. The local DOE field office maintains the Blanket Public COA and will request approval from the DOE OAM when modifications to the COA are necessary.

New activities at Argonne National Laboratory (Argonne) utilize operation of the Prairie Hawk, SuperHawk, and Prairie Gull Pro Unmanned Aircraft Systems (UAS) in Class G airspace below 700' Above Ground Level (AGL) in the vicinity of Brookeridge Air Park under the jurisdiction of C90 - Chicago Terminal Radar Approach Control (TRACON). These UASs and Unmanned Aerial Vehicles (UAVs) have a mass of approximately nine (9)-pounds (lb.) and are collectively referred to as "small drones." Use of these small drones have been evaluated wholistically at Argonne. The Argonne analysis demonstrates that, even at terminal velocity a falling drone would not possess sufficient kinetic energy to penetrate the roof of existing nuclear facilities to the extent necessary to impact existing accident scenarios related to object impacts with nuclear facilities. With respect to fire initiation potential, the drones approved under the Federal Aviation Administration (FAA) authorizations contain no flammable materials (i.e. no fuel). Consequently a small drone impact into a nuclear facility does not represent a fire initiator.

At Argonne National Laboratory, the FAA has approved the use of small drones as a platform for environmental research and infrastructure inspection over the Argonne Site. Authorization to perform this research required coordination with the U.S. Department of Energy (DOE) Office of Aviation Management (OAM); approval from the FAA to safely integrate the operation of UAV and UAS into the National Airspace System; approval from the local DOE site office; and coordination with the Nuclear Waste Management Division Safety Basis Group. A Pilot-in-Command (PIC) is the person who has final authority and responsibility for the operation and safety of flight of UAV and UAS drones. An individual is designated as PIC before or during the drone flight, and holds the appropriate category, class, and type rating, for the conduct of the flight. The responsibility and authority of the PIC is further described and defined by 14 CFR 91, *General Operating and Flight Rules* Section 3. The PIC must maintain Responsibility and Authority of the UAV, UAS drone at all times. The PIC position may rotate duties as necessary with equally qualified pilots; this responsibility may change during flight. A signed and approved Job Safety Analysis must be completed either by a Contractor, Project Specialist, or a Technical Representative in association with drone activities.

Background

The use of drones, UAV, and UAS is on the rise for both recreation and countless commercial applications in the public and private sector. Use of UAV, UAS, and drones can provide a

unique cost-effective means for conducting research, while minimizing personnel, and maximizing safety. In the public sector, this can translate to a significant savings for the taxpayer. Included in these applications are the operation of small drone operations in the proximity and in collocation with U.S. DOE Nuclear Facilities.

This Best Practice was established to define and prescribe small drone operating requirements in the National Airspace System (NAS) for the purpose of environmental research and inspection of DOE infrastructure at Argonne. Operation of drones over the Argonne site is a new activity, not previously discussed in the Documented Safety Analysis (DSA) for Nuclear Facilities. However, the operation of the drones in association with the environmental research and infrastructure inspection activities have a limited mass (less than 9-lb) and contain no cargo identified as flammable material as part of routine operations. The Argonne drone operation is considered a "routine operation" for the laboratory constituting no measurable hazard to a nuclear facility. The analysis performed by Argonne establishes the framework to conclude small drone operations do not represent a significant hazard that could challenge the existing DSA assumptions regarding hazardous materials or parameters affecting rates of release of hazardous materials from a nuclear facility event or operation.

Defining Unmanned Free Balloons

A balloon is a lighter-than-air aircraft that is not engine driven, and that sustains flight through the use of either gas buoyancy or an airborne heater.

The procedures established at Argonne apply to unmanned free balloons that carry payloads as described in 14 CFR Part 101, *Moored Balloons, Kites, Amateur Rockets, and Unmanned Free Balloons*, Section 101.1(a)(4) (i.e., payload more than four (40-lb with weight/size ratio of more than three (3) ounces per square inch (oz/in^2); carries a payload that weighs more than six (6)-lb; carries a payload of two (2) or more packages weighing more than twelve (12)-lb; or uses a rope or other device for suspension of the payload that requires an impact force of more than fifty (50)-lb to separate the suspended payload from the balloon). Payloads of some units may weigh several hundred pounds with changes to the physical shape of the balloons at various altitudes/flight levels. The balloon and payload may ascend at a rate of 400 feet a minute (fpm). Once over the descent area, the payload is normally released from the balloon and descends by parachute at a minimum rate of 1,000 fpm. The balloon normally deflates automatically when the payload is released. The operator is required to advise Air Traffic Control (ATC) one (1) hour in advance of descent in accordance with 14 CFR Section 101.39,.

Some operators equipped balloons with transponder beacons in addition to radar reflection device or material required by 14 CFR Section 101.35. At cruise altitude the balloon's communications equipment and transponder, if so equipped, are operated intermittently to conserve battery energy.

Radar reflection devices use "flight follow" to track the flight of balloons to the extent that equipment capabilities permit. If radar "flight following" is not possible, tracking should be attempted by communication with the "chase plane," telephone contact with the operator, pilot, or ground observation reports.

Analysis Challenges

When analyzing systemic small drone activities across a U.S. DOE site, such as Argonne, the Safety Basis analyst must take into consideration parameters as outlined within 10 CFR 830, *Nuclear Safety Management*, especially in association with the review of a proposed activity in association with the Unreviewed Safety Question (USQ). Prior to the recent update to the Rule, quantification of an *implicit* reduction in the *Margin of Safety* was subjective and could not be definitively demonstrated. Even with a thorough analysis, an argument could be proposed for an implicit reduction in the *Margin of Safety* for a Nuclear Facility. Based on interpretations of legacy publications of 10 CFR 830, *Nuclear Safety Management*, the *Margin of Safety* to a Nuclear Facility can be reduced if the proposed activity has the potential to:

- Adversely affect protective barriers, physical process parameters, initial conditions, or initiating events leading up to or affecting the course of previously analyzed accidents not related to identified equipment important to safety.
- Impact implied redundancy, independence, response time, or failure points of systems, structures, or components not identified in the safety bases as equipment important to safety that can affect the course of previously analyzed accidents.
- Bypass or invalidate automatic activation features of systems not identified as important to safety that can affect the course of previously analyzed accidents.
- Reduce conservatism used in industry accepted practices or accident analysis assumptions, calculations, and models.

Historically, there have been five (5) accident events involving the operation of rogue drones at Argonne. Research conducted in association with the use of small drones across site-wide Argonne environmental research and infrastructure inspection operations were unable to uncover source documentation associated with the incidents. Accident conditions were reported to the appropriate authorities(DOE-OAM, FAA-FSDO, and local law enforcement), hostile intent cannot be easily assessed (i.e., malicious acts, espionage), and therefore cannot be evaluated as a part of a DSA.

The Small Airplane Directorate recently received a safety recommendation to address control actuation values for the control of emergency deflation systems required by 14 CFR Part 31, *Airworthiness Standards: Manned Free Balloons*, Section 55. This recommendation was prompted by a rough landing accident of a commercial Firefly 11 balloon. The accident balloon was equipped with a simple parachute vent (envelope valve) and rotational vents. The flight manual for the Firefly 11 states in windy conditions or in tight landing situations, the rotating vent may be used to supplement the envelope valve when deflating the envelope, just prior to and during final touch down. In a post-accident test, the 21 a-pound FAA inspector could not apply the force necessary to operate the rotating vent while simultaneously operating the envelope valve. The following guidance for control force is intended to prevent this situation in future balloon projects.

Balloons become derelict when a moored balloon slips its mooring and becomes a hazard to air navigation or when an unmanned free balloon flight cannot be terminated as planned.

Conclusion

Argonne National Laboratory has elected to use small drones and unmanned free balloons to conduct environmental research and infrastructure inspection over the site. A systemic evaluation was conducted to ensure operation of small drones in proximity to Nuclear Facilities would not negatively impact the Safety Basis of existing Nuclear Facilities. Although accidents have been reported in association with drone usage at Argonne, analysis demonstrates that, even at terminal velocity a falling drone would not possess sufficient kinetic energy to penetrate the roof of existing nuclear facilities to the extent necessary to impact existing accident scenarios related to object impacts with nuclear facilities.

Small drone (less than 9-lb) operation does not increase the magnitude or location of existing hazards, nor does it potentially affect equipment or administrative controls in place that diminish the probability of accidents currently postulated in Argonne DSA documentation and analysis. Therefore, small drone operation cannot increase the probability of an accident previously evaluated in the existing facility safety basis. The consequences of an accident are determined by the nature (type) of the accident, the energy released by the accident, the quantity of radioactive material potentially involved in the accident (material at risk), the release rate and degree of filtration, settling, and plate-out of the radioactive materials and hazardous chemicals, and the effectiveness and reliability of the mitigative structures, systems, or components (SSCs) and administrative controls.

By focusing on key areas in Nuclear Facility processes, significant success can be achieved in support of SSCs. The systems employed at Argonne incorporates approaches and lessons learned throughout industry with respect to UAV, UAS, and drone usage.

The use of small UAV/UAS (drones) is on the rise for both recreation and countless commercial applications in the public and private sector. Use of small UAV/UAS (drones) can provide a unique cost effective means for conducting research, while minimizing personnel, and maximizing safety. Drone operation at Argonne National Laboratory is now considered a routine operation for the laboratory constituting no measurable hazard to a Nuclear Facility.

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References:

- United States Dept. of Energy/Argonne National Laboratory, FAA FORM 7711-1 UAS COA, 14 CFR Part 91 and 107, FAA Order 8020.11
- Aircraft Accident and Incident Notification, Investigation, and Reporting Documented Safety Analysis (DSA), Technical Safety Requirements (TSRs) and, Unreviewed Safety Question (USQ)
- DOE-STD-3014-2006 "*Accident Analysis for Aircraft Crash into Hazardous Facilities*"
- 10 CFR 830 Subpart B "Nuclear Safety Management"
- Jeffrey Johnson, Chief of Defense Nuclear Safety, NNSA*, "Interim Guidance: Response to Unmanned Aerial Systems"* Memo to Distribution, 10 April 2015
- Aircraft Certification Service, ACE-I 00, 12/22/1999
- FAA Order JO 7110.65Z, Air Traffic Control, Special Flights, Unmanned Free Balloons
- 14 CFR 91, General Operating and Flight Rules