# Safeguarding Urban Air Mobility with Safe Operation Monitor: Ensuring Safety and Compliance for Machine Learning

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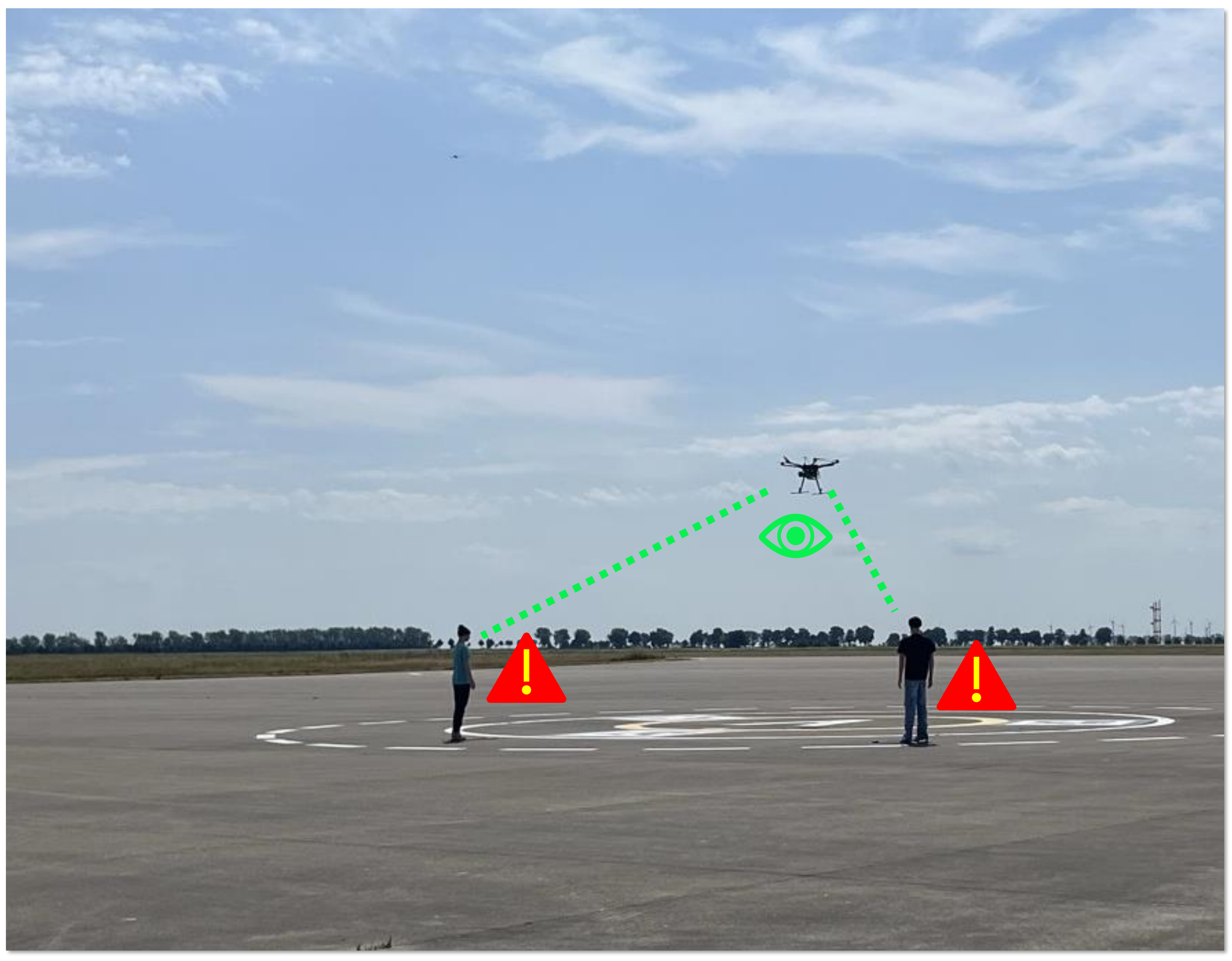
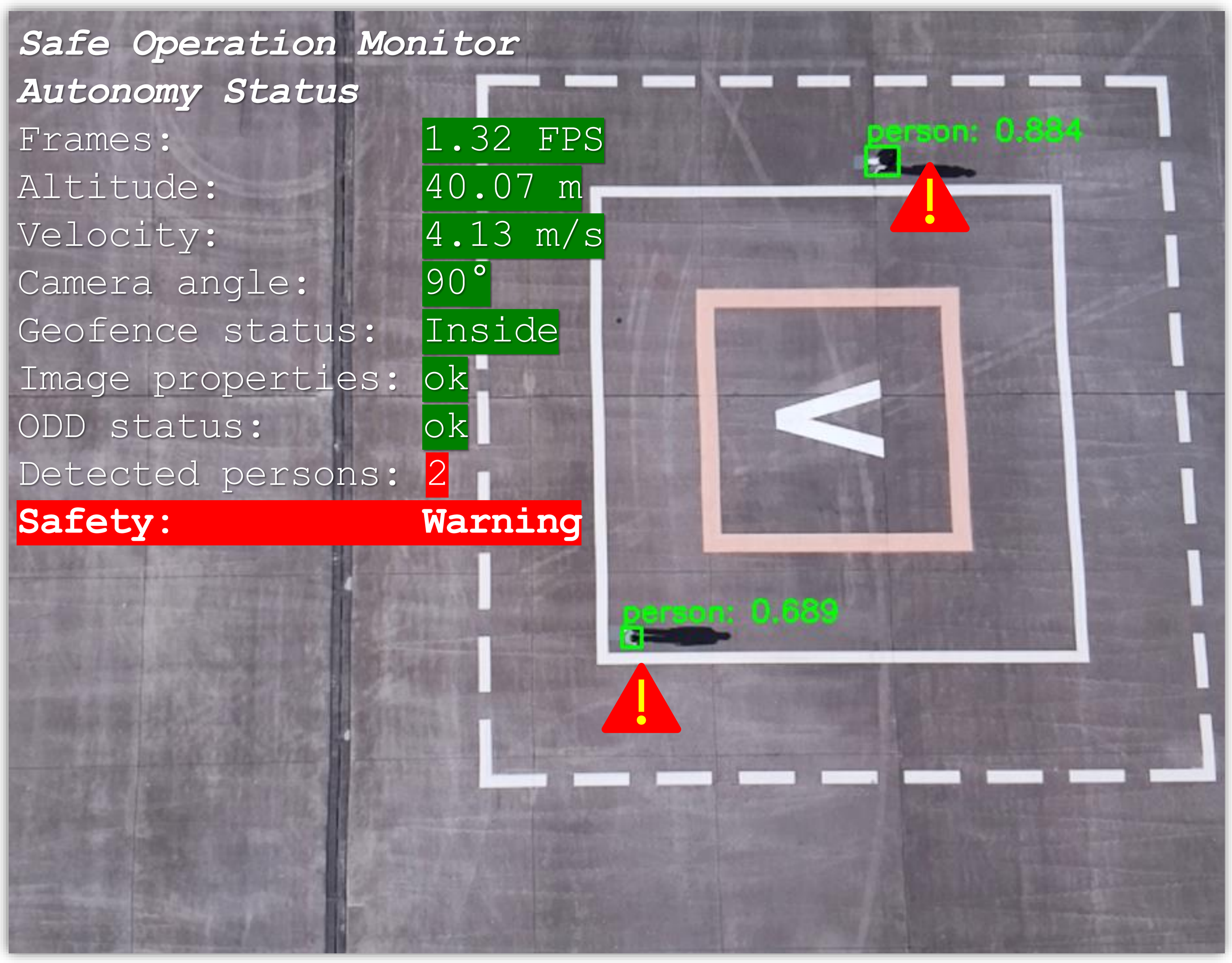





The drone is detecting and identifying potential risks during operation. Left: Two persons are detected during the landing on a vertidrome. Right: Onboard image of the drone with the ***Autonomy Status*** assessment and bounding boxes for the detected persons. The landing attempt is considered unsafe and aborted, since two persons have been detected.

## 1. Vision of Autonomy for UAM

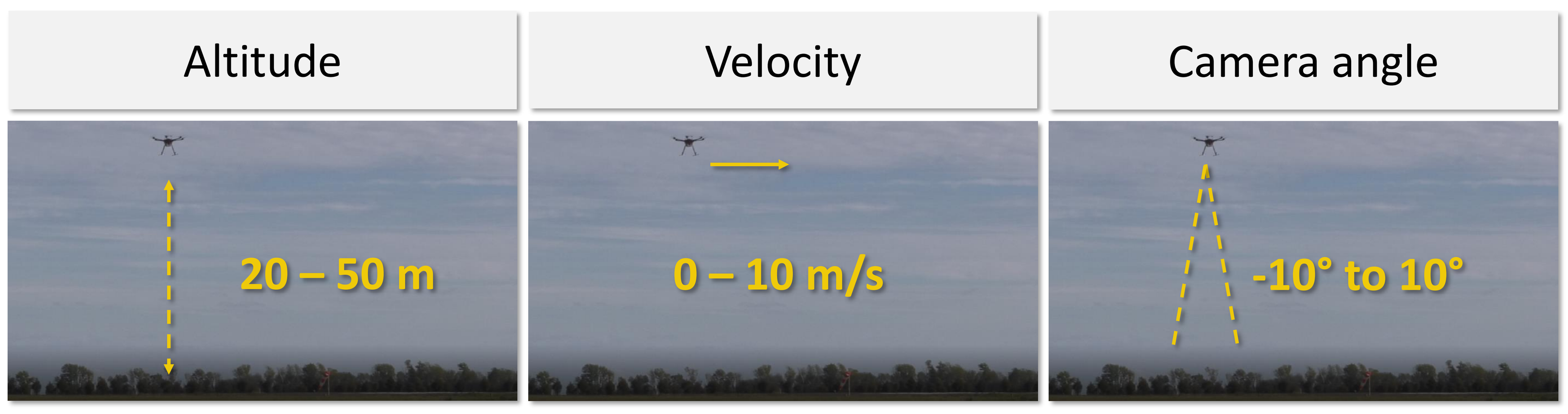
With Urban Air Mobility (UAM), autonomous air taxis are envisioned to work without pilots. Furthermore, drones for emergency goods, or even last mile deliveries are planned to fly autonomously to their destination. Without an onboard pilot, the autonomy itself must ensure safety of the operation. In this use case, a machine learning component is used to detect persons on the ground. If a person is detected on a vertidrome, any attempts to land are deemed unsafe.

### Challenges of Autonomy

Machine learning is often considered to be a black box, since the behavior is driven by data and not explicitly defined. Therefore, certification is a challenge. In 2021, EASA released first guidance on the certification of machine learning, specifically considering data aspects and operational aspects. This work package focuses on evaluation of the applicability of the EASA guidance document and selected certification objectives through the demonstration of a ***Safe Operation Monitor***. The monitor can safeguard the machine learning component and assess the risk of the operation.

## 2. Monitoring the Operational Design Domain

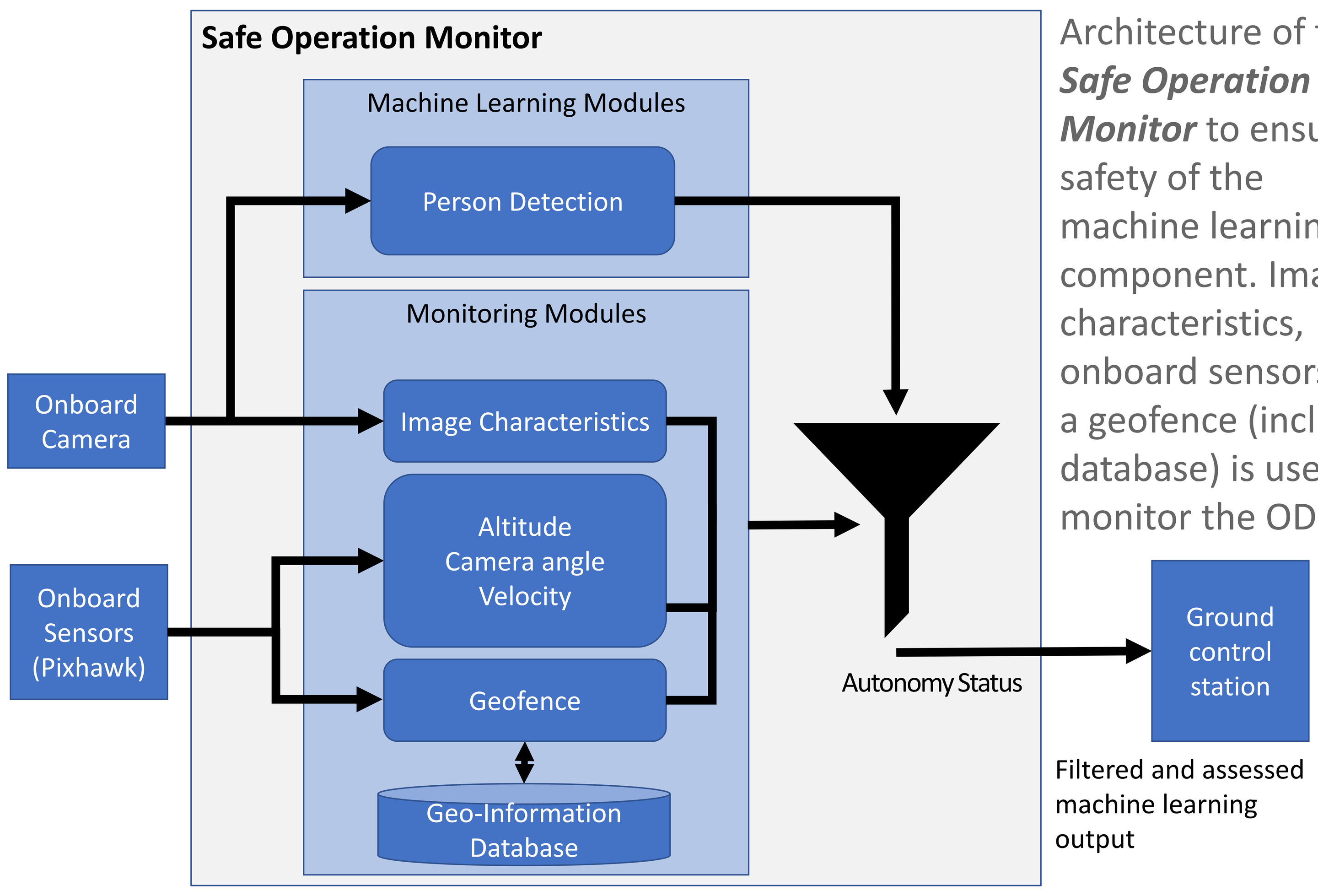
To assess machine learning safety, an ***Operational Design Domain (ODD)*** is defined. The ***ODD*** can be used to formalize operating conditions, in which the machine learning component is expected to operate without errors. The following picture shows three examples of ***ODD*** properties: altitude, velocity, and camera angle. Since the available training data was only specified in defined ranges, the machine learning component can only operate safely inside of these ranges.




Visual explanation of the concept of the ***Operational Design Domain (ODD).***

## 3. Save Operation Monitoring Architecture

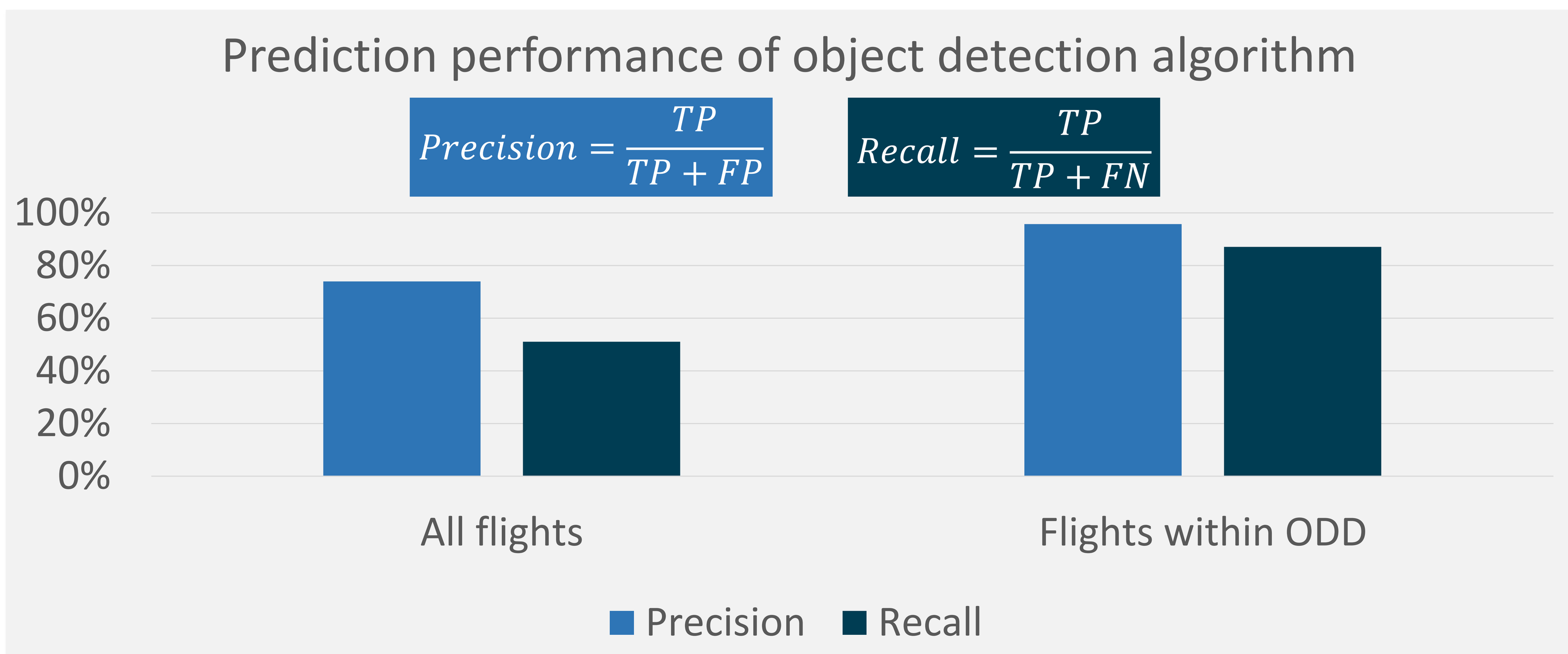
To ensure the safety of the operation, the ***ODD*** is continuously monitored. If any property of the ***ODD*** is violated, the machine learning component and the ***Autonomy Status*** is considered unsafe and corresponding results are not trusted.




Architecture of the ***Safe Operation Monitor*** to ensure safety of the machine learning component. Image characteristics, onboard sensors, and a geofence (including database) is used to monitor the ODD.

## 4. Evaluating the Safe Operation Monitor

A correct detection is called a true positive (TP), an incorrect detection is a false positive (FP), and a person that was not detected is called a false negative (FN). The machine learning performance for object detection tasks is measured with the ***Precision*** and ***Recall*** metrics. As a result, the ***ODD*** has a huge impact on the machine learning performance. Furthermore, the ***Safe Operation Monitor*** supports the safety of the operation.




Comparison of the machine learning performance: all flights versus only flights inside the ***ODD.*** Machine learning performance increases significantly, if ***ODD*** is monitored.

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More Information: **Ensuring Safety of Machine Learning Components Using Operational Design Domain**
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