Task 5: Summarize 3 Videos from SUAS 2023

1. Istanbul Technical University - ITUNOM UAV Team. (Winners)

- **Introduction:**

The ITUNOM UAV Team, based at Istanbul Technical University, consists of 25 dedicated members divided into four specialized sub-teams: avionics, software, mechanics, and PR. In this comprehensive report, the team delves into the intricate details of their UAV development, testing, and capabilities for the Student Unmanned Aerial Systems (SUAS) competition.

- **Team Structure:**

The team's structure is designed for efficiency and specialization, with each sub-team focusing on a crucial aspect of the project:

- The avionics team handles the UAV's electronic systems and avionics.
- The software team is responsible for developing the software for autonomous flight and mission control.
- The mechanics team ensures the mechanical aspects of the UAV are robust.
- The PR team manages communication and public relations.

- **Mission Objectives:**

For the SUAS competition, the team's primary mission objectives are as follows:

1. Autonomously complete the mission within 30 minutes.
2. Ensure the UAV's batteries remain within a safe margin.
3. Cover a 10-mile route with an average speed of 32 mph.
4. Successfully carry and drop five payloads.
5. Execute Object Detection, Localization, and Classification (ODLC) both safely and stably.

- **Key Technologies and Systems:**

➢ ***Positioning:*** The team employs an RTK system to enhance positioning accuracy, critical for waypoint capture and ODLC precision.

➢ ***Imaging:*** Their imaging system includes a nimble gimbal and high-quality camera to capture sharp images for ODLC.

➢ ***ODLC System:*** A segmented system is used, capable of detecting shapes, colors, and letters on objects, essential for ODLC and identifying drop locations.

➢ ***Payload Delivery:*** A custom-designed USB-controlled winch system ensures payloads are delivered safely.

- **Communication System:**

The team's robust communication system comprises a telemetry modem (RFD 900X) for data transmission over a 40 km range and a Futaba T14 SG radio controller with a 2.4 GHz bandwidth for direct UAV control.

- **Obstacle Avoidance:**

To ensure mission safety, they integrated a LiDAR system with bend ruler path planning, allowing their UAVs to navigate around obstacles autonomously.

- **Testing and Performance:**

➢ ***Flight Tests:*** The team conducted a total of 28 flights, with 21 of them fully loaded. These flights included testing turning radius, flight speed, and battery performance, all of which met or exceeded competition requirements.

- ➢ ***Payload Drops:*** A total of 34 airdrops were attempted, with 32 deemed successful, demonstrating their UAV's ability to deliver payloads safely.

- ➢ ***Communication:*** Extensive tests ensured seamless communication between the ground station and UAV, even at distances exceeding 1,000 feet.

- ➢ ***Autopilot:*** Rigorous testing showed that their autopilot system performs excellently under various conditions.

- **Mission Execution:**

- ✓ **12-Mile Flight:** The team's UAV successfully completed a 12-mile flight while fully loaded, surpassing the competition's requirements.

- ✓ **Waypoint Capture:** The UAV demonstrated precise waypoint capture capabilities, with a maximum error of only 25 feet.

- ✓ **Turn Radius:** Thanks to its rotary wing design, the UAV easily performed turns within a 150 feet radius.

- **Conclusion:**

The ITUNOM UAV Team has meticulously designed, tested, and optimized their UAV to excel in the SUAS competition. Their adherence to safety, precision, and autonomous capability makes them a strong contender, and they look forward to showcasing their achievements in the upcoming competition.

2. University College London - UCL Artificial Intelligence and Robotics (UCL AIR)

- ### Introduction:

The ITUNOM UAV Team, representing University College London (UCL), takes pride in being the first UK team to join the esteemed SUAS competition. With just seven undergraduate mechanical engineering students on their development team, they showcase their dedication and innovative prowess in the competition

- ### Team Structure:

- Team Leader: Jack Howe leads the team, bringing valuable UAS experience.
- Ground Control Operator: Khaled Aga manages ground control operations.
- Safety Pilot: Arman Abu Talebi ensures safe flight operations.
- Software Engineers: Milan Katry and Albert Moreno focus on software development.
- Hardware Engineers: Siraj Herani and Melvin Goye specialize in hardware components.

Technical Design Highlights:

Acceptance Criteria: The team developed a comprehensive functions, objectives, and constraints table to guide their design. They aimed for a minimum speed of 50 meters per second to complete the mission within 25 minutes.

UAV Design: Their UAV design is deeply influenced by competition rules and objectives.

Key components include:

- Cube Orange and ESCs for control.
- Custom-built arms housing motors.
- Lithium-ion batteries for power.
- LiDAR and GPS for navigation.
- Payload delivery system.
- Jetson computer and variable zoom camera for image analysis.

Camera: They employ a CZ10 Gimble camera with optical and hybrid zoom capabilities, ensuring high-quality image capture for detection and classification tasks.

Object Detection: The team utilizes advanced techniques, including K-Means Clustering for color detection, YOLO V8 for shape recognition, and OCR for alphanumeric classification.

Airdrop Mechanism: To safely deliver bottles to specified targets, the team developed a proprietary airdrop mechanism using a DC motor winch and servo doors. Proximity sensors ensure accuracy and safety during drops.

Communication: For reliable air-ground communication, the team employs two telemetry systems:

- RFD-900 radios with a 40 km range, using Mavlink for data transfer.
- Hearlink system, with an air unit and controller, providing a secondary ground control station.

Navigation and Autonomy: The Pixhawk Cube Orange, running Ardupilot firmware, handles navigation. Obstacle avoidance is a crucial aspect, utilizing 2D LiDAR, point cloud data analysis, and a Kalman filter-based obstacle trajectory prediction system.

Conclusion:

Despite their small team of seven members, the ITUNOM UAV Team has meticulously designed and developed a highly capable UAV to meet and exceed the requirements of the SUAS competition. Their innovative approach, attention to detail, and commitment to safety and precision position them as strong contenders in the competition.

3. Cornell University - Cornell University Unmanned Air Systems (CUAir)

- **Introduction**

Cornell University Unmanned Air Systems (CU Air) is a dynamic interdisciplinary student project team known for its innovative work in designing, manufacturing, programming, and flying custom-built unmanned aerial systems (UAS). In 2023, CU Air proudly presents Artemis, a Vertical Takeoff and Landing (VTOL) system, as its entry for the Student Unmanned Aerial Systems (SUAS) competition. Artemis is the culmination of tireless effort and dedication by more than 50 undergraduate students from various academic disciplines, demonstrating CU Air's commitment to pushing the boundaries of UAS technology.

Artemis represents a significant milestone in CU Air's journey. Conceived during the challenging times of the COVID-19 pandemic, the project has undergone numerous iterations and improvements to enhance its capabilities. In its latest iteration, Artemis V2 boasts an array of impressive features.

- **Imaging Systems:** A custom two-axis camera gimbal is integrated to ensure stable and precise imaging. The Sony R10C camera with a 20-megapixel resolution and a 16-50mm zoom lens delivers high-quality images.
- **Payload Delivery:** Artemis features a sophisticated parachute drop system for precise payload delivery, essential for meeting SUAS competition objectives.

CU Air's Dedicated Flight Line:

The CU Air 2023 flight line comprises talented team members who play critical roles in ensuring Artemis's successful mission:

- Jack Williamson: Safety Pilot and Imaging Systems Lead (Class of 2024).
- Aden Zemorsky: Ground Control Station (GCS) Operator and Full Team Lead (Class of 2023).
- Owen Soper: Imaging Ground Server Operator and Object Detection, Localization, and Classification (ODLC) Coordinator (Class of 2023).
- Polina Ermoskina: Team Captain and Mechanical Supervisor (Class of 2024).
- Ibiyemi Abiyudin: Imaging Plane System Operator and Imaging Systems Member (Class of 2023).
- Sean Yu: AirDrop Coordinator and Structures and Payloads Member (Class of 2023).
- Ashley Zeng: Electrical and Antenna Tracker Supervisor and Electrical Lead (Class of 2024).
- Eric Kim: Autonomous Vision Supervisor and Intelligent Systems Member (Class of 2024).

  These dedicated individuals bring their expertise and passion to CU Air's mission.

- ## Acceptance Criteria and Design Overview:

CU Air has meticulously set acceptance criteria and system-level requirements to ensure Artemis's successful mission. These criteria include a mission flight time goal of 25 minutes, the ability to achieve autonomous flight, and precise airdrop capabilities. Achieving these requirements necessitated careful design considerations:

- **VTOL Capability**: Artemis's four vertical propellers and pusher propeller allow for efficient VTOL operations, making it adaptable to various mission scenarios.
- **Custom Electronics Bay (E-bay):** The E-bay houses essential components such as batteries, custom PCBs, and the Pixhawk Cube flight controller. Custom PCBs facilitate precise control over flight and airdrop systems.
- **Custom GCS:** CU Air developed a proprietary Ground Control System (GCS) to manage aircraft vitals, mission progress, and waypoint navigation. This centralized system enhances efficiency during mission demonstrations.

- ## Testing and Validation:

To ensure Artemis meets rigorous performance standards, extensive testing was conducted. This included materials testing to determine optimal 3D printing filaments and carbon fiber fabric, wing loading tests, and numerous flight tests. Artemis excelled in turn radius, flight time, angle of climb and descent, and runway space tests, meeting all requirements.

- ## Autopilot and Path Planning:

Artemis employs the Pixhawk Cube flight controller with a full sensor suite for autonomous navigation. The Autopilot system, based on the open-source ArduPilot framework, offers robust support for waypoint navigation, VTOL flight modes, and failsafe mechanisms. CU Air developed a custom web browser-based Ground Control Station (GCS) to facilitate operator control and monitoring of mission progress. Path planning algorithms autonomously generate waypoints over the airdrop boundary as target geolocation data becomes available.

- **Imaging and ODLC Systems:**

CU Air's imaging system is central to Artemis's success. It includes a Sony R10C camera with a custom-built gimbal for stable imaging. The system supports geotagging of images and uses both manual vision and Autonomous Vision System (AVS) algorithms for target identification and classification. Testing on target sightings demonstrated remarkable geolocation accuracy and classification confidence levels.

- **Conclusion.**

In conclusion, CU Air's Artemis project embodies innovation, teamwork, and technical excellence. Developed by a passionate team of over 50 undergraduate students, Artemis represents CU Air's dedication to advancing UAS technology. With its robust design, cutting-edge imaging systems, and rigorous testing, Artemis is well-prepared to excel in the SUAS competition and make a lasting impact in the field of unmanned aerial systems. CU Air's journey exemplifies the remarkable achievements possible through collaboration and unwavering commitment to pushing the boundaries of technology.