Dream with Us: High School Edition

2025-2026 Engineering Challenge: AgAir: Integrating UAS into the Agriculture Industry

Detailed Background Document

Table of Contents

I. Overview: What is an Uncrewed Aircraft System? 1

Payload Element(s) 3

Air Vehicle Element 4

Command, Control, and Communications (C3) Element 4

Support Equipment Element 6

Operator Element 6

II. AgAir: Integrating UAS into the Agriculture Industry Challenge Details 7

Challenge 7

Approach 11

Concept of Operations (CONOPS) 12

Preparation 12

Pest Detection 12

Sample Gathering 12

Post-Mission 13

III. Mission Requirements 13

UAS Command, Control, and Communications (C3) 13

Detect and Avoid (DAA) 14

Lost Link Protocols 14

Background Information and References 15

IV. UAS Personnel/Labor Guidelines 16

Operational and Support Personnel 16

V. Business Case Guidelines 18

Cost Analysis 18

Logistical Details 19

Feasibility and Risk 20

VI. Public Affairs/Communications Plan 21

Public Relations Strategy Template 21

Audience and Messaging 21

Creating Sample Media Products 22

Distribution Plan 24

Authors 26
Acknowledgments 26

List of Figures

Figure 1. Basic UAS configuration with major elements identified. 2
Figure 2. UAS design approach with major element options identified. 3
Figure 3. Example C3 configuration and associated interfaces. 5

List of Tables

No table of figures entries found.

I. Overview: What is an Uncrewed Aircraft System?

An uncrewed aircraft system (UAS) can be defined as an aircraft without an operator or flight crew onboard the aircraft itself. UAS are remotely controlled using manual flight controls (i.e., teleoperation) or autonomously operated using uploaded control parameters (e.g., waypoints, altitude hold, or minimum/maximum airspeed for example).

UAS are typically used to perform a variety of tasks or applications that are considered too dull, dangerous, dirty, or deep for humans or crewed platforms (also known as the "4Ds"). Their civilian/commercial uses include aerial photography/filming, agriculture, communications, conservation/wildlife monitoring, damage assessment/infrastructure inspection, fire services and forestry support, law enforcement/security, search and rescue, weather monitoring and research. They provide an option that is economical and expedient, without putting a human operator (i.e., pilot) at risk.

UAS are commonly referred to as uncrewed aerial vehicles (UAV)s, uncrewed aerospace, aircraft or aerial systems, remotely pilot aircraft (RPA), remotely piloted research vehicles (RPRV), and aerial target drones. However, the term UAS itself is reflective of a system as a whole, which has constituent components or elements that work together to achieve an objective or set of objectives. These major elements, depicted in Figure 1, include the air vehicle element, payload, data-link (communications), command and control (C2), support equipment, and the operator (human element).

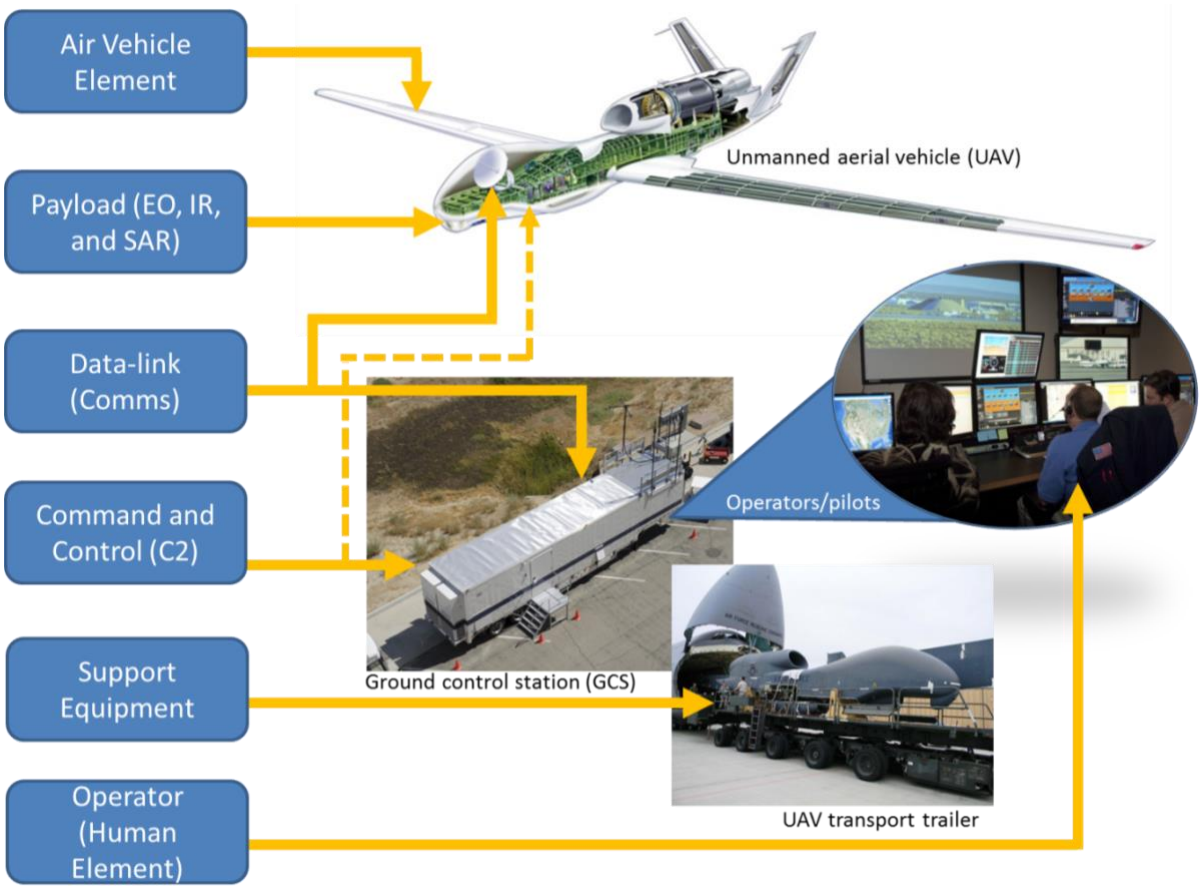


Figure 1. Basic UAS configuration with major elements identified.

The UAS you will develop in this challenge is comprised of similar elements, or parts of the system.

NOTE: For purposes of component categorization and functionality simplification, the datalink/communications and command and control (C2) have been combined into a single element (i.e., command, control, and communications [C3]). Each team will choose different quantities, sizes, types, and configurations of the various components to create a unique UAS design using the approach depicted in Figure 2.

Also of note is pointing out that your team will develop the entire *system* and not just the uncrewed vehicle.



Figure 2. UAS design approach with major element options identified.

A high-level description of each part of the system follows.

Payload Element(s)

The payload represents the first element to be examined in the design of a UAS. This traditionally represents the primary purpose of the platform. One example of a payload is the visual/exteroceptive sensor(s), explained in further detail below. These sensors capture information about the operating environment. This information can be used to provide situational awareness relative to the orientation and location of the aerial vehicle.

Visual/exteroceptive sensors – used to capture information (e.g., visual data) about the operating environment. Provides the operator with situational awareness, such as the orientation and location of the aerial vehicle element of a UAS. Common sensors include:

- ***CCD/CMOS camera (e.g., Daytime TV, color video)*** – digital imaging sensor, typically returns color video for live display on the ground control station (GCS) terminal.
- ***Thermal (e.g., infrared [IR])*** – sensor used to measure and image heat (i.e., thermal radiation).
- ***LiDAR*** – measures distance and contours of remote bodies (e.g., terrain) through use of reflected laser light. Typically requires significant amount of pre- or post-processing to render and display the data.

- ***Synthetic Aperture Radar (SAR)*** – measures distance and contours of remote bodies (e.g., terrain) through use of reflected radio waves. Typically requires significant amount of pre- or post-processing to render and display the data.
- ***Multispectral camera*** – an all-encompassing visual sensor for capturing image data across the electromagnetic spectrum (e.g., thermal, radar, etc.).

Air Vehicle Element

The air vehicle element (i.e., UAV) represents the remotely operated (uncrewed) aerial component of the UAS. There can be more than one UAV in a UAS, and each is made up of of several subsystem components, including the following:

- ***Airframe*** –the structural aspect of the vehicle. The placement/location of major components on the airframe, including payload, powerplant, fuel source, and command, control, and communications (C3) equipment, will be determined by your team. This element can be purchased as a commercially-off-the-shelf (COTS) option or custom designed.
- ***Flight Controls*** – the flight computer (e.g., servo controller), actuators, and control surfaces of the air vehicle.
- ***Powerplant (propulsion)*** – the thrust generating mechanism, including the engine/motor, propeller/rotor/impeller, and fuel source (e.g., battery or internal combustion fuel)
- ***Sensors (onboard)*** – the data measurement and capture devices
  NOTE: *These subsystem components could be purchased as a single commercial off-the-shelf (COTS) option, could be modified/supplemented using other options, or entirely custom designed.*

Command, Control, and Communications (C3) Element

The level of autonomy of an aircraft is determined by the capabilities of the Command Control and Communications (C3) system.

C3 represents how your team will get data to (e.g., control commands) and from (e.g., telemetry and onboard sensor video) the vehicle (or any additional uncrewed/robotic systems) while in operation. Your configuration will depend on the design choices made by your team. Some of these items will be included in the weight and balance calculations for the Air Vehicle Element (i.e., airborne elements), while the remaining will be included in the ground control station (GCS). The following image (Figure 3), depicts an example C3 interface overview of a medium complexity UAS.

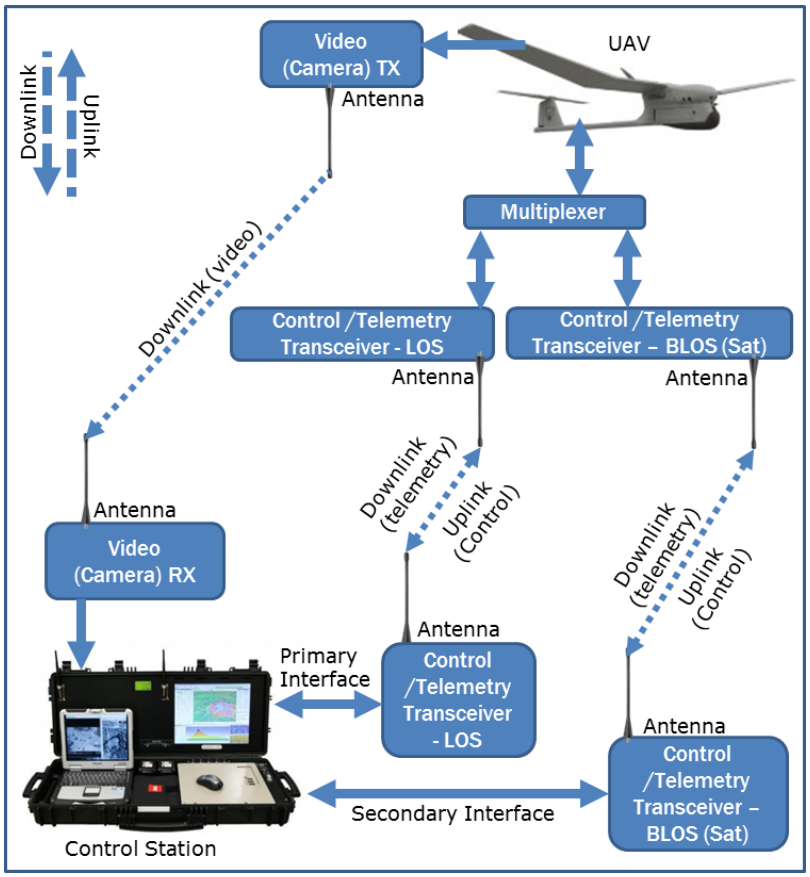


Figure 3. Example C3 configuration and associated interfaces.

Primary C3 element subsystem components include:

- ***Control commands and telemetry equipment*** – the capture, processing, transmission, receipt, execution, and display of all data associated with control and feedback of the air vehicle element. The following represent the types of controls.
    - **Manual** – operator performs remote control of the UAV.
    - **Semi-autonomous** – operator performs some of the remote control of the UAV, system performs the rest (pre-determined prior to flight).
    - **Autonomous** – operator supervises system control of the UAV (pre-determined prior to flight and uploaded during flight).
    - **Control switching** – use of a multiplexer device provides a method to switch between different control methods (e.g., switch between manual and autonomous control).
- ***Primary video data equipment (non-payload)*** – the capture, transmission, receipt, and display of visual data from the primary video sensor (non-payload), if applicable.
  NOTE: *Primary video is typically used to operate the aircraft from an egocentric (i.e., first person view [FPV]) perspective*
- ***Remote sensing (primary payload sensor) equipment*** – the capture, storage or transmission and display of data from the primary payload sensor.

Additional details concerning this element can be found in the UAS Command, Control, and Communications (C3) section.

Support Equipment Element

Support equipment represents those additional items required to assist in UAS operation and maintenance in the field. These can include but are not limited to the following:

- **Launch and recovery systems** – components used to support the UAV to transition into flight or return the aircraft safely.
- **Flight line equipment** – components used to start, align, calibrate, or maintain the UAS.
    - Refueling/recharging system
    - Internal combustion engine starter
- **Transportation** – used to deliver equipment to the operating environment.
- **Power generation** – portable system capable of producing sufficient power to run the GCS and any additional support equipment; typically internal combustion using gasoline.
- **Operational enclosure** – portable work area for the crew, computers, and other support gear.

Operator Element

The operator element represents the people required to operate and maintain the system. These roles will be dependent on the design of the system. These can include but are not limited to the following:

- Pilot in command (PIC)
- Secondary operator (co-pilot or spotter)
- Payload/sensor operator
- Sensor data post-processer specialist
- Support/maintenance personnel

  NOTE: *You will identify your crew based on your UAS design according to the provided mission requirements. For example, if the payload is configured to automatically detect over specific areas identified using GPS, a specific operator may not be necessary. However, the appropriate system design would need to be established to support such operations.*

The details concerning this element can be found in the UAS Personnel/Labor Guidelines section of this document.

II. AgAir: Integrating UAS into the Agriculture Industry Challenge Details

Uncrewed Aircraft Systems (UAS) have near-term potential for many civil and commercial uses. The 2025-2026 Dream with Us Design Challenge will focus on Uncrewed Aircraft Systems (UAS) and implementing UAS into the agriculture industry. This year's mission is to develop an uncrewed aircraft system that will detect agricultural pests that affect your team's geographical area and make a detrimental economic impact, and identify suspected affected areas and take plant samples in order to more effectively optimize crop production. The teams will identify, compare, analyze, demonstrate, and defend the most appropriate component combinations, system/subsystem design, operational methods. Engineering Technology concepts will apply to this challenge, including the application of science and engineering to support product improvement, industrial processes, and operational functions. In addition, a business case and a communications plan will be included to better support the challenge scenario. Through use of an inquiry-based learning approach with mentoring and coaching, student teams will have an opportunity to learn and apply the skills and general principles associated with the challenge in a highly interactive and experiential setting. Students will need to consider and demonstrate an understanding of the various Uncrewed Aircraft System elemental (subsystem) interactions, dependencies, and limitations (e.g., power available, duration, range of communications, functional achievement) as they relate to the operation, maintenance, and development to justify their proposed business case.

To support the inquiry-based learning approach, each team will perform and document the following in an engineering design notebook:

1) ***Task Analysis*** - analyze the mission/task to be performed
2) ***Strategy and Design*** - determine the engineering design process, roles, theory of operation, design requirements, system design, integration testing, and design updates
3) ***Costs*** - calculate costs and the anticipated capabilities associated with both design and operation

Teams will work together with coaches and mentors to identify what is needed while pursuing the completion of this challenge. By connecting your own experience and interest, participants will have an opportunity to gain further insight into the application of design concepts, better understand the application of Uncrewed Aircraft System technology, and work collaboratively towards the completion of a common goal.

Challenge

This year's challenge is to design Uncrewed Aircraft Systems (UAS), create a theory of operation, and develop a business and communication plan for the system based on the following scenario:

Scenario: *Agricultural pests cost billions of dollars in losses across the globe every year. Besides losses through yield reductions and reduced quality, there are also the costs of using pesticides or other methods to mitigate the pests, particularly if pesticides are being used indiscriminately rather than*

strategically. The strategic use of uncrewed aircraft is making significant impacts in reducing the impact of agricultural pests. Properly implemented, agricultural output can be increased while also reducing resource use. In addition to food crops, pests can also have a large impact on other agricultural products such as trees.

Your state government is interested in developing an uncrewed aircraft system (UAS) that can help in the fight against an agricultural pest that has an economic impact in your state. The state government wants a UAS that can be used to detect signs of the pest(s), identify plants that have been potentially impacted by these pests, and also take samples from the infected plant(s). Your company has been asked to design a UAS that will be tested locally within the state to determine its feasibility and potential economic impact.

Your company will select the specific pest(s) based on your local region. This pest selection and corresponding impacted plant(s) will determine many of the UAS design choices. The state government agency in charge of the program has created a set of design criteria outlined below.

Overall Design:
A single uncrewed aircraft that can detect signs of the pest infestation, plants potentially impacted, then take a sample of the impacted plant(s) for further analysis. The aircraft must have a communication range of at least 5 mi. The aircraft should maximize the amount of area it can cover in the least amount of time.

Detection:
Based on the selection of the local agricultural pest, the uncrewed aircraft must:

- *Detect signs of the pest(s). What sensors are required to do this from an uncrewed aircraft?*
- *Transmit sensor data for further analysis at the ground station.*

Sampling:
Based on the selection of the local agricultural pest(s), the uncrewed aircraft must:

- *Take a relevant sample. What type of sample is needed (e.g., leaf, stem, bark, soil)?*
- *Safely carry the sample to the ground station.*
- *If more than one sample is gathered during the same flight, storage must limit cross-contamination.*

Ground Station:

- *Operated by two (2) people.*
    - *One (1) to operate and monitor the aircraft.*
    - *One (1) to monitor the sensor data, interpret the results, and determine if a sample is needed.*
- *Include necessary equipment to operate and monitor the aircraft.*
- *Include necessary equipment to receive sensor data and analyze sensor data.*
- *Include equipment to collect and store samples for transportation.*

Transportation and Storage:

- *Maximum of two (2) containers: one (1) for ground station equipment and one (1) for aircraft.*
- *Each container can have maximum internal dimensions of 34×24×12.5 in.*
- *Each container can have up to an additional 3 in. in each direction for the external dimensions to account for the container material and any external latches, handles, and wheels.*
- *Each container can weigh up to 80 lb. including the weight of the container.*
- *Any batteries and fuel can be stored separately for safety and are not counted as part of the two main containers.*

Safety:

- *Be able to fly safely among plants during detection and sampling.*
- *Include a detect and avoid system to avoid collisions with stationary and moving objects such as the plants, birds, other aircraft, people, and other objects.*
- *The level of autonomy is up to your company, but some level of semi-autonomous flight is expected to reduce pilot workload and help fly near the plants.*

Benchmark mission:

To judge the effectiveness and efficiency of the design, the uncrewed aircraft must complete a specified benchmark detection and sampling mission. The time to complete the mission, the overall cost, and safety considerations will be factors in determining whether your company is awarded the contract.

- *Use the provided diagram for the benchmark mission:*
    - *The ground station is 3 mi from the test field. All samples must be returned to the ground station, and any required refueling or battery change/recharge must be performed at the ground station.*
    - *The elevation of the ground station must be relevant to your region. You can assume that there is no elevation change from the ground station to the test field.*
    - *The test field is 0.5 mi by 0.5 mi and contains the plant(s) that you selected based on the local agricultural pest(s).*
    - *A single uncrewed aircraft must survey the entire field and return ten samples. Each sample location is provided in the diagram as an "X". You can assume that the sample location is at the center of their respective square.*
    - *The aircraft is not required to perform the full detection survey and sampling in a single flight. Reference the criteria that samples must be kept separate.*

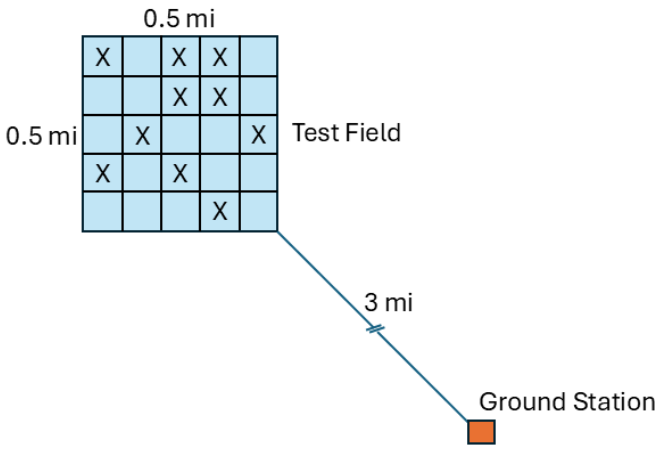


Figure: Benchmark mission diagram.

Business case:

The business case will be structured similarly to a group applying for a work contract. Teams will create an operating budget for the operation of their aircraft and the associated system that supports the aircraft. The aircraft must complete the benchmark detection and sampling mission. The business case must detail both the fixed and variable costs and provide some of the logistical details on the personnel needed to operate the system. Contracts are being evaluated based on how well the mission is performed and how much it will cost. Teams should include the following details in their business plan:

- ***Account for all costs****: Teams will need to account for all the costs of operating the aircraft and system*
    - ***Fixed costs****: Calculate the fixed costs. These include the cost of all the equipment needed to fly such as the aircraft, Command Communication equipment (command center, communication arrays, etc.), support equipment (any other things you might need to operate), etc.*
    - ***Variable costs****: Calculate the variable costs to fly. For this challenge, it will include the operating costs needed to complete the benchmark mission. This will include the amount spent on fuel, charging batteries, replacement parts, and personnel.*
- ***Basic logistical details****: In addition to a budget, teams should explain the roles of all personnel and how they will be used to accomplish their mission. Teams need to determine the tasks that need to be performed and what positions are being used to accomplish those tasks.*

Public Affairs/Communications plan:

How are you able to make an argument to the agriculture industry that using UAS in their business is a good idea? Many within the agriculture industry have used specific technology for years and are unsure if there is a real need or benefit to adding UAS to their business. Your team will need to convince them that this is needed.

In the communications plan, teams will compile information from the technical parts of the project, along with the business plan to help explain why it is important and cost-effective to utilize UAS in agriculture. The teams' communication plans should have the following characteristics:

- ***Audience and purpose:***
  - *Communications should be written for the appropriate audience, keeping in mind that some people in the agriculture industry may not have technical background in the areas needed to understand the project*
  - *There should be a compelling reason(s) to use the proposed desig.*
- ***Plan for communication:***
  - *In this section teams should come up with a plan to promote the use of UAS within their agricultural business.*
  - *Include the type of information being shared, along with how that information will be shared (for example, via social media platforms, brochures, videos, infographics, etc.*
  - *Explain how materials will be distributed and the audience(s). Keep in mind that you may need to get broader support from the general population.*

Approach

Each team will operate from the perspective of a small company that is seeking funding for the demonstration of a prototype system. The following steps are recommended in pursuit of a response to the challenge scenario:

1. Consider all aspects and requirements of the challenge.
2. Research local agricultural pests that have an economic impact.
3. Perform background research on the topic, available tools and techniques for handling these pest(s), including any existing strategies.
4. Develop a theory of operation that can be adapted as you learn more about the challenge.
5. Create an initial design (conceptual design).
6. Analyze the design and determine potential effectiveness and possible shortcomings (i.e., identify process[es] to validate and verify preliminary design and operation; determine detection efficiency, sampling efficiency, airframe efficiency, airframe cost, and business costs; include redesigns and revisions).
7. Continue research and design (document detailed design, design decisions, lessons learned, recalculated variables; redesigns and analysis of those redesigns, as necessary).

The successful proposal should include an estimate of the project's budget as well as the potential cost savings, while striving to demonstrate and illustrate how the solution efficiently helps with pest detection and mitigation.

It is strongly recommended that teams conduct their own research on the topic to answer the following questions to develop a challenge solution:

- How can your design be a benefit to agriculture?
- How does your design compare to existing designs or strategies?
- What sensors are needed to gather the required environmental data?
- What is required for safe flight?
- What is required for the aircraft to detect and avoid obstacles?

- What are the benefits or capabilities of adding UAS to crop production?
- How are you addressing the mission requirements and how will the requirements affect your design?

From a business perspective, you may also want to consider the various operational factors and design capabilities that may affect the cost. From the communications perspective, consider some of the potential challenges of convincing your audience for the need to add UAS to agriculture.

Concept of Operations (CONOPS)

A concept of operations (CONOPS) is used by many different organizations, and each has slightly different requirements. The basic purpose of a concept of operations is to describe the characteristics of a system from the viewpoint of a user of the system. It is used to communicate the characteristics to all stakeholders. Stakeholders include anyone who plays a part in its use. For this challenge, the CONOPS will be used to explain the operation of your system through the benchmark mission. A CONOPS should be clear, concise, and easy to understand. You can describe the operation through paragraphs, lists, and figures.

The CONOPS section has multiple parts to consider.

Preparation

Describe the characteristics of the system during the initial preparation prior to a mission. Some considerations for this section:

- What steps are required to set up the ground control station and any other equipment?
- What steps are required to prepare for the mission?
- Who performs each step in the preparation?
- Where do the steps take place?
- What is required for a safety check of the aircraft and environment?

Pest Detection

Describe the characteristics of the system during its flight while it is detecting pests. Some considerations for this section:

- How does the system detect pests?
- What communications between members of the team and to the aircraft are required during the mission process?
- What other communications are required during the flight? Between aircraft and operator(s)? Between aircraft if there is more than one?

Sample Gathering

Describe the characteristics of the system during its flight to gather samples. Some considerations for this section:

- How does the system determine that a sample is needed?
- How does the aircraft gather a sample?
- How is the sample stored on the aircraft? Can multiple samples be gathered in a single flight?
- What communications are required during the process of gathering a sample?
- What other communications are required during the flight? Between aircraft and operator(s)? Between aircraft?

Post-Mission

Describe the characteristics of the system at the end of a mission. Some considerations for this section:

- What steps are required when the mission is complete?
- What steps are required to store the aircraft?
- What steps are required to store the ground control station and any other equipment?
- Who performs each step?
- Where do the steps take place?

III. Mission Requirements

Part of the requirements for the UAS are focused on the ability to fly safely in the national airspace and near plants and possibly people. During the mission, there is the possibility that the uncrewed aircraft may be flying near other uncrewed aircraft and manned aircraft. Keep in mind there are specific guidelines in place about the prioritization of crewed and uncrewed flight and safety. There are many areas that organizations are currently working on in order to achieve safe uncrewed flight. A few of these areas will be focused on for this design. The following sections provide some additional information to aid in the UAS design.

Since no pilot is onboard an uncrewed aircraft, tasks that are usually the responsibility of the pilot must be handled by some other means. Methods must be developed to pilot the aircraft, monitor the aircraft, communicate with air traffic control, and if necessary, watch for other aircraft, handle changes to the flight plan, and deal with emergencies. The following sections highlight some of these tasks.

UAS Command, Control, and Communications (C3)

There are many different levels of autonomy. A major decision for the team is determining the level of UAS autonomy since this decision will influence the needed avionics. The aircraft must be able to monitor itself and its environment. Some basic required measurements to do this include:

- Measuring its airspeed
- Measuring its orientation (roll, pitch, yaw)
- Awareness of its location and flight direction

Communications systems are very important with UAS. All communications systems come with some latency (a delay in communications) that can depend on the type of communication, power, and

distance. Deciding on different communications systems need to include these time delays. Since communications is such a key factor, redundancy must be designed into the system. Your team will need to determine what methods will be the primary form of communications, which systems will be used as backup, and how much redundancy should be included.

Part of the C3 system for a UAS is the ground control station. At the ground control station, the operator/controller can monitor the aircraft and can make command decisions if/when necessary. The ground control station may also be part of the detect-and-avoid system depending on where decisions are made. Having a communications system that can handle the necessary tasks is essential.

Detect and Avoid (DAA)

The purpose of a detect-and-avoid system (sometimes referred to as sense-and-avoid) on a UAS is to be able to sense objects that might pose a threat, detect if an object becomes a conflict (potential collision), and be able to avoid any obstacles.

During flight, the uncrewed aircraft may be operating near manned aircraft. Safety of people in other aircraft are a priority. While flying, your aircraft and larger aircraft will have some type of transponder that provides location and airspeed. Aircraft with a transponder are known as cooperative obstacles. Your aircraft must be able to detect these cooperative obstacles and non-cooperative obstacles. These non-cooperative obstacles may be stationary (such as a building) or moving (such as aircraft without a transponder). There are multiple ways UAS may sense obstacles through sensors such as visual, IR, acoustic, radar, etc. Selection of these sensors will depend on their weight, field of view, and how objects are detected, and sometimes, dependent on budget.

After an object is sensed, it must be determined if the object poses a threat to the aircraft and if there is the possibility of a collision. Aircraft typically have a defined boundary around the aircraft where its sensors can detect an obstacle and have time to make maneuvers to avoid a collision. Analyzing sensor information and determining if there is a threat can be done on the aircraft, off the aircraft at the ground control station, or a combination of both. The equipment selected for the C3 must be compatible with the method(s) selected for the DAA.

The final step in the DAA is for the aircraft to make maneuvers to avoid a conflict when necessary. Similar to the analysis of sensor information, the commands to make these maneuvers may be completed on the aircraft, at the control station, or a combination of both. Note that some level of decision must be done on the aircraft in case there is not enough time to alert the aircraft operator.

Lost Link Protocols

To ensure public safety, protocols must be developed and used when there is a loss of communication with the UAS. Loss of communication may be partial or total, and loss of communication can occur with the UAS or with the ground control station. Whenever there is a loss of communication, any other aircraft in the area must be notified so that they may take any necessary actions (e.g., move away from the vicinity of the loss-of-communication aircraft).

Multiple situations can result in a partial loss of communications. Some situations include the loss of the transponder signal from the aircraft (broadcasting), the loss of receiving transponder signals from other aircraft, or the aircraft switching to secondary communications (e.g., using satellite communication if radio frequency (RF) communication is loss).

- When there is a partial loss of communications, define the actions that the aircraft and the operator/controller will do. Will there be attempts to regain missing communications? When will there be a decision for the aircraft to return to the originating airport or divert to another location, or land?

A total loss of communication occurs when the ground control station cannot send information to or receive information from the UAS. Consider two situations with total loss of communication: transponder still working and transponder not working.

- With total loss of communications, what will the aircraft do? Stay on current path or move to designated altitude/location? How long will the aircraft attempt to regain communication before it returns to the originating location or divert to another location?

Background Information and References

Safely flying UAS near other aircraft is an ongoing challenge. Below are a few sources of additional material on the subject.

Background information from manned aviation that may be relevant to understanding UAS development:

- https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook
- https://www.faa.gov/sites/faa.gov/files/2022-06/risk_management_handbook_2A.pdf

Background papers on UAS and Autonomous Operations:

- NASA Regional Air Mobility report: 2021-04-20-RAM.pdf (nasa.gov)
- A Systematic Approach to Developing Paths Towards Airborne Vehicle Autonomy: https://ntrs.nasa.gov/api/citations/20210019878/downloads/NASA-CR-20210019878final.pdf
- Digital Flight operations https://ntrs.nasa.gov/citations/20210025961

Background on information related to plant pests:

- Your state's department of agriculture will have information about agricultural pests that have an economic impact in your state.
- The agricultural departments/colleges at universities and colleges in your state will have information about local agricultural pests.
- The U.S. Department of Agricultural tracks agricultural pests that have had large scale impacts in the USA. Some pests can be found on their Plant Pests and Diseases page: https://www.aphis.usda.gov/plant-pests-diseases

IV. UAS Personnel/Labor Guidelines

The costs of the system are not solely measured in terms of the cost to purchase individual components but are also reflective of the cost to operate and maintain the system. The following subsection provides some details for both personnel and labor areas. These areas will be based on your design and logistical plan, coupled with research regarding typical time needed to perform such activities and guidance from your industry mentors to estimate time required to perform necessary actions to complete the mission. Use this experience to better understand what roles would be required, at a minimum, to create your design from conception to final delivery.

NOTE: *Not all personnel and labor areas may be necessary. Some personnel may take on more than one role. If a person performs more than one job, that person must be paid the higher amount (if applicable) for all of their time. Also keep in mind that oftentimes operations and missions may take longer than anticipated so estimating personnel costs can be more than anticipated, rarely less.*

Operational and Support Personnel

Any UAS performing remote sensing require a variety of roles to be fulfilled by personnel on the ground to ensure safe and successful completion of the mission. Different aircraft and application types will require different roles and different numbers of ground support personnel. For the purposes of this competition, a basic minimum ground support personnel configuration can be assumed. Make sure to account for an extra hour to address time that personnel work prior to preparation and post-mission. The typical roles are outlined as follows:

NOTE: *Full-time Equivalent (FTE) is used to indicate one person assigned full-time to the designated role. For this competition, fractional FTEs will not be allowed. For operational cost calculation purposes, fractions of an hour should be rounded up to the next highest hour. Costs are not dependent on individual salaries but are instead tied to the value a company assigns to the role when their services are quantified and passed on to an external customer.*

The term "fully loaded" refers to any and all costs for this person's time.

1) **Payload Operator [$35/hr. fully loaded cost per 1.0 FTE]:** This person is required when payload data is telemetered from the aircraft or requires manual operation during task execution. This person will typically sit at a ground station, interacting with a graphical user interface (GUI) for the purpose of controlling the payload operations in real-time. If the payload is cargo, this position may involve overseeing the loading of the cargo containers, making sure they are safely secured, and overseeing the unloading of the containers.

2) **Range Safety/Aircraft Launch & Recovery/Maintenance [$35/hr. fully loaded cost per 1.0 FTE]:** This individual can be assigned multiple non-concurrent roles and is typically a highly qualified technician. Range safety includes ensuring frequency de-confliction prior to and during the mission as well as airspace de-confliction. This individual will be trained in the use and operation of a spectrum analyzer to ensure that the communications and aircraft operations frequencies are not conflicting with other potential operations in the area. This individual will also monitor

air traffic channels to ensure that the airspace remains free during the task. This individual will be responsible for coordinating with the air traffic management personnel in advance of the operation to ensure that the appropriate airspace restrictions are communicated to piloted aircraft operating in the area. This individual may also be responsible for aircraft launch and recovery operations as well as any required maintenance (e.g., refueling or repairs) in between flights.

3) **Launch and Recovery Assistants/Package Handlers [$15/hr. fully loaded cost per 1.0 FTE]**: In the case of some unmanned aircraft, one or two assistants may be required to help position the aircraft for takeoff and recover after landing. This person can also be used for refueling and reloading of packages.

4) **Operational Pilot [$35/hr. fully loaded cost per 1.0 FTE]**: The operational pilot is ultimately the pilot responsible for the safe flight of the aircraft, including any pre-flight checks on the aircraft. In the case of autonomous or semi- autonomous operations, the operational pilot is responsible for monitoring aircraft state (attitude, altitude, and location) to adjusting aircraft flight path as required for success of the application task. The pilot will typically spend most of the operation looking at a screen at the ground control station monitoring the telemetry from the aircraft's on-board flight control computer and adjusting the aircraft's programming as necessary.

5) **Data Analyst [$50/hr. fully loaded cost per 1.0 FTE]**: This person is required when payload sensor data from the unmanned aircraft cannot be processed in real-time. This role can be a requirement for telemetered data where real-time search algorithms are not available at the ground station. This role is also a requirement when sensor data is recorded on board the aircraft for download and analysis upon aircraft recovery (i.e., no data telemetry). This role may or may not be required, depending on the sensor payload selection.

V. Business Case Guidelines

This year's business case is to calculate the cost to complete the benchmark mission. The cost in combination with the effectiveness and efficiency of the design will determine the company that wins the contract to further develop their system within their state. Only fixed costs and variable costs to complete the benchmark mission will be considered for this proposal.

The following is an elaboration of the five key components of a business case that will assist you in being successful in your proposal. Think of following key components of a business case to help you develop your business case section:

1. Provides the rationale for proposed budget
2. Explains how the project will complete the required objectives effectively
3. Outlines the overall feasibility and risks
4. Explains why the proposed solution/ budget is the best choice for the contract
5. Provides the overall scope, timeframe, and budget plan

Cost Analysis

Teams will conduct an analysis of their costs to determine how much it really costs to fly. While knowing how much it will cost to fly would allow your company to determine the lowest price they can charge customers, any additional costs in order to be profitable will not be considered in this year's challenge. Costs are a factor in deciding if the design is a viable solution.

Costs are divided into two categories: variable or operating costs, and fixed costs. Operating costs include items such as the cost of fuel and the cost of the personnel needed to fly. Fixed costs are also known as equipment and supply costs. These include equipment costs such as tools, communications equipment, etc. Below are more details on each of these types of cost and how to calculate them:

Operating Costs (Variable Costs)

Operating costs include the cost of the personnel required for flights and supporting the system, the cost of the fuel for flying, and any materials needed for repairs. While there will only be one line item for all operating costs in the budget summary it will still be important that you document the following areas in your notebooks:

1. Understand how many flights are conducted to complete the mission.
2. The cost to conduct each flight, including how you determined that cost. Make sure to include a breakdown of your total variable costs for personnel, fuel, and room for repair materials.

Calculating Operating Costs

Calculating the operating costs can be determined by first calculating the number of flights to complete the benchmark mission. Next, teams will need to determine how much each flight will cost to perform. This cost requires knowing the amount of time of each flight, the necessary personnel, the personnel payrates, the cost of fuel (if applicable), and any materials that will be available to make repairs. Teams must also determine the amount of time required for preparation and post-mission. Below are formulas for calculating both the operating cost for the day and the operating cost:

Operating Costs for the Mission = Cost of Personnel* + Cost of Fuel** (+ any potential repair costs)

*Cost of Personnel is the total costs for all personnel required to fly, reload, refuel, repair the UAV during the mission. This cost also includes the personnel cost during the time to complete the preparation and post-mission. Assume that the people working are paid for the entire time on site regardless of whether they are actively completing a task or not. If personnel leave early explain why their presence is not required to complete the remaining tasks during the rest of the mission. Personnel may not leave and then come back in order to reduce costs.

**This will depend on what fuel the aircraft consumes, the rate at which fuel is consumed while flying, and the number of flights throughout the day.

Fixed Costs (Equipment and Supply Cost)

Fixed costs include any equipment and support equipment you need to perform the mission. There should be a breakdown of the fixed costs into the following categories, giving the total cost of all parts in each area as well as the total for the fixed costs:

Airframe Costs

Includes the engine and any component of the aircraft other than communication equipment and sensors.

Payload – Pest Detection Costs

Cost of all components related to the equipment/sensors used for pest detection.

Payload – Sample Gathering Costs

Cost of all components related to the equipment used for sample gathering.

Command, Control, and Communication Costs (C3)

Costs include any equipment on the ground or on the UAV. Included are the costs of the equipment/sensors required for the DAA.

Support Equipment Costs

Includes any additional equipment required for the system.

Calculating Fixed Costs

To calculate fixed costs you must add up the costs of all components of your aircraft.

Fixed costs = Air Frame Costs + Payload Pest Detection Costs + Payload Sample Gathering Costs + Command, Control, and Communications (C3) Costs + Support Equipment Costs

Logistical Details

As you put together the plan for the mission, make sure that you use the personnel needed to accomplish the mission. It will be important to have enough people to fulfill all of the roles your plan

requires. When choosing what jobs are needed, make sure to use the guidelines in the personnel section of the detailed background. In addition, you will need to justify that there are enough people for each role, that someone is not doing a role they cannot perform (e.g., a package handler piloting an aircraft), or that someone is not performing two (2) roles at the same time. Some personnel can perform multiple roles; however, make sure you pay them for the more expensive position the entire time and they are not forced to perform two (2) tasks at the same time.

Feasibility and Risk

Can your system perform how you say it will when completing these objectives? Are you adequately accounting for safety to meet the mission requirements? Are you able to perform the tasks better/more profitably? Have you adequately accounted for the mission requirements so your aircraft can operate safely? Before attempting to convince the client that your team is capable of developing and launching this plan, you must be convinced yourself. It is at this stage of developing the plan and the business case that experience counts. If you are not certain of the risks or of your own capability, do not neglect to reach out to subject matter experts. Risks can get in the way of successfully completing the mission objectives while meeting the mission requirements. Be sure to intensively brainstorm possible risks. You do not want to leave something out of your business case or be asked something by a reviewer—and are unable to give an answer.

VI. Public Affairs/Communications Plan

Public Relations Strategy Template

For the Dream with Us 2025-2026 challenge, your team is asked to develop a set of materials to make the case to support the utilization of UAS to identify potential pests that are affecting crops, including collecting plant samples to test for disease or damage. Materials can include the following from the Public Relations Strategy Template (note: a different format can be used if desired):

Title

Background or Overview

- Provide background for the strategy (such as a short summary of the design challenge and why it matters), along with a brief summary of your public relations strategy.

Purpose

- Briefly explain why a public relations strategy is important in this situation. What challenges, beyond the technical challenges themselves, can make it difficult to get support?

Audience and Intended Outcome

- Could include primary and secondary audiences, if applicable (Include an outcome for each audience: why are you connecting with them? What do you want to happen because of their involvement?)

Key Messages

- What are the main points you are trying to make? This section can be bullet points, it does not need to be formal

Key Dates

- To-Do List, Due Dates, and Person(s) responsible for action item(s)

Team Members, Roles, and Contact Info.

Products to be Created

- Include samples in this section
    - Product and format (Is this an image? A social media post? A poster? Presentation? Include all items here)

Distribution Plan

- How will products and messaging go out to the audiences specified? For example, will social media be used? If so, which ones and what is the timing? What other methods will be used?

Other Items of Note

Is there anything your team should be aware of? Upcoming current events that could influence the outcome? Other considerations?

Audience and Messaging

When developing a Public Relations Strategy Document the key is to have a well-written strategy document is that it is:

- An internal planning document (this is not something shared with the public)
- The provided template contains the following sections (note: teams may choose to use a different format, but the same basic elements should be included)
    - Contains the products or a description of products that will be shared with the public

- Products should be appropriate for the intended audience. Make sure to think of the following elements
- Communications goal
- Methods of communication how will that method(s) impact your messaging
- The tone you want to use and how the tone will affect the message being given

Creating Sample Media Products

Teams will have to develop a sample of the communications materials that will be used in their overall communications plan. There may be a variety of types of media used depending on the plan developed by the team. When developing materials, it is important to think of the following:

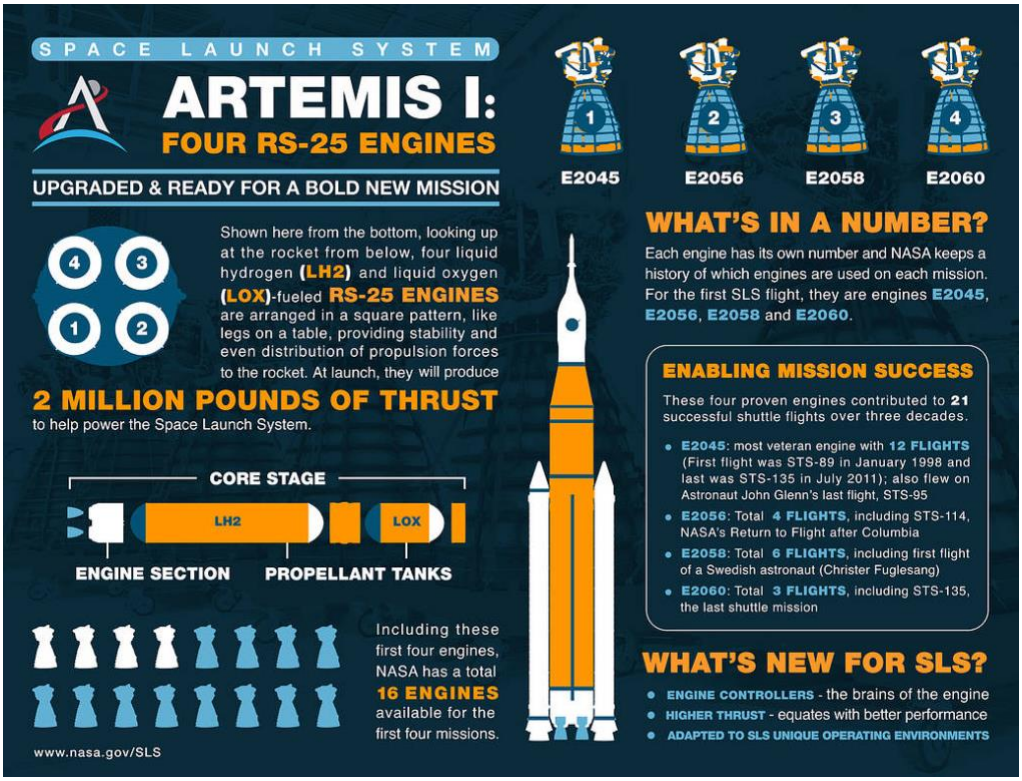
- How information included was chosen
- Why the design is an important tool and benefit for the agriculture industry
- How the information is organized
- What kind of information was *not* included and why

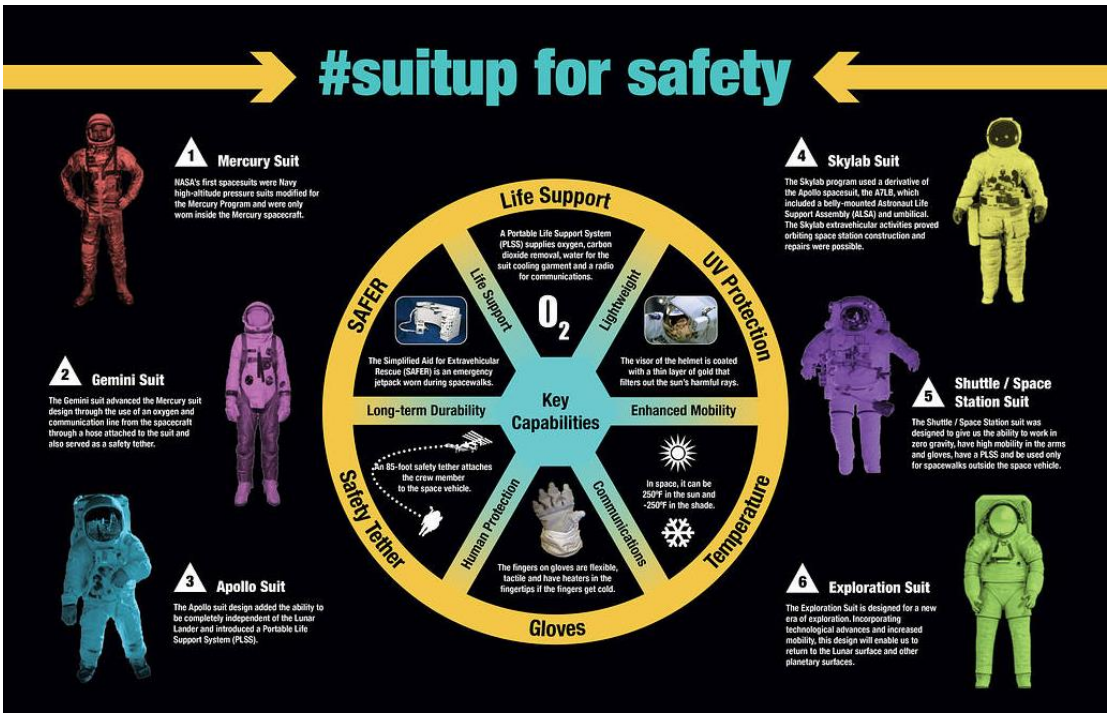
Keep in mind while developing the communication materials that not everyone seeing this going to have a technical background. However, they will likely be the ones to decide whether to pay for the UAS. It will be important to show the value of your design in the communication materials produced. The communications materials allow teams to show their work to a target audience. Teams can determine what materials they would like to develop depending on their strategy. Below are examples of communications materials that can be developed. There is no set number of sample materials that need to be created but should be enough to show the team's communications strategy and talents (Note that these are possible options however there may be additional methods of communication not listed).

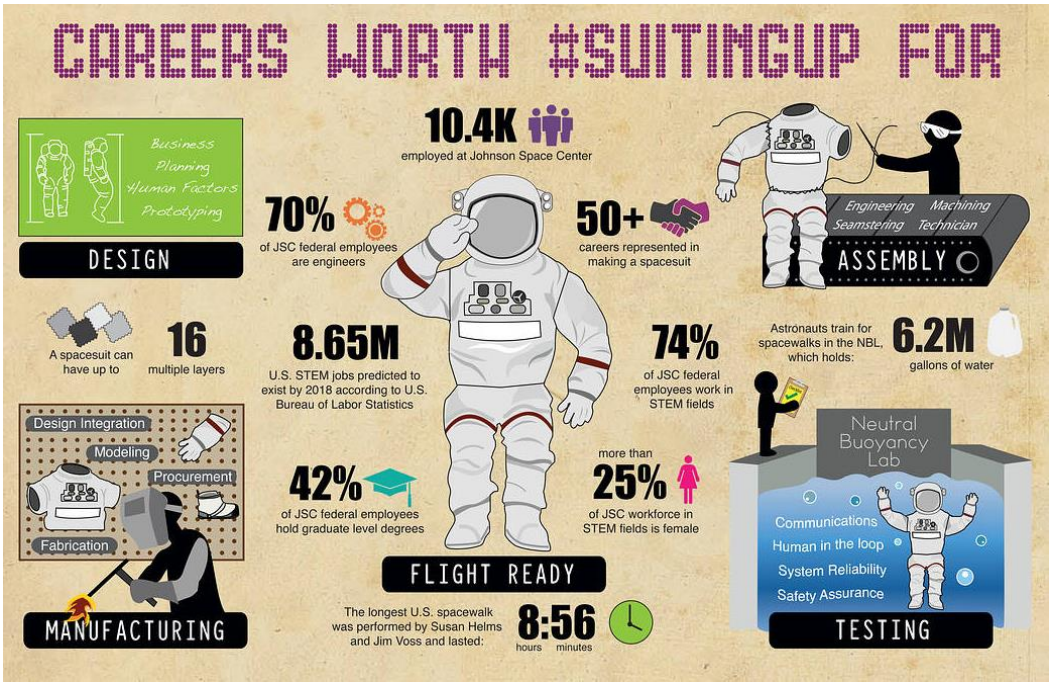
Infographics

Infographics are a method for communicating a lot of information using images words and numbers in an easier to understand way. They are used to graphically describe an often complicated concept. They are used to convey a large volume of information in a small space. There are many ways to organize information into an infographic depending on what needs to be communicated and the complexity behind the information. Ideally the infographic alone should be able to clearly convey enough information that a reader will be able to absorb the information in a relatively short period of time.

Below are several examples of infographics used by NASA for different projects:


SPACE LAUNCH SYSTEM
ARTEMIS I:
FOUR RS-25 ENGINES
UPGRADED & READY FOR A BOLD NEW MISSION
Shown here from the bottom, looking up at the rocket from below, four liquid hydrogen (LH2) and liquid oxygen (LOX)-fueled RS-25 ENGINES are arranged in a square pattern, like legs on a table, providing stability and even distribution of propulsion forces to the rocket. At launch, they will produce
2 MILLION POUNDS OF THRUST
to help power the Space Launch System.
CORE STAGE
LH2
LOX
ENGINE SECTION
PROPELLANT TANKS
Including these first four engines, NASA has a total 16 ENGINES available for the first four missions.
www.nasa.gov/SLS
1
2
3
4
E2045
E2056
E2058
E2060
WHAT'S IN A NUMBER?
Each engine has its own number and NASA keeps a history of which engines are used on each mission. For the first SLS flight, they are engines E2045, E2056, E2058 and E2060.
ENABLING MISSION SUCCESS
These four proven engines contributed to 21 successful shuttle flights over three decades.
E2045: most veteran engine with 12 FLIGHTS (First flight was STS-89 in January 1998 and last was STS-135 in July 2011); also flew on Astronaut John Glenn's last flight, STS-95
E2056: Total 4 FLIGHTS, including STS-114, NASA's Return to Flight after Columbia
E2058: Total 6 FLIGHTS, including first flight of a Swedish astronaut (Christer Fuglesang)
E2060: Total 3 FLIGHTS, including STS-135, the last shuttle mission
WHAT'S NEW FOR SLS?
ENGINE CONTROLLERS - the brains of the engine
HIGHER THRUST - equates with better performance
ADAPTED TO SLS UNIQUE OPERATING ENVIRONMENTS


#suitup for safety
1 Mercury Suit
NASA's first spacesuits were Navy high-altitude pressure suits modified for the Mercury Program and were only worn inside the Mercury spacecraft.
2 Gemini Suit
The Gemini suit advanced the Mercury suit design through the use of an oxygen and communication line from the spacecraft through a hose attached to the suit and also served as a safety tether.
3 Apollo Suit
The Apollo suit design added the ability to be completely independent of the Lunar Lander and introduced a Portable Life Support System (PLSS).
4 Skylab Suit
The Skylab program used a derivative of the Apollo spacesuit, the A7LB, which included a belly-mounted Astronaut Life Support Assembly (ALSA) and umbilical. The Skylab extravehicular activities proved orbiting space station construction and repairs were possible.
5 Shuttle / Space Station Suit
The Shuttle / Space Station suit was designed to give us the ability to work in zero gravity, have high mobility in the arms and gloves, have a PLSS and be used only for spacewalks outside the space vehicle.
6 Exploration Suit
The Exploration Suit is designed for a new era of exploration. Incorporating technological advances and increased mobility, this design will enable us to return to the Lunar surface and other planetary surfaces.
Key Capabilities
Life Support
A Portable Life Support System (PLSS) supplies oxygen, carbon dioxide removal, water for the suit cooling garment and a radio for communications.
O_2
Lightweight
The visor of the helmet is coated with a thin layer of gold that filters out the sun's harmful rays.
UV Protection
Enhanced Mobility
Temperature
In space, it can be 250°F in the sun and -250°F in the shade.
Communications
The fingers on gloves are flexible, tactile and have heaters in the fingertips if the fingers get cold.
Human Protection
Gloves
An 85-foot safety tether attaches the crew member to the space vehicle.
Safety Tether
Long-term Durability
The Simplified Aid for Extravehicular Rescue (SAFER) is an emergency jetpack worn during spacewalks.
SAFER
Life Support

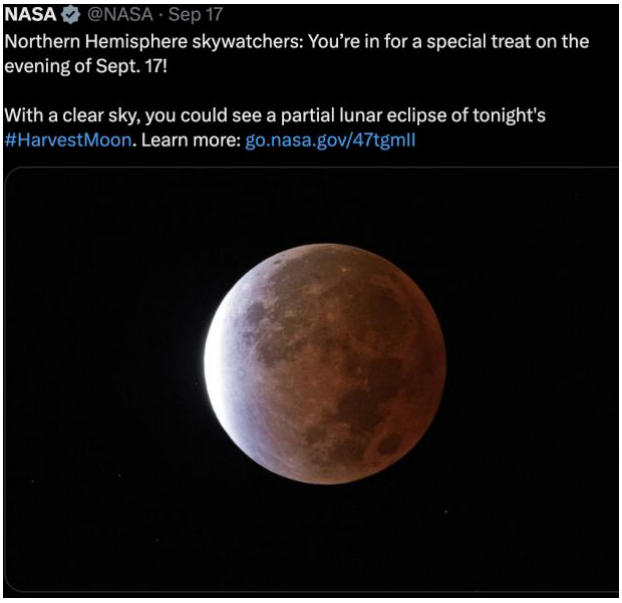


(Source of infographics used for examples: NASA)

Social Media Posts

Social media posts are a great way to get messages to a large group of people. However, some of the options limit how much you can share. For social media communications it will be important that you can effectively communicate your message briefly while capturing key information, keeping in mind the specific audience that will engage with that specific social media platform. Social media posts should also be engaging so viewers of the content pay attention to what is being communicated.

Some examples of these use some text and/or images to both convey the message and to engage their audience:



Source NASA on X

Press Releases

Press releases are used to create awareness of a certain topic area to a target audience. They should be concise, factual, and easy to be covered by other media. They are used for a variety of purposes such as:

- Announcing news
- Communicating organizational changes
- Building relations
- Responding to a crisis

It is important for a press release to communicate "Who, What, When, Where, Why." Try to keep Press Releases short, about no more than a page in length. Keep in mind that press releases are usually used when something noteworthy is happening (not just an informational piece) so consider why this press release is being written—what is happening?

Authors

Dr. Robert Deters
Associate Professor, Embry-Riddle Aeronautical University-Worldwide

April Lanotte
Stakeholder and Workforce Development Lead, NASA Aeronautics Research Mission Directorate

Dr. Brent Terwilliger
Associate Professor, Embry-Riddle Aeronautical University-Worldwide

Acknowledgments

Special thanks to past contributors: Jeffrey Coppola, Andrew Shepherd, Brian Sanders, James Marion, Paul Lange, Debra Bourdeau, and Stefan Kleinke.