Microsoft / FlightFX

Joby S4 Microsoft Flight Sim User Manual

For Microsoft Flight Simulator 2020 / 2024

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FOR SIMULATION USE ONLY - DESIGNED FOR SINGLE-PILOT OPERATION

This manual is designed to provide clear, concise instructions for operating the Joby S4 electric vertical takeoff and landing (eVTOL) aircraft within Microsoft Flight Simulator. The content herein is tailored for both new and experienced pilots, offering detailed guidance on the unique aspects of the Joby S4's operation. This simulation is based on an early development version of the aircraft and may not fully reflect the final production model. Some concessions have been made to simplify single-pilot operations within the simulation environment.

PHOTOSENSITIVE SEIZURE WARNING

A small percentage of individuals may experience seizures when exposed to certain visual stimuli, such as flashing lights or patterns commonly found in video games. This can occur even in individuals with no prior history of epilepsy or seizures. If you experience any symptoms such as dizziness, vision changes, twitching, or loss of consciousness, stop playing immediately and consult a physician.
To minimize the risk of photosensitive seizures:

- Play in a well-lit room.
- Take regular breaks, especially if you feel tired or fatigued.

If you or a family member has a history of seizures or epilepsy, consult a doctor before using this simulation.

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ABOUT THE JOBY S4

The Joby S4 is a cutting-edge tiltrotor eVTOL aircraft developed by Joby Aviation. Designed with urban air mobility in mind, the S4 emphasizes silent operation, making it an ideal choice for air taxi services in densely populated areas. The aircraft is a single-pilot design with seating for up to four passengers.

Development History

Founded in 2009, Joby Aviation set out to create an all-electric aircraft that would meet rigorous safety standards, operate with minimal noise, and be economically viable. The initial design, the two-seat S2, featured a fixed-wing with a V-tail and 12 tilting rotor systems powered by electric motors. While the S2 never entered production, its extensive simulations laid the groundwork for the S4.

The S4 continues the fixed-wing design philosophy, featuring a high-wing monoplane configuration with a forward-swept V-tail. It is powered by six tilting rotor systems: one on each end of the V-tail and four on the main wing. Each rotor is driven by a 70-kilowatt electric motor, with advanced noise-reduction features designed for quiet operation during takeoff, landing, and hover.

Design Features

- Safety and Redundancy: Each motor has dual windings and dual inverters to ensure redundancy. If any rotor system fails, the remaining rotors can compensate, allowing the aircraft to remain operational.
- Flight Control System: The Joby S4 is equipped with a fully fly-by-wire (FBW) flight control system, designed to optimize pilot efficiency. The system includes two inceptors—one on the right side (RHI) for controlling altitude and direction, and one on the left (LHI) for speed and acceleration. The controls adapt dynamically based on the current flight mode, offering intuitive operation across all phases of flight.
- Quiet Operation: The aircraft operates with minimal noise, emitting just 45.2 decibels during overhead flight and 65 decibels during takeoff, landing, and hovering—levels that are considered background noise in urban environments.

Specifications

- Dimensions: 21 feet in length, 38 feet 1 inch wingspan.
- Power: Powered by high-density lithium-ion polymer batteries, housed in titanium cases, and cooled by liquid systems.
- Performance: Service ceiling of 15,000 feet, range of 150 miles, and a maximum cruise speed of 200 miles per hour.

Cockpit Overview

The S4 features a Garmin G3000 fully integrated flight deck, equipped with high-resolution color displays and synthetic vision. The cockpit design prioritizes pilot situational awareness, providing all necessary flight information at a glance.

Unique Capabilities

The Joby S4's ability to transition seamlessly from vertical to forward flight and back again, combined with its silent operation, makes it a revolutionary step forward in urban air mobility. It is not designed for conventional rolling takeoffs or landings, relying entirely on its vertical takeoff and landing (VTOL) capabilities.

COCKPIT OVERVIEW

1. MFD (Multi-Function Display)
2. PFD (Primary-Flight Display)
3. MFD SOFTKEYS
4. PFD SOFTKEYS
5. GTC (Garmin Touchscreen Controller)
6. LEFT-HAND INCEPTOR (LHI)
7. RIGHT-HAND INCEPTOR (RHI)
8. REMOTE CONTROL PANEL
9. BATTERY SWITCH
10. SPEED HOLD JOYSTICK
11. DECELERATION BUTTON
12. DISENGAGE BUTTON
13. LEVEL BUTTON

The Joby S4 cockpit is designed for intuitive, single-pilot operation, featuring a combination of advanced avionics and user-friendly controls. The layout prioritizes ease of use and situational awareness, ensuring that all critical information is readily accessible to the pilot.

Key Components

1. Garmin G3000 Integrated Flight Deck
    - Primary Flight Display (PFD): Displays essential flight information, including airspeed, altitude, attitude, and heading. The PFD also includes a split-screen moving map view for navigation.
    - Multi-Function Display (MFD): Provides detailed information on the aircraft's systems, including power management, energy consumption, range, and battery status.
    - Garmin Touchscreen Controller (GTC): A touch-sensitive interface used for flight planning, navigation, and system settings.
2. Inceptors
    - Left-Hand Inceptor (LHI): Used to control the aircraft's speed and acceleration. The LHI is mapped to the throttle axis in your control scheme.
    - Right-Hand Inceptor (RHI): Used to control the aircraft's altitude, pitch, bank, and yaw, depending on the flight mode.
3. Flight Mode Annunciator (FMA)
    - Displays the active flight mode and other flight-related statuses, such as TRC (Translational Rate Command) or speed hold.
4. Battery Switch
    - Powers the aircraft's systems, initiating the startup sequence.
5. Softkeys
    - Located below the PFD and MFD, these keys are used to interact with various system menus and settings.
6. DECELERATION Button
    - Used to activate the Deceleration to Hover or Deceleration to Waypoint modes, depending on the flight phase.
7. Speed Hold Joystick
    - Allows the pilot to set and adjust the target speed in 10-knot increments during forward flight.
8. LEVEL Button
    - Engages the Level Hold mode, adjusting the control surfaces to maintain straight and level flight.
9. DISENGAGE Button
    - Disengages all active automatic modes, returning the aircraft to manual control.

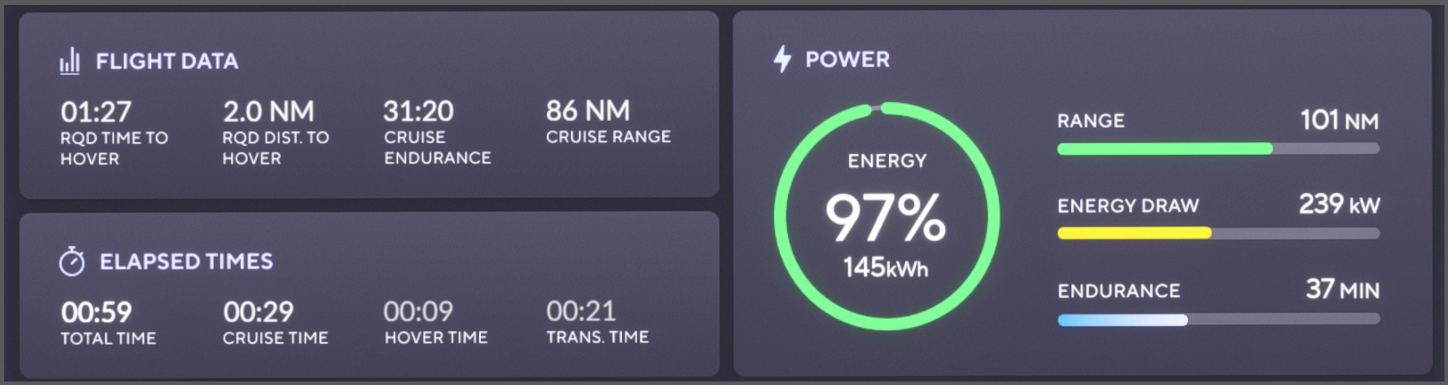
Cockpit Lighting

- Nav and Strobe Lights: Used to signal that the aircraft is powered on and preparing for operations. These can be activated using the softkeys on the MFD.

Energy Management Display

- **Energy Bars**: Show the current battery capacity, power usage, and remaining flight time. These bars dynamically update based on the mode of operation, power settings, and airspeed.

This layout ensures that all essential controls are within easy reach, and critical information is displayed prominently, allowing the pilot to manage the Joby S4 efficiently across all phases of flight.



DEFINITION OF FLIGHT PHASES

The Joby S4's behavior and control responses vary depending on the flight phase. The aircraft automatically determines its current flight phase based on various factors, such as speed, altitude, and ambient conditions, without requiring pilot intervention. Understanding these phases is crucial for effectively managing the aircraft during different stages of flight.

1. Ground Phase

- **Active Condition**: The aircraft is on the ground, detected via weight on wheels sensors, with flight mode set to FLY.
- **Controls**:
  - **Left-Hand Inceptor (LHI)**: Controls ground speed, with full forward deflection requesting a 15-knot taxi speed. Full backward deflection requests 0 knots, bringing the aircraft to a stop.
  - **Right-Hand Inceptor (RHI)**: Used for steering the aircraft on the ground via the twist axis. Forward/backward movements are disabled.

2. Thrust-Borne Flight Phase (Hover)

- **Active Condition**: The aircraft is in flight with an indicated airspeed below 40 KIAS.
- **Controls**:
  - **LHI**: Controls target ground speed, with a notch below full forward deflection requesting a 40-knot speed. Full forward deflection switches to "FLY" mode, prompting a transition to wing-borne flight.
  - **RHI**: Controls vertical speed, with backward deflection commanding a climb and forward deflection commanding a descent. Centering the RHI holds altitude.

3. Transition Flight Phase

- **Active Condition**: The aircraft is transitioning from hover to conventional flight mode, with an indicated airspeed between 40 KIAS and approximately 80 KIAS.
- **Controls**:
  - **LHI**: Controls acceleration and deceleration, with full forward deflection requesting 0.3G acceleration and full backward deflection requesting -0.3G deceleration.
  - **RHI**: Controls vertical speed and pitch, depending on the current phase of transition.

4. Wing-Borne (Conventional) Flight Phase

- **Active Condition**: The aircraft is in forward flight with an indicated airspeed above approximately 80 KIAS.
- **Controls**:

- **LHI**: Controls acceleration/deceleration, similar to the transition phase.
- **RHI**: Controls pitch (nose up/down) and bank (left/right), allowing the pilot to maneuver the aircraft as in a conventional fixed-wing aircraft.

Flight Director V-Bars

- The flight director V-bars provide a visual indication of the current flight mode:
  - **Gray V-Bars**: Indicate hover mode.
  - **Cyan V-Bars**: Indicate forward flight mode.

Flight Mode Transitions

- **Hover to Forward Flight**: Achieved by pushing the LHI to full forward deflection to increase airspeed above 40 KIAS. The nacelles will tilt forward, transitioning the aircraft into wing-borne flight.
- **Forward Flight to Hover**: Activated by pulling back the LHI below the midpoint to reduce airspeed below 80 KIAS, at which point the nacelles tilt upwards to supplement wing lift. The Deceleration to Hover mode can be used to automate this transition.

These flight phases are crucial to understanding how the Joby S4 operates and what control inputs are required at each stage. Familiarity with these phases will allow pilots to smoothly transition between different modes of flight and effectively manage the aircraft's performance.

CONTROL RESPONSES IN DIFFERENT FLIGHT PHASES

The Joby S4's control responses are dynamically adjusted based on the current flight phase, providing optimized handling for each mode of operation. This section details how the inceptors (LHI and RHI) behave across different phases of flight.

Flight Phases and Inceptor Responses

INCEPTOR	AXIS	FLIGHT MODE			
		GROUND	HOVER	HOVER - WITH TRANSLATIONAL RATE COMMAND (TRC)	TRANSITION/ CONVENTIONAL
LEFT-HAND INCEPTOR	FORWARD / BACKWARD	SPEED	SPEED	SPEED	ACCELERATION
RIGHT-HAND INCEPTOR	FORWARD / BACKWARD	VERTICAL SPEED	VERTICAL SPEED	VERTICAL SPEED	PITCH
	LEFT / RIGHT	-	BANK	SIDE SPEED	BANK
	TWIST LEFT / RIGHT	STEERING	HEADING	HEADING	YAW

Inceptor Functions by Flight Phase

Ground Phase

- **Left-Hand Inceptor (LHI)**: Controls taxi speed by moving the inceptor forward or backward, ranging from 0 to 15 knots.
- **Right-Hand Inceptor (RHI)**: Controls vertical speed for liftoff, but no lateral (bank) control. Twist axis controls steering (yaw).

Hover Phase

- **LHI**: Adjusts the ground speed, with forward deflection increasing speed up to 40 knots. Full forward deflection transitions to forward flight.
- **RHI**: Controls vertical speed. Pulling back climbs; pushing forward descends. Centering holds altitude.

Hover Phase with TRC

- **LHI**: Controls lateral movement and speed up to 40 knots.
- **RHI**: Offers precise control over vertical speed and heading. TRC allows for highly controlled lateral and vertical movements without drift.

Transition/Conventional Flight Phase

- LHI: Controls acceleration or deceleration with forward/backward deflections. Centering holds current speed.
- RHI: Controls pitch (nose up/down) and bank (left/right). The aircraft behaves like a conventional fixed-wing aircraft in this phase.

Ground Phase Controls

In the ground phase, the Joby S4's controls are tailored for taxiing and preparing for vertical takeoff. Understanding how to effectively use the inceptors during this phase is crucial for safe and efficient ground operations.

LEFT-HAND INCEPTOR (LHI) - Ground Phase

FORWARD / BACKWARD MOVEMENT:

- Function: Adjusts target ground speed.
- Operation:
  - Full forward deflection: Requests a taxi speed of 15 knots.
  - Full backward deflection: Requests 0 knots, bringing the aircraft to a stop.
  - Intermediate positions: Gradually adjusts target speed between 0 and 15 knots.
- Display: Target ground speed is shown on the MFD, with current speed and target speed visually represented.

Note: The Joby S4 lacks a traditional braking system. Ground braking is automatically managed by reducing the target speed below the current speed, causing the aircraft to decelerate and stop.


Full Backwards => 0 KTS Ground Speed (Stop)
Full Forward => 15 KTS Ground Speed


Selected Ground Speed target value
Selected Ground Speed reprentation
Current Ground Speed visual reprentation
Current Ground Speed value
08 KTS
GROUND SPEED
04 KTS
HOVER CONTROLS
FLIGHT DATA
20:59
CRUISE ENDURANCE
49 NM
CRUISE RANGE
RQD TIME TO HOVER
RQD DIST. TO HOVER
ELAPSED TIMES
00:00
TOTAL TIME
00:00
CRUISE TIME
00:00
HOVER TIME
00:00
TRANS. TIME
POWER
ENERGY
49%
73kWh
RANGE
3 NM
ENERGY DRAW
80 kW
ENDURANCE
55 MIN
FLY

RIGHT-HAND INCEPTOR (RHI) - Ground Phase

FORWARD/BACKWARD MOVEMENT:

- **Function**: Controls vertical speed (VS) for liftoff.
- **Operation**:
    - **Pulling back**: Initiates a climb, translating into a vertical lift-off.
    - **Pushing forward**: Vertical descent commands are disabled in this phase.
    - **Vertical speed**: Adjusted between 0 and 750 feet per minute (FPM), depending on the deflection amount.

LEFT/RIGHT:

- Function: No lateral control in ground phase.

TWIST CLOCKWISE/COUNTER-CLOCKWISE:

- **Function**: Controls steering by adjusting the aircraft's heading.
- **Operation**:
    - Twist left: Rotates the aircraft's nose counterclockwise.
    - Twist right: Rotates the aircraft's nose clockwise.
- **Usage**: Steering can be performed using the twist axis or a dedicated rudder pedal if available.

Taxiing Tips

- **Throttle Management**: Apply gentle throttle movements to achieve smooth taxi operations. Abrupt throttle adjustments can result in sudden stops or rapid acceleration, which may affect ground handling.
- **Steering**: Use the twist axis on the RHI for steering. The aircraft is highly responsive, capable of making tight turns even in restricted spaces.
- **Stopping**: Reduce the LHI deflection to 0 knots to bring the aircraft to a stop. The aircraft will automatically cut power to the motors, allowing for a quick and controlled stop without traditional brakes.

Important Considerations

- **Energy Management**: Ground operations draw power from the battery. Monitor the energy display to ensure sufficient power for the upcoming flight.
- **TRC**: Translational Rate Control (TRC) is not active in the ground phase. Ensure TRC is armed before takeoff to assist with precision during hover.

This section provides the foundational knowledge needed to maneuver the Joby S4 safely and efficiently on the ground, preparing it for a vertical takeoff.

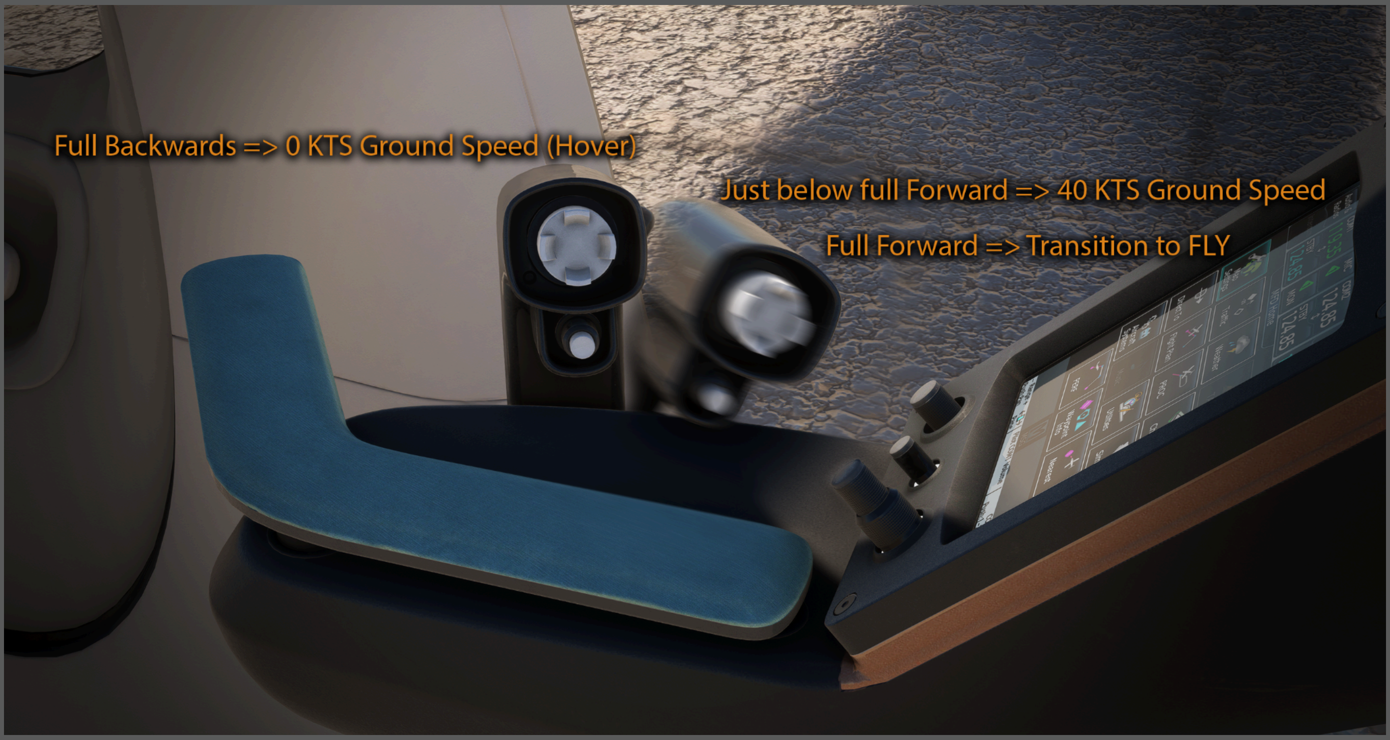
THRUST-BORNE CONTROLS (HOVER)

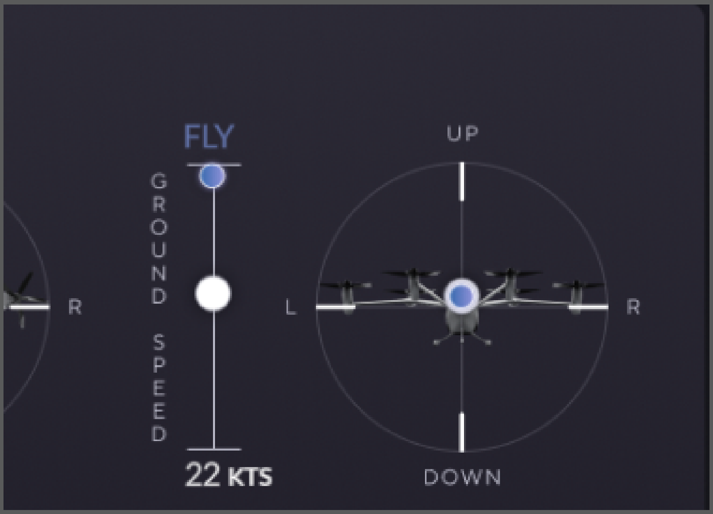
During the hover phase, the Joby S4 operates in a thrust-borne state, where vertical lift is provided entirely by the rotors. This phase is active when the aircraft's indicated airspeed is below 40 KIAS. The control inputs in this phase are designed for precision maneuvering, allowing for stable vertical and lateral movements.

LEFT-HAND INCEPTOR (LHI) - Hover Phase

FORWARD/BACKWARD MOVEMENT:

- **Function**: Adjusts target ground speed.
- **Operation**:
  - **Full forward deflection**: Changes the target selected speed to "FLY," initiating a transition to wing-borne flight as the airspeed exceeds 40 KIAS.
  - **Intermediate deflections**: Adjusts speed between 0 and 40 knots.
  - **Full backward deflection**: Commands 0 knots, bringing the aircraft to a hover.
- **Display**: The MFD shows the current and target ground speed, assisting the pilot in maintaining or adjusting hover speed.





RIGHT-HAND INCEPTOR (RHI) - Hover Phase

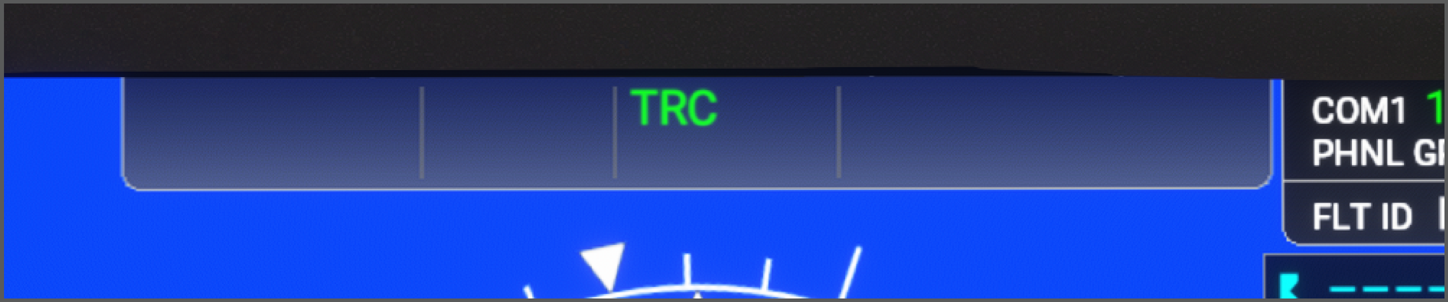
FORWARD/BACKWARD MOVEMENT:

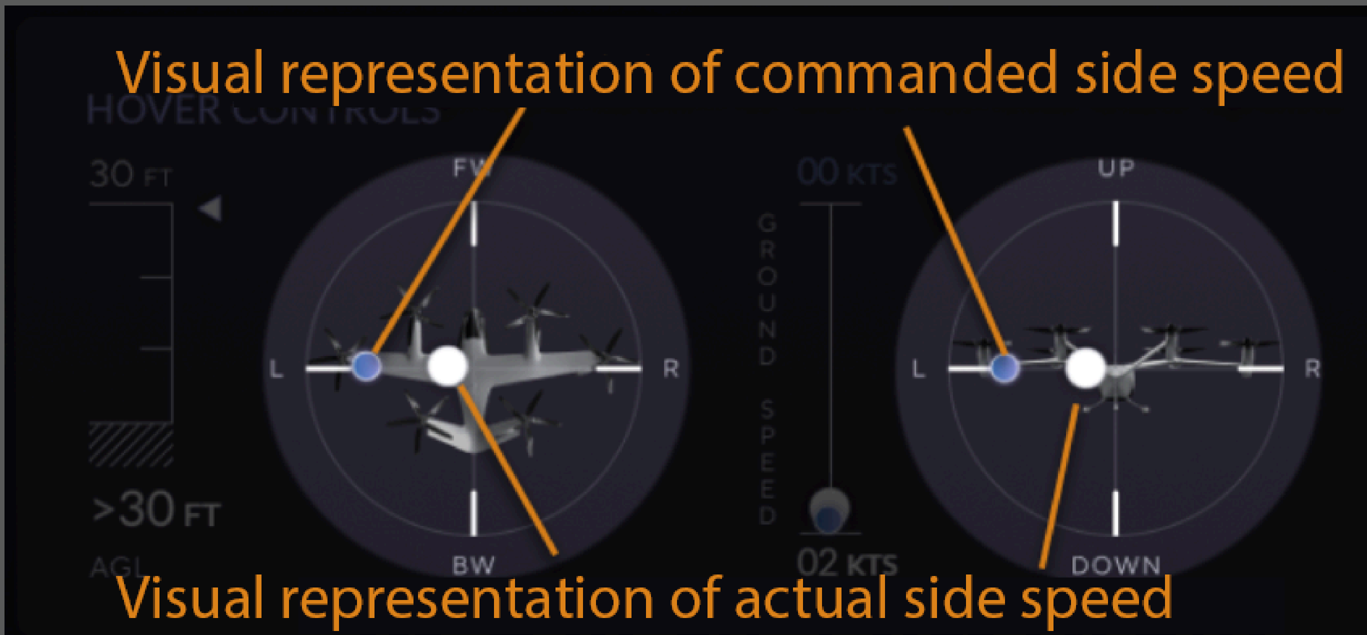
- **Function**: Controls vertical speed.
- **Operation**:
  - **Pulling back**: Commands a climb up to 750 feet per minute.
  - **Pushing forward**: Commands a descent down to -750 feet per minute.
  - **Centering the RHI**: Engages altitude hold, maintaining the current altitude.
- **Display**: Vertical speed indicators on the MFD assist in monitoring climb or descent rates.

LEFT/RIGHT MOVEMENT:

- **Function**: Controls lateral movement.
- **Operation**:
  - **Deflecting left or right**: Commands a bank or side-slip movement depending on whether TRC is active.
  - **With TRC active**: The RHI controls side-slip, allowing precise lateral positioning without altering the aircraft's heading.
  - **With TRC inactive**: The RHI controls banking, affecting the aircraft's roll angle.

The following images are indicative of a state where **TRC** is active (note the **TRC** illuminated in the Annunciator Panel):





The following images are indicative of a state where **TRC** is inactive (**TRC** is extinguished in the Annunciator Panel):

TWIST CLOCKWISE/COUNTER-CLOCKWISE:

- **Function**: Adjusts heading.
- **Operation**:
  - **Twist left**: Rotates the aircraft's nose counterclockwise.
  - **Twist right**: Rotates the aircraft's nose clockwise.
- **Usage**: The twist function allows for precise heading adjustments, essential during hovering, especially in tight spaces or for positioning over a helipad.

TRANSLATIONAL RATE CONTROL (TRC) - Hover Phase

TRC Overview:

- **Purpose**: TRC mode is designed for precise control during hover, allowing the pilot to make small, controlled movements in any direction without drift.
- **Activation**: TRC is armed by default during hover and remains armed unless manually toggled off.
- **Operation**: TRC limits the aircraft's movements to a specific rate, ensuring that lateral, vertical, and rotational movements are smooth and controlled.

TRC Indicators:

- **Visual Indicator**: When TRC is active, the annunciator panel will display "TRC" in white.
- **Control Response**: In TRC mode, the RHI's left/right deflection commands side-slip rather than bank, maintaining the aircraft's heading while allowing lateral movement.

Usage Scenarios for TRC in Hover

- **Precision Landing**: TRC is particularly useful when landing on small platforms, such as helipads. It allows the pilot to maneuver the aircraft with high precision, holding the position until landing is complete.
- **Obstacle Avoidance**: During hover, TRC helps in avoiding obstacles by allowing precise lateral or vertical adjustments without unintentional drift or rotation.

Important Notes on Hover Phase

- **Energy Consumption**: Hovering is energy-intensive. Monitor the energy display and consider transitioning to forward flight when feasible to conserve power.
- **Wind Compensation**: TRC automatically compensates for wind and turbulence, holding the aircraft steady even in challenging environmental conditions.

"TRANSITION" PHASE & WING-BORNE (CONVENTIONAL) FLIGHT PHASE

The transition phase occurs as the Joby S4 moves from hover to wing-borne flight, with the aircraft gaining speed and gradually shifting lift from the rotors to the wings. The wing-borne (conventional) flight phase is fully engaged when the aircraft reaches a speed where the wings provide the necessary lift, allowing for efficient forward flight.

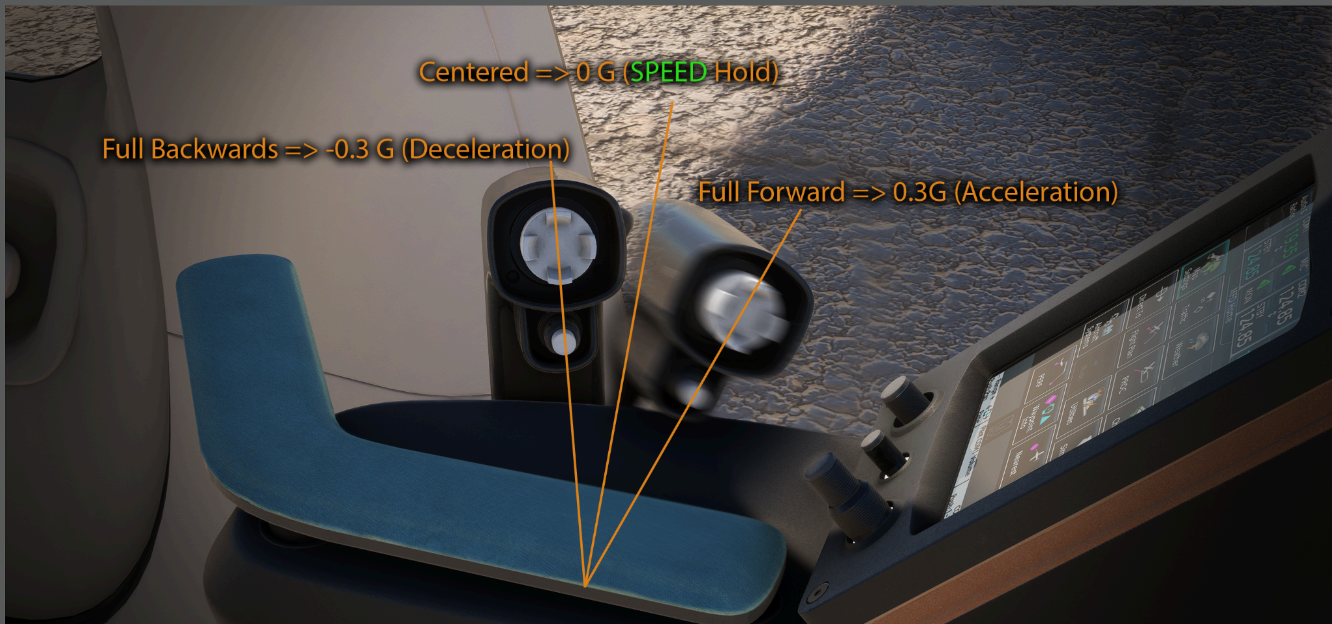
LEFT-HAND INCEPTOR (LHI) - Transition & Wing-Borne Flight Phases

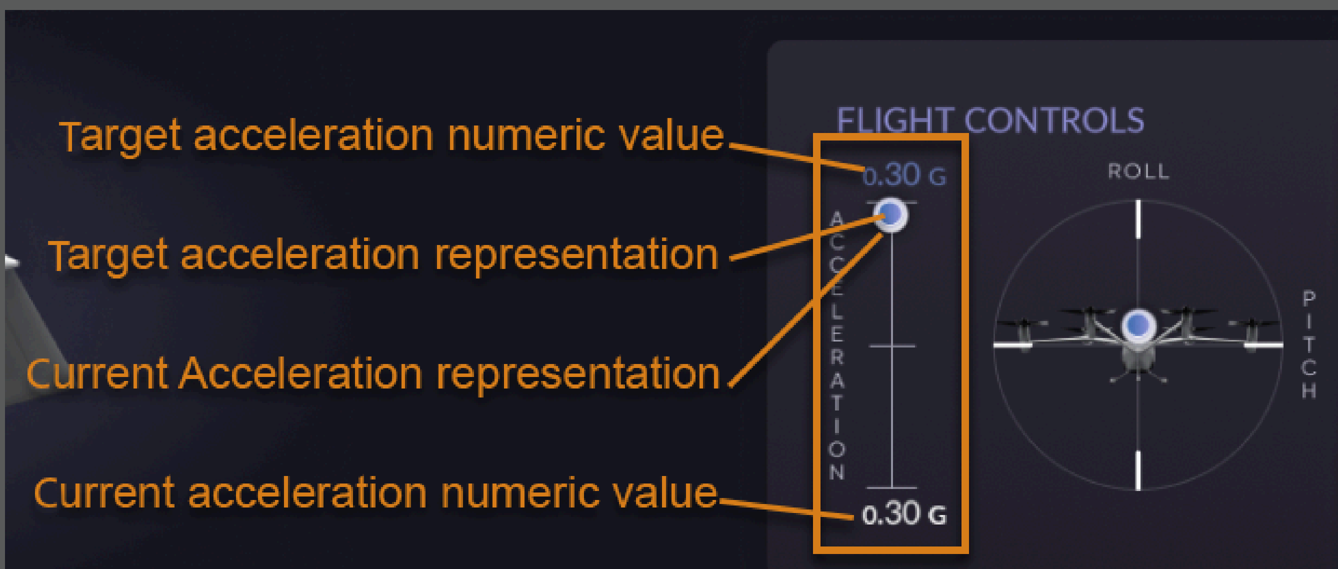
Forward/Backward Movement:

- **Function**: Controls acceleration and deceleration.
- **Operation**:
  - Full forward deflection: Requests 0.3G acceleration, increasing the aircraft's speed.
  - Full backward deflection: Requests -0.3G deceleration, reducing speed.
  - Centered position: Engages speed hold, maintaining the current airspeed.
- **Display**: The MFD shows acceleration or deceleration rates and target speed, helping the pilot manage the transition smoothly.

Transitioning to Forward Flight:

- **Procedure**: Push the LHI to full forward deflection to increase airspeed beyond 40 KIAS. As the speed increases, the nacelles tilt forward, and the aircraft transitions to wing-borne flight.
- **Visual Indicator**: The flight director V-bars will change from gray to cyan, indicating that the aircraft has transitioned to forward flight mode.





RIGHT-HAND INCEPTOR (RHI) - Transition & Wing-Borne Flight Phases

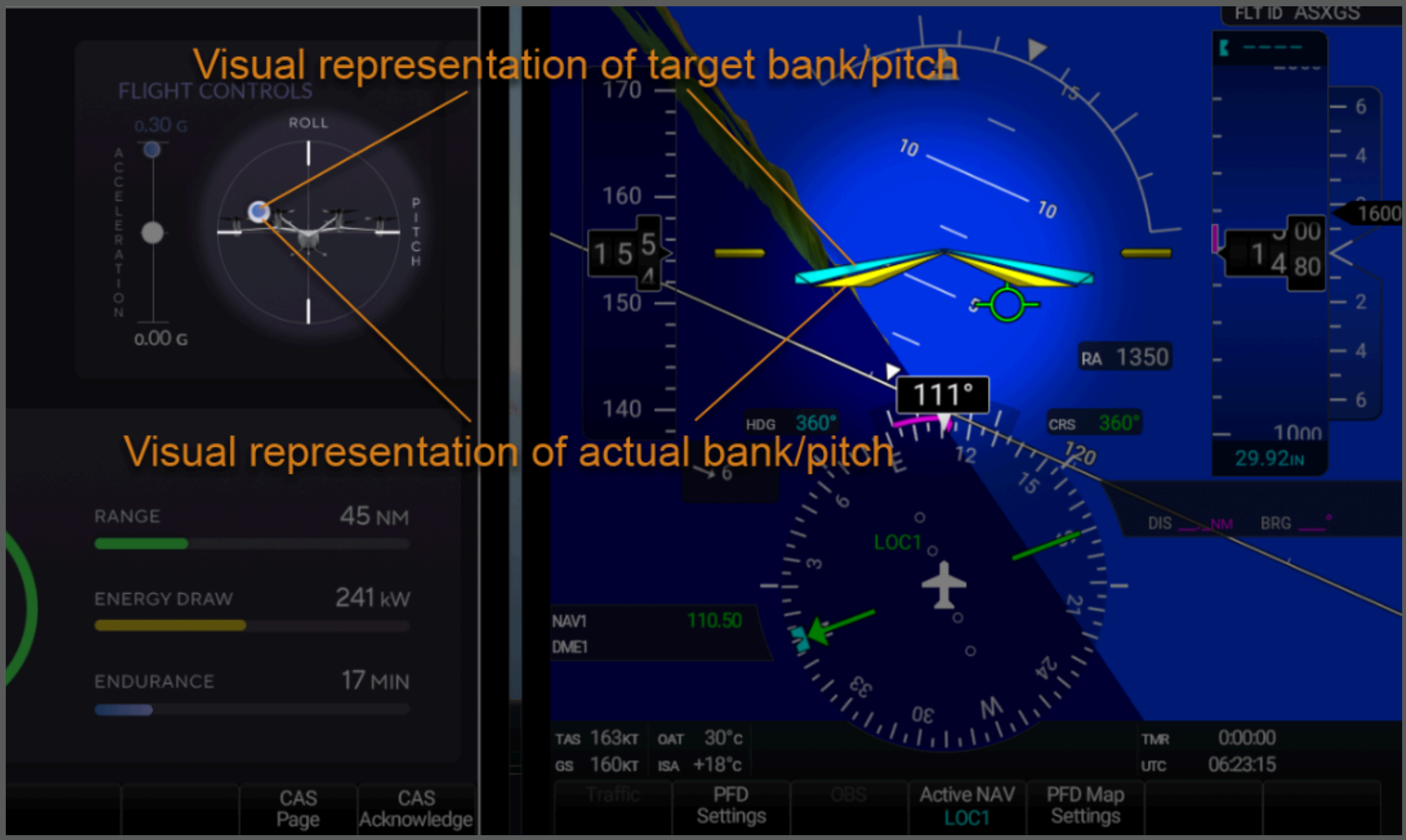
Forward/Backward Movement:

- **Function**: Controls pitch rate.
- **Operation**:
  - Pulling back: Raises the aircraft's nose, increasing pitch and altitude.
  - Pushing forward: Lowers the nose, decreasing pitch and altitude.
  - Centered position: Holds the current pitch, maintaining level flight.

Left/Right Movement:

- **Function**: Controls roll rate (banking).
- **Operation**:
  - Deflecting left or right: Commands a roll to the left or right, allowing the aircraft to bank and turn.
  - Centered position: Maintains the current bank angle, holding the aircraft steady.

Target bank that the aircraft will track is represented both on MFD and PFD as shown in the below image:



Twist (Clockwise/Counter-Clockwise):

- **Function**: Adjusts yaw rate.
- **Operation**:
  - Twist left: Commands a left yaw, turning the aircraft's nose to the left.
  - Twist right: Commands a right yaw, turning the aircraft's nose to the right.
  - Centered position: Returns the aircraft to coordinated flight, aligning the nose with the flight path.

Envelope Protection

Safety Limits:

- **Bank**: Limited to 45 degrees to prevent excessive rolling.
- **Pitch**: Limited to 30 degrees in either direction to avoid steep climbs or descents.

Automatic Adjustments:

- **Protection Mechanisms**: If the pilot commands inputs that exceed these limits, the fly-by-wire (FBW) system automatically adjusts the inputs to keep the aircraft within safe operational parameters.

Speed and Level Hold Modes

Speed Hold Mode:

- **Activation**: Can be activated during transition or conventional flight by centering the LHI or using the Speed Hold Joystick.
- **Function**: Maintains the selected airspeed by automatically adjusting thrust.
- **Display**: The Flight Mode Annunciator (FMA) displays “SPEED” when active, and a cyan speed target bug appears on the MFD.

Level Hold Mode:

- **Activation**: Toggled by pressing the LEVEL button.
- **Function**: Maintains straight and level flight, automatically adjusting pitch to hold zero vertical speed.
- **Display**: The FMA shows “LEVEL” when active, indicating that the aircraft is maintaining a level attitude.

DECELERATION TO HOVER and DECELERATION TO WAYPOINT Modes

Deceleration to Hover:

- **Function**: Automatically decelerates the aircraft to transition back into hover mode.
- **Activation**: Toggled by pressing the DECELERATION button. The system calculates the required deceleration and manages the transition, bringing the aircraft to a hover above a specific point.
- **Display**: The FMA displays “DCL TO HVR” when active.

Deceleration to Waypoint:

- **Function**: Decelerates the aircraft to a hover above a specified waypoint, typically a destination airport entered into the flight plan.
- **Activation**: Toggled by holding the DECELERATION button for more than 1 second. The system considers current speed and distance to the waypoint to manage the deceleration effectively.
- **Display**: The FMA shows “DCL TO WP” when active.

Important Considerations for Transition & Wing-Borne Flight

- **Nacelle Positioning**: During the transition to wing-borne flight, the nacelles gradually tilt forward. Ensure that the aircraft’s airspeed is adequate for this transition to prevent loss of lift.
- **Energy Management**: Forward flight is more energy-efficient than hovering. Consider transitioning to forward flight as soon as feasible to conserve battery life.

- Wind Effects: Be mindful of wind conditions during the transition. Strong winds can affect the aircraft's stability, particularly when moving from hover to forward flight.

This section outlines the critical control responses and operational considerations for the Joby S4 during the transition and wing-borne flight phases, ensuring pilots have the necessary knowledge to manage these phases effectively.

INSTRUMENTATION INDICATIONS

The Joby S4 is equipped with advanced instrumentation to monitor the aircraft's systems and provide the pilot with critical flight data. These instruments are essential for managing energy consumption, navigating flight phases, and ensuring safe operations.

The Systems Monitor page is always displayed on the G3000 Multi-Function Display (MFD). It provides real-time information on the following:

Energy (Battery Capacity)

- **Display**: Shows the remaining battery capacity as a percentage and in kilowatt-hours (kWh).
- **Maximum Capacity**: 150 kWh.
- **Usage**: Represents the absolute value of remaining energy, functioning similarly to a fuel gauge in conventional aircraft.

Range

- **Display**: Represents the aircraft's maximum possible range based on the current power consumption rate and ground speed. The range is measured in nautical miles (NM).

- **Dynamic Updates**: Adjusts in real-time based on changes in speed, power usage, or environmental conditions.

Energy Draw

- **Display**: Shows the current power consumption rate, measured in kilowatts (kW).
- **Typical Values**:
  - **Hovering in Place**: ~450 kW
  - **Thrust-Borne Climb**: ~600 kW
  - **Conventional Cruise (130 KIAS)**: ~100 kW
  - **Conventional Climb/Max Acceleration**: ~250 kW
- **Importance**: Monitoring energy draw is crucial for ensuring sufficient power reserves during critical flight phases like hover and transition.

Endurance

- **Display**: Indicates the remaining flight time in minutes based on current power consumption.
- **Real-Time Updates**: Adjusts dynamically as energy draw changes, providing an accurate estimate of how long the aircraft can operate before battery depletion.

Cruise Endurance

- **Display**: Shows the time remaining in hours, minutes, and seconds (HH:MM) until the battery reaches the point where only enough energy remains for a 3-minute hover safety margin.

Cruise Range

- **Display**: Represents the maximum distance in nautical miles that the aircraft can travel while maintaining enough energy for a 3-minute hover safety margin.

Required Time to Hover

- **Display**: Shows the expected time required to decelerate into a stable hover state if the pilot starts decelerating at the current moment at a rate of -0.1G.
- **Real-Time Updates**: This value is continuously updated based on actual acceleration rates, providing precise information on when the aircraft will enter hover mode.

Required Distance to Hover

- **Display**: Similar to the required time to hover, this value represents the expected distance to hover if the pilot decelerates immediately at a rate of -0.1G. It helps the pilot plan for hover entry during landing or maneuvering.

Elapsed Time

- Display: Shows the total time spent in each phase of the flight (e.g., ground, hover, forward flight). The active phase is displayed in a brighter color, while inactive phases are grayed out.
- Importance: Provides useful information for tracking operational efficiency and managing battery usage over the course of the flight.

OPERATIONS

The Joby S4's operations are divided into several phases, from startup to landing. This section outlines the necessary steps and best practices for managing each phase effectively.

STARTUP

Procedure:

1. Battery Switch: Turn the battery switch (#9) to the ON position.
2. Garmin System Boot: Wait for the Garmin G3000 system to power on and initialize.
3. Clear Splash Screen: Press the rightmost MFD softkey (#3) to clear the Garmin splash screen and proceed to the system synoptics page.
4. Aircraft Mode (Load Mode vs. Fly Mode):
    - Upon startup, the aircraft is set to LOAD mode by default. In this mode, power is cut to the motors, and the nacelles are locked in the upright position. This ensures safe egress and ingress without activating flight systems.
    - Switch to FLY Mode: Press the 7th MFD softkey to toggle between LOAD and FLY mode. In FLY mode, the aircraft will respond to pilot inputs, and power will be delivered to the motors.

- Press right most MFD SOFTKEY (#3) to continue into the System Synoptics Page.
- Joby starts with “AIRCRAFT MODE” set to **LOAD** mode. This mode cuts the power to the motors and forces the electric motor angles to the upright position; it also disables all input responses to the controls for safe aircraft egress and ingress.
- To allow power to the motors and control over the aircraft, press the 7th MFD SOFTKEY to toggle the aircraft mode between “**LOAD**” and “**FLY**.”

- Once the aircraft is in **FLY** mode, the aircraft will respond to the pilot’s inputs on the controls accordingly.

TAXI

The Joby S4 is capable of ground taxiing in **FLY mode**, even though it relies on vertical takeoff and landing (VTOL) for flight.

Procedure:

1. **Set to FLY Mode**: Ensure the aircraft is in FLY mode, with motors ready for operation.
2. **Taxi Speed**: Use the **Left-Hand Inceptor (LHI)** to select your desired taxi speed:
   - Push forward to increase speed (up to 15 knots).
   - Pull backward to slow down or stop.
3. **Steering**: Use the **Right-Hand Inceptor (RHI)** twist axis or rudder pedals (if available) to steer the aircraft.
4. **Stopping**: Reduce the LHI input to 0 knots to stop the aircraft. As the Joby S4 has no traditional braking system, it automatically stops when the selected speed is lower than the actual ground speed.

Tips for Ground Taxiing:

- **Gentle Throttle Movements**: Apply throttle gently to avoid sudden starts or stops, ensuring smooth taxi operations.
- **Tight Maneuvering**: The Joby S4 is highly agile and capable of making tight turns. Use the twist axis on the RHI for precise steering in confined spaces.
- **No Brakes**: Remember that the Joby S4 lacks conventional brakes. Ground braking is managed by adjusting the throttle to 0 knots.

LIFT OFF

The Joby S4 performs a vertical takeoff (VTO), eliminating the need for a takeoff run.

Procedure:

1. **Set to FLY Mode:** Confirm the aircraft is in FLY mode.
2. **Vertical Speed Selection**: Use the Right-Hand Inceptor (RHI) to select the required vertical speed:
   - Pull back on the RHI to initiate a climb.
   - The motors will spool up, and the aircraft will ascend vertically based on the input.
3. **Altitude Hold**: Center the RHI to maintain the current altitude after achieving lift-off.

Tips for Lift-Off:

- **TRC (Translational Rate Command):** TRC is enabled by default, simplifying vertical and lateral movements during takeoff. TRC helps maintain precise control, particularly useful when operating from confined areas such as helipads.

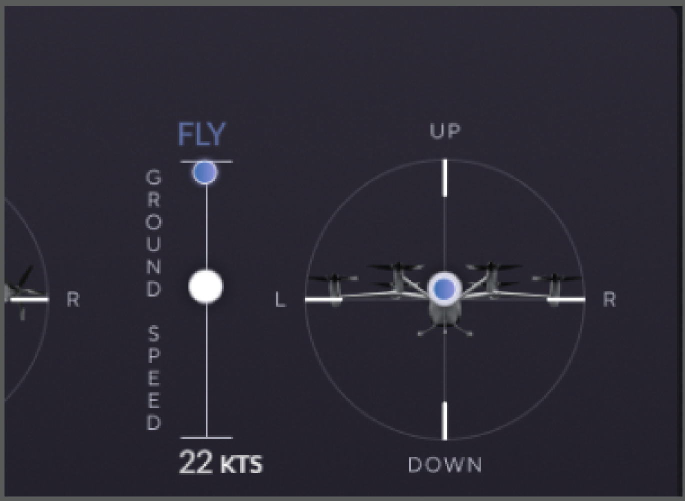
- **Avoid Sudden Inputs:** Gentle RHI inputs allow for smooth ascents and descents, minimizing the risk of instability during vertical takeoff.

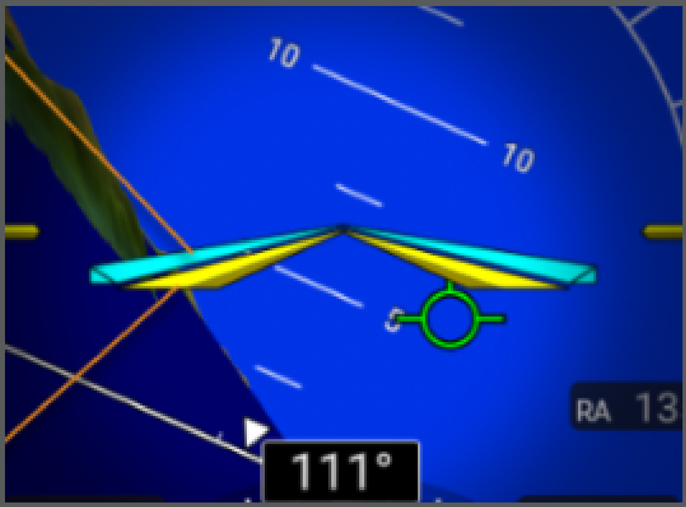
TRANSITION TO FORWARD FLIGHT

Once airborne, the Joby S4 can transition from vertical to forward flight by increasing airspeed and allowing the wings to provide lift.

Procedure:

1. **Increase Airspeed**: Push the **Left-Hand Inceptor (LHI)** to full forward deflection. This changes the target speed to “FLY,” commanding the aircraft to accelerate beyond 40 knots.
2. **Transitioning**: As the airspeed increases, the **nacelles tilt forward**, reducing reliance on vertical thrust and shifting to wing-borne flight.
3. **Monitor Flight Mode**: The Flight Mode Annunciator (FMA) will update as the aircraft transitions into forward flight. The TRC annunciation will extinguish, indicating the switch to conventional controls.





NOTES:

- **Energy Efficiency**: Hovering is energy-intensive, so it’s advisable to transition to forward flight as soon as conditions allow. Forward flight is more efficient and conserves battery life.
- **Smooth Transition**: Avoid abrupt inputs during the transition phase. Gradually increasing speed ensures a smoother shift from hover to forward flight.

DECELERATION BACK TO HOVER

Transitioning back to hover mode from forward flight requires a controlled deceleration process. This phase is crucial for safe landing and precise positioning over a target, such as a helipad.

Procedure:

1. **Reduce Speed**: Pull back on the Left-Hand Inceptor (LHI) to decelerate the aircraft. The LHI can be pulled back to below the midpoint to request negative acceleration (deceleration).
   - **Initial Deceleration**: As the aircraft drops below the conventional speed threshold (approximately 80 KIAS), the motors will begin tilting upwards to compensate for the loss of wing lift, allowing the aircraft to transition back into hover mode.
2. **Monitor Airspeed**: Once the airspeed drops below 40 knots, hover controls become active, and the aircraft will rely on vertical thrust to maintain altitude.
   - **TRC Engagement**: If TRC (Translational Rate Command) was armed earlier, it will automatically activate when the aircraft reaches hover speeds, assisting with precision control.
3. **Vertical Speed Management**: Use the Right-Hand Inceptor (RHI) to control the vertical speed during the transition to hover. Pulling back on the RHI will command a climb, and pushing forward will command a descent.
   - **Limitations**: The Fly-By-Wire (FBW) system maintains the vertical speed attained during the transition but limits the descent rate to a range of -750 to 750 feet per minute (fpm).

Key Considerations:

- **Smooth Deceleration**: Gradually pull back the LHI to avoid abrupt changes in speed. This ensures a smoother transition from forward flight to hover.
- **Visual Cues**: Use the Flight Mode Annunciator (FMA) and the MFD displays to monitor the aircraft's transition into hover mode.
- **TRC Activation**: Ensure TRC is armed for enhanced control when entering hover. This will allow the aircraft to hold position with minimal pilot input, compensating for wind and turbulence.

FLIGHT ASSISTANCE AND AUTOMATIC FUNCTIONS

The Joby S4 is equipped with several automation functions that assist the pilot during different phases of flight. These automatic modes reduce pilot workload, especially during critical phases such as hovering, transitioning, or precision landings.

MODE: TRANSLATIONAL RATE COMMAND (TRC)

TRC Overview:

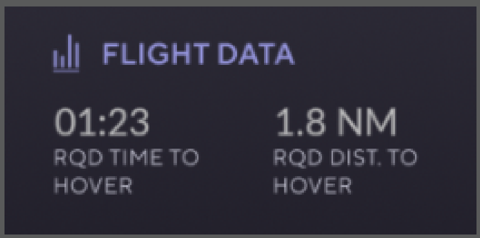
- Purpose: TRC simplifies hover operations by allowing the pilot to set a target lateral or vertical speed, enabling precise and stable control of the aircraft in hover mode. It counteracts external factors like wind, turbulence, or carried momentum, helping to maintain position during hover.
- Operation:
  - Right-Hand Inceptor (RHI): The RHI is used to set a target side speed or heading, allowing the pilot to make small lateral or vertical adjustments without unintentional drift.
  - Automatic Position Hold: TRC allows the aircraft to hold position with minimal input, making it particularly useful for tasks like centering the aircraft over a helipad.

TRC Mode Activation:

- Arming: TRC is armed by default from aircraft startup and remains armed even if the aircraft transitions into forward flight. It will automatically activate once the aircraft returns to hover speeds.
- Toggling: TRC can be toggled on or off with a short press of the DECELERATION button (#11).
- Visual Indicator: When TRC is active, it is displayed as "TRC" on the Flight Mode Annunciator (FMA). A white "TRC" indicates that the mode is armed.

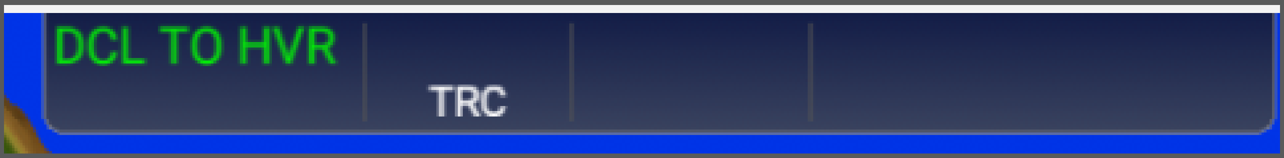
MODE: DECELERATION TO HOVER

Purpose: The Deceleration to Hover function simplifies the transition from forward flight to hover mode by automatically decelerating the aircraft to enter a stable hover.



Operation:

- **Automatic Deceleration**: The power delivery system commands a deceleration rate of -0.1G, gradually reducing the aircraft's forward speed until it enters hover mode.
- **MFD Display**: The FLIGHT DATA section of the MFD shows the expected deceleration distance and time if Deceleration to Hover is activated at the current moment. This information helps the pilot plan for deceleration and hover entry.



Activation:

- **Manual Activation**: Deceleration to Hover can be activated with a short press of the Deceleration button (#11) during the transition or conventional flight phases.
- **Visual Indicator**: The FMA will display "DCL TO HVR" when Deceleration to Hover is active.

Key Benefits:

- **Smooth Transition**: Automatically manages deceleration, helping the pilot focus on altitude and positioning as the aircraft prepares to hover.
- **Pilot Assistance**: The dynamic updates on the MFD provide valuable guidance, helping the pilot estimate where the aircraft will stop.

MODE: DECELERATION TO WAYPOINT

Purpose: Deceleration to Waypoint automatically decelerates the aircraft to a hover state directly above a pre-designated waypoint, such as a destination airport or helipad.

Operation:

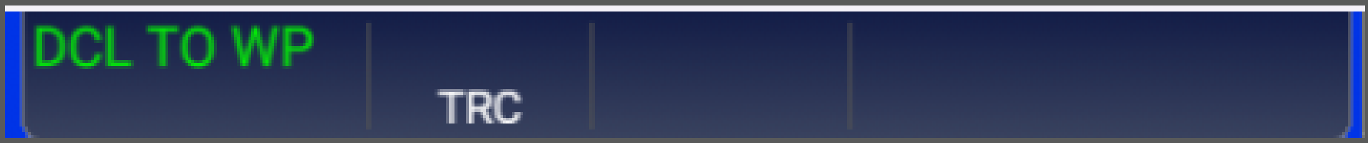
- **Waypoint Tracking**: The system calculates the required deceleration based on the aircraft's current speed and the distance to the destination waypoint. The destination waypoint's icon on the moving map is used as the exact target for deceleration.
- **Minimum Deceleration**: Deceleration to Waypoint will not apply a deceleration lower than 0.8G. If the destination waypoint is too far, the system will maintain a 0G deceleration until the aircraft is within effective deceleration range.

Activation:

- **Manual Activation**: Deceleration to Waypoint can be activated with a long press of the Deceleration button (#11) for more than one second during forward flight, provided a destination waypoint is set in the flight plan.
- **Visual Indicator**: The FMA will display “DCL TO WP” when Deceleration to Waypoint is active.

Key Considerations:

- **Direct Path Assumption**: The system assumes a direct path to the waypoint. Pilots must ensure that the aircraft’s heading is aligned with the destination to avoid unnecessary course adjustments.
- **Automatic TRC Arming**: TRC is automatically armed when Decel to Waypoint is active, ensuring precise control upon entering hover at the waypoint.



MODE: SPEED HOLD

Purpose: Speed Hold allows the pilot to maintain a selected indicated airspeed by automatically adjusting thrust.

Operation:

- **Manual Speed Selection**: Use the **Speed Hold Joystick (#10)** to set a target speed, cycling through speeds in 10-knot increments (50 to 180 KIAS).
- **Automatic Adjustment**: Once activated, the power delivery system automatically adjusts thrust to maintain the selected speed.

Activation:

- **Toggling**: Speed Hold can be activated by pressing the Speed Hold Joystick (#10) or by centering the LHI in the transition or conventional flight phases.
- **Visual Indicator**: The FMA displays “SPEED” when Speed Hold is active, and a cyan speed target bug appears on the MFD.

Benefits:

- **Energy Efficiency**: Speed Hold ensures stable, efficient flight by maintaining a constant airspeed, reducing pilot workload during long-range cruise operations.


SPEED
COM1 118.90
APPROACH
FLT ID ASXGS
130KT
140
120
RA 2450
237°
HDG 360°
CRS 360°
29.92IN
950

MODE: LEVEL HOLD

Purpose: Level Hold mode maintains straight and level flight by automatically adjusting the control surfaces to keep the aircraft's vertical speed at zero.

Operation:

- **Automatic Pitch Adjustments**: Level Hold adjusts the pitch to maintain zero vertical speed, ensuring that the aircraft remains level.

Activation:

- **Manual Activation**: Press the **LEVEL button (#13)** to engage Level Hold.
- **Visual Indicator**: The FMA will display "LEVEL" when active.

Benefits:

- **Hands-Free Stability**: This mode is useful during straight-line flight when the pilot needs to maintain altitude without continuous manual inputs.

DISENGAGE

Purpose: The DISENGAGE button provides a quick way to disable all active automatic modes, returning full manual control to the pilot.

Activation:

- **Manual Activation**: Press the **DISENGAGE button (#12)** to disengage all active modes.
- **Importance**: This function allows the pilot to override automatic systems if manual input is required for more precise or emergency maneuvers.

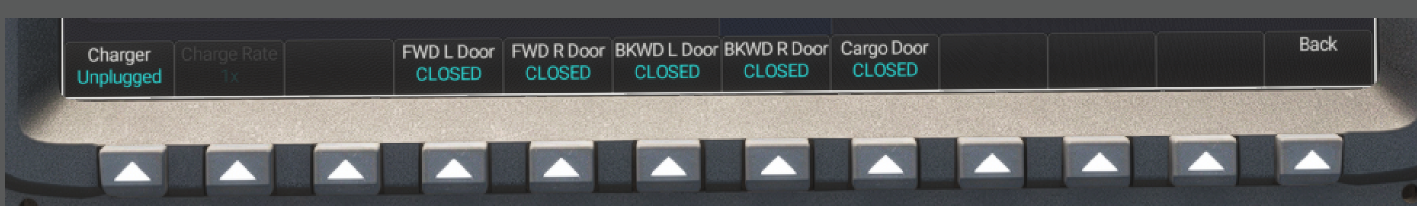
SIMULATION ACTIONS

In the Microsoft Flight Simulator environment, the Joby S4 is simulated to reflect real-world operational behaviors as closely as possible, including vertical takeoff and landing, hover operations, and forward flight. This section outlines key simulation actions and how they differ from real-world operations, providing helpful guidance to maximize the experience.

Sim Actions Menu

This is a menu provided on the MFD softkeys for the purposes of easier user interaction within the Microsoft Flight Simulator Environment - where the user can access various functions to interact with the Joby S4 (i.e., open cabin doors, etc). This is accessed through the softkey button #1 on the MFD.

Once in this menu , various functions can be toggled via the corresponding softkey .



This menu enables connecting the battery charger, controls the charge rate and controls the state of the aircraft doors.

Simulation-Specific Notes

1. Vertical Takeoff (VTO) and Landing
   - Takeoff: The vertical takeoff capability is one of the primary features of the Joby S4. Ensure the aircraft is in **FLY mode**, and gently use the Right-Hand Inceptor (RHI) to control vertical lift.
   - Landing: Upon descent, ensure the aircraft is in hover mode, assisted by TRC if necessary. Control the descent rate using the RHI, and aim to reach a gentle touchdown. Upon detecting weight on wheels, the simulation automatically reduces power.
2. Flight Mode Annunciator (FMA)
   - The FMA helps pilots stay aware of the current flight mode. Whether you are in hover, forward flight, or transitioning between modes, the FMA visually indicates which flight phase is active. This allows pilots to monitor the status of TRC, Deceleration to Hover, or Deceleration to Waypoint modes.
   - Visual Cues: The FMA is always visible on the PFD, displaying active modes such as TRC, LEVEL, or SPEED.
3. Flight Controls & Inceptors
   - The Left-Hand Inceptor (LHI) and Right-Hand Inceptor (RHI) replace conventional yokes or joysticks, providing intuitive control tailored to eVTOL operations. Ensure your control scheme in Microsoft Flight Simulator accurately reflects this functionality.
   - Steering in Ground Mode: Use the twist axis of the RHI or rudder pedals for precise ground steering while taxiing.

- **Inceptor Behavior in Hover and Transition**: Pay close attention to how the inceptors behave differently in hover and transition phases. Practice is recommended to get accustomed to the subtle differences in control sensitivity between these phases.

4. **Power Management & Energy Consumption**
   - Energy consumption is a critical aspect of managing the Joby S4's performance in simulation. Monitoring the energy draw and battery status in real time is crucial for completing flights successfully. **Forward flight** is far more energy-efficient than hovering, so it's best to transition out of hover mode when possible to conserve battery life.
5. **Speed Management**
   - **Speed Hold Mode** is designed to maintain a constant airspeed, reducing pilot workload during long-distance flights. Make use of the **Speed Hold Joystick** to set your target speed, especially during forward flight phases where speed adjustments are frequent.
6. **Landing at Waypoints**
   - The **Deceleration to Waypoint** feature allows you to automatically decelerate and hover above a pre-designated waypoint, making landing at helipads or specific coordinates easier. Ensure that the waypoint is correctly set in the flight plan before initiating Deceleration to Waypoint mode.
7. **Replay Functionality**
   - Microsoft Flight Simulator includes replay functionality, which is useful for reviewing flights and learning from different phases of operations. Using replay after complex maneuvers like hovering over a helipad or transitioning between flight modes can help you improve your control over the aircraft.

CONTROL MAPPING CONSIDERATIONS

To fully leverage the capabilities of the Joby S4 in Microsoft Flight Simulator, it's important to configure your control setup properly. The unique handling characteristics of eVTOL aircraft, combined with the need for precise throttle and directional control, make it essential to map the correct functions to your hardware controls. Below are recommendations for optimal control mapping.

Control Inceptor Mapping

The Joby S4 uses two inceptors (LHI and RHI), which behave differently depending on the flight mode. Properly mapping these to your physical controls is critical for intuitive flying.

Left-Hand Inceptor (LHI)

- **Function**: Controls acceleration/deceleration and taxi speed.
- **Recommended Mapping:**
  - **Throttle Axis:** Map the LHI forward/backward movement to your hardware throttle axis.
  - **Throttle Increase/Decrease**: Assign a throttle slider or joystick axis for smooth power adjustments.
  - **Speed Hold Activation**: Map a button to the Speed Hold Joystick to easily toggle speed hold mode.

Right-Hand Inceptor (RHI)

- **Function**: Controls vertical speed, pitch, and bank.
- **Recommended Mapping**:
  - **Joystick or Yoke**: Map the RHI forward/backward and left/right movements to the pitch and roll axes on your hardware joystick or yoke.
  - **Twist Axis or Rudder Pedals:** Use either a twist joystick axis or rudder pedals for yaw control, mimicking the RHI's twist functionality.
  - **Precision Control:** Ensure that yaw control is smooth, especially during hover or when using TRC.

Button Mapping for Flight Modes

The table below outlines mappable functions and their corresponding binding in microsoft flight simulator controls menu:

JOBY S4 FUNCTION	MICROSOFT FLIGHT SIMULATOR BINDING	NOTE
SPEED HOLD MODE	ARM AUTOTHROTTLE	
SPEED SELECT INC	INCREASE AUTOPILOT REFERENCE AIRSPEED	
SPEED SELECT DECREASE	DECREASE AUTOPILOT REFERENCE AIRSPEED	
DECELERATION	AUTOPILOT AIRSPEED HOLD	Short and long presses possible
DISENGAGE	TOGGLE DISENGAGE AUTOPILOT	
LEVEL	TOGGLE AUTOPILOT WING LEVELER	

Several critical flight modes in the Joby S4 require quick activation via buttons or switches. Mapping these functions to easily accessible hardware buttons will improve flight efficiency and reduce pilot workload.

Flight Mode Toggle

- **Fly/Load Mode:** Map a button to toggle between **Fly mode** and **Load mode** on the aircraft systems. This is especially useful during startup and when transitioning between ground and flight operations.

DECELERATION Button

- **Deceleration to Hover/Waypoint:** Map the Deceleration button (#11) to your controller for both short-click (Deceleration to Hover) and long-click (Deceleration to Waypoint) activations. This allows for seamless mode transitions during flight.

TRC Toggle

- **TRC Activation:** Assign a button to toggle **TRC** on and off. TRC is especially useful in hover mode, and quick access to this function allows the pilot to activate precision controls as needed.

Level Hold

- **LEVEL Mode Activation:** Map a button to engage **Level Hold mode** to maintain straight and level flight. This is particularly helpful when you need to focus on navigation or energy management without adjusting pitch manually.

Speed Hold

- **Speed Hold Activation:** Map a button to engage/disengage Speed Hold mode, allowing you to maintain a steady airspeed in forward flight. This function works well with mapped throttle controls, especially in transition or cruise phases.

Disengage Button

- **DISENGAGE Button:** Map a button to the DISENGAGE function (#12), which immediately disables all active flight assistance systems. This is important during emergencies or when manual control is preferred.

Rudder Pedals vs. Twist Axis

For those using a joystick with a twist axis:

- **Twist Axis (Joystick):** If using the twist function on your joystick, ensure that the yaw sensitivity is configured for smooth, precise movements. The Joby S4 requires fine control of yaw during hover and transition phases.
- **Rudder Pedals:** If you have dedicated rudder pedals, map these to the yaw controls for a more immersive and precise experience, particularly during taxiing and hover operations.

Additional Control Configurations

Landing Gear Toggle

- The Joby S4 does not have conventional retractable landing gear, so this function can be ignored in control mapping. However, pilots can remap the landing gear button to any other essential flight function, such as toggling between flight modes or activating TRC.

Camera Controls

- **View Adjustments:** Ensure camera controls are mapped to allow quick adjustments between cockpit and external views. External views are particularly useful during landing maneuvers where visual alignment with the ground is critical.

Custom Profiles

- **Saved Profiles**: If you fly multiple types of aircraft in Microsoft Flight Simulator, create a dedicated profile for the Joby S4 that optimizes control mappings for eVTOL operations. Switching between profiles ensures you maintain proper control over different aircraft types.

Control Sensitivity Adjustments

Pitch and Roll Sensitivity

- **Smooth Inputs:** Adjust pitch and roll sensitivity for the RHI to allow for smoother control responses, especially during transitions between hover and forward flight. Excessive sensitivity can make hover control difficult.

Throttle Sensitivity

- **Gradual Adjustments:** Set the throttle sensitivity curve for the LHI to ensure gradual power adjustments. This will help maintain stability during hover and avoid rapid changes in altitude or speed.

Dead Zones

- **Prevent Drift:** Configure small dead zones for yaw, pitch, and roll axes to prevent unintentional inputs caused by joystick or throttle drift.

Final Control Mapping Tips

- **Practice Makes Perfect:** Familiarize yourself with the Joby S4's unique control setup. Practice transitioning between hover, forward flight, and landing to master the use of both inceptors and the mapped functions.
- **Hover Mode:** Hover operations demand fine control. Make sure the sensitivity settings on your joystick or throttle allow for precise, delicate inputs, particularly when using TRC.
- **Flight Automation**: Map essential flight automation functions (TRC, Speed Hold, and Level Hold) to easily accessible buttons to reduce workload and focus on precise control.

ENERGY MANAGEMENT STRATEGIES

Efficient energy management is critical for operating the Joby S4, especially given the limitations of battery capacity during extended flight. Understanding how different phases of flight impact energy consumption will help pilots maximize range and endurance while maintaining safe operational parameters.

Battery Capacity and Energy Usage

The Joby S4 is powered by high-density lithium-ion batteries, with a total capacity of 150 kWh. This capacity is displayed as a percentage on the MFD and is essential for planning the duration of your flight.

Key Metrics:

- **Battery Capacity**: Monitored in kilowatt-hours (kWh) and as a percentage.
- **Energy Draw**: Measured in kilowatts (kW), it shows how much power the aircraft is using at any given moment.
- **Range**: Shows how far the aircraft can travel based on the current energy draw and speed, typically displayed in nautical miles (NM).
- **Endurance**: The remaining flight time, displayed in minutes, based on current power usage.

Flight Phase Impact on Energy Usage

Each phase of flight consumes energy differently. Pilots should be mindful of these differences to optimize the aircraft's performance and range.

- **Hovering**: Hovering is the most energy-intensive phase, drawing significant power from the motors to maintain altitude.
  - **Typical Usage**: ~450-600 kW.
  - **Recommendation**: Limit the time spent in hover mode whenever possible, especially when transitioning between takeoff and forward flight, to conserve battery life.
- **Forward Flight (Wing-Borne)**: Forward flight is significantly more efficient than hovering, as the wings provide lift, reducing the power required from the motors.
  - **Typical Usage**: ~100-250 kW, depending on airspeed and altitude.
  - **Recommendation**: Transition to forward flight as early as feasible during takeoff to conserve energy and increase range. Use Speed Hold mode to optimize power consumption and maintain a steady cruise speed.
- **Climbing**: Climbing in forward flight uses more power, but less than hovering while climbing.
  - **Typical Usage**: ~250 kW during moderate climbs.
  - **Recommendation**: Perform climbs at a moderate rate to avoid excessive energy draw and reach cruising altitude efficiently.

- **Descent**: Descent typically uses minimal power, as the aircraft benefits from gravity to reduce energy consumption. However, energy consumption increases dramatically during vertical descent arrests, meaning coming to a hover after a vertical descent – especially if the vertical descent rate is high.
    - **Recommendation**: Plan descents early to take advantage of lower energy usage, particularly before entering hover mode during landing.

Range vs. Endurance Considerations

Balancing range and endurance is essential when managing battery power during a flight. Use the dynamic data on the MFD to adjust your flight plan based on energy consumption and available battery reserves.

- **Range**: Indicates how far the aircraft can travel while maintaining a reserve of battery power.
    - **Recommendation**: Monitor range carefully during longer flights and plan for transitions to forward flight to optimize distance.
- **Endurance**: Represents the remaining flight time in minutes.
    - **Recommendation**: Ensure you have sufficient endurance for the landing phase, including hovering and possible delays. Aim to land with a minimum of 3-5 minutes of hover time in reserve.

Energy Management Techniques

To optimize energy consumption and maximize range, follow these best practices:

- **Use Forward Flight Whenever Possible**: Hovering drains the battery more quickly than forward flight. Limit hovering to short durations, especially in urban air mobility (UAM) environments.
- **Monitor Energy Draw**: Keep a close eye on the Energy Draw indicator on the MFD. If power consumption is too high during cruise, reduce speed or adjust altitude for better efficiency.
- **Utilize Speed Hold**: Engaging Speed Hold mode during forward flight can help optimize the aircraft's power consumption by maintaining a steady airspeed.
- **Transition to Hover Efficiently**: Use Deceleration to Hover or Deceleration to Waypoint to manage the transition from forward flight to hover smoothly. This ensures you decelerate efficiently and with minimal energy loss.
- **Plan for Contingencies**: Always ensure there is enough energy remaining for unexpected delays or missed approaches. Landing with a battery reserve allows for corrections and adjustments during the final approach.

LANDING PROCEDURES

The Joby S4's landing process is designed around its vertical landing capabilities. Precise control and careful energy management during the landing phase are essential to ensure a safe and smooth landing.

Approach to Hover

The approach to landing begins by slowing down from forward flight and entering hover mode. The Deceleration to Hover and Deceleration to Waypoint modes are designed to help with this transition.

Procedure:

1. **Decelerate**: Begin pulling back the Left-Hand Inceptor (LHI) to reduce speed.
    - **Deceleration to Hover**: If you are landing manually, activate Deceleration to Hover to automatically Decelerate the aircraft at an optimal rate, ensuring you smoothly transition from forward flight to hover mode.
    - **Deceleration to Waypoint**: If you are landing at a specific location (e.g., a helipad or waypoint), activate Deceleration to Waypoint to decelerate and hover directly over the waypoint.
2. **Monitor Airspeed**: As the airspeed drops below 40 KIAS, hover controls will become active. Use the MFD and visual cues to monitor the transition.

Entering Hover Mode

Once the aircraft has decelerated to below 40 KIAS, it will automatically enter hover mode, with the rotors taking over to provide vertical lift.

Procedure:

1. **TRC Mode**: Ensure that TRC mode is armed. TRC allows you to control the aircraft with precision, ensuring stability and position-holding during the hover.
2. **Vertical Speed Control**: Use the Right-Hand Inceptor (RHI) to adjust your vertical speed. Pull back to climb or push forward to descend.
    - Maintain Altitude: Centering the RHI will maintain your current altitude.
    - Side Slipping: Lateral movements of the RHI allow you to side-slip, useful for fine-tuning your position before landing.

Key Considerations:

- **Energy Monitoring**: Hovering consumes a significant amount of energy. Ensure you have sufficient battery reserves to complete the landing.

- **Smooth Control**: Avoid abrupt movements of the RHI to maintain stable hovering. Gradual inputs allow for more controlled descent and lateral adjustments.

Final Descent and Touchdown

The final descent phase requires careful control of vertical speed to ensure a smooth landing. TRC is essential for managing this phase with precision.

Procedure:

1. **Align Over Landing Zone**: Use TRC mode to position the aircraft directly above your intended landing zone, such as a helipad. Small movements of the RHI will allow you to adjust your position laterally and rotationally.
2. **Reduce Vertical Speed**: Begin to reduce your vertical speed by gently pushing forward on the RHI.
    - Descent Rate: Aim for a descent rate of around -300 fpm for a smooth landing. TRC will help ensure a steady descent.
3. **Monitor Altitude**: As you approach the ground, use visual and instrument cues to ensure a precise touchdown.
4. **Landing Detection**: Upon landing, the aircraft's sensors will detect weight on the wheels and automatically cut power to the rotors, completing the landing.

Post-Landing Procedures

Once the aircraft has touched down, the systems automatically adjust to complete the landing process safely.

Procedure:

1. **Power Cutoff**: Once the aircraft detects weight on wheels, the rotors will automatically shut down, cutting power and preventing further movement.
2. **Switch to LOAD Mode**: After landing, switch the aircraft from FLY mode to LOAD mode by pressing the corresponding softkey on the MFD. This ensures that the motors are locked and the aircraft is safe for egress.

Key Considerations:

- **TRC for Precision**: Keep TRC mode active throughout the descent and landing to maintain full control over the aircraft's position and movements.
- **Gentle Touchdown**: A slow and steady descent ensures a smooth landing. Sudden drops or excessive descent rates can lead to a hard landing, which may affect the aircraft's performance in the simulation.

Landing in Challenging Conditions

Landing the Joby S4 in challenging conditions, such as high winds or turbulent environments, requires additional control finesse.

Procedure:

1. **Compensate for Wind**: Use TRC to maintain position against wind drift. The system automatically compensates for wind in hover mode, but manual input may be required for stronger gusts.
2. **Maintain Low Descent Rate**: Keep your descent rate low to avoid losing control during the final approach. A gentle descent with minor corrections is key to stable landings in adverse conditions.
3. **Plan for Additional Battery Use**: Hovering in strong winds may require more energy to maintain stability, so ensure adequate power reserves are available before beginning the landing process.

EMERGENCY PROCEDURES

In simulation or real-world operations, it is crucial to know how to handle potential emergencies. The Joby S4 is equipped with multiple safety features to help mitigate risks. However, in the simulator, learning how to react swiftly to emergencies is key to mastering the aircraft's operation.

Power Loss or Battery Depletion

Situation: Sudden loss of power due to battery depletion or system malfunction can result in the loss of control. If the battery reaches critical levels, the aircraft may not be able to maintain thrust for hover or forward flight.

Procedure:

1. **Monitor Battery Levels**: Always monitor the energy status on the MFD during flight. If the battery reaches critical levels, plan an immediate descent or landing.
2. **Switch to Forward Flight**: Forward flight consumes less power than hovering. If you experience low battery during hover, immediately transition to forward flight to conserve energy and maintain altitude.
3. **Emergency Landing**:
    - If there is no suitable runway or helipad, prepare for an emergency descent.
    - Use the Right-Hand Inceptor (RHI) to control vertical speed and ensure a gentle descent.
4. **Control Descent**: Attempt to decelerate and transition into hover as close to the ground as possible. Keep the descent rate under control using TRC to ensure a smooth touchdown.
5. **Complete Landing**: Once on the ground, immediately power off the aircraft to conserve the remaining battery.

Prevention:

- Regularly check energy consumption and always maintain a buffer for emergency landings.
- Avoid hovering for extended periods unless absolutely necessary to conserve energy.

Loss of Control Due to Environmental Factors

Situation: Strong winds, turbulence, or other environmental factors can cause instability, particularly during hover or while transitioning between flight modes.

Procedure:

1. **Engage TRC Mode**: If the aircraft becomes unstable in hover mode, ensure TRC is active. TRC compensates for environmental forces such as wind and can help stabilize the aircraft.

2. **Return to Forward Flight**: If hovering becomes too difficult due to environmental factors, transition into forward flight to stabilize the aircraft. Forward flight minimizes the effects of wind and turbulence.
3. **Manual Yaw and Pitch Adjustments**: Use the Right-Hand Inceptor (RHI) to control pitch and yaw manually if the automated systems cannot compensate for the conditions.
4. **Emergency Descent**: If stability cannot be regained, begin a controlled descent using the RHI. Adjust the descent rate to ensure a smooth touchdown.

Prevention:

- Always check weather conditions before flight and avoid operating in high winds or turbulent areas.
- Practice manual control during hover in light wind conditions to become familiar with the aircraft's response to environmental factors.

Fly-By-Wire (FBW) System Failure

Situation: If the Fly-By-Wire (FBW) system fails, the aircraft may no longer respond to the inceptors as expected. This could happen due to electrical failure or a software malfunction in the simulation.

Procedure:

1. **Check Control Inputs**: Immediately verify that the Left-Hand Inceptor (LHI) and Right-Hand Inceptor (RHI) are responding correctly. If inputs are unresponsive or the aircraft behaves erratically, the FBW system may have malfunctioned.
2. **Engage Manual Override**: Use the **DISENGAGE button (#12)** to manually override the automatic systems and regain direct control of the aircraft. This returns the inceptors to manual mode, where inputs will directly affect the aircraft's pitch, roll, and thrust.
3. **Immediate Descent**: If FBW failure persists, prioritize an immediate descent. Use the RHI to control your descent rate and attempt to stabilize the aircraft.
4. **Land as Soon as Possible**: Initiate an emergency landing and aim for a flat, safe surface. Bring the aircraft to hover, if possible, and complete the landing process manually.

Prevention:

- Regularly monitor the health of the FBW system on the MFD, ensuring all systems are functioning before takeoff.
- In the simulator, check for control responsiveness periodically during flight to detect any early signs of malfunction.

Motor Failure

Situation: While highly unlikely in a simulator environment, simulating an motor failure can help you understand how the Joby S4's redundant systems work.

Procedure:

1. **Assess the Failure**: If one or more motors fail, the remaining rotors are designed to compensate. Monitor the MFD to assess the extent of the motor failure.
2. **Switch to Forward Flight**: Forward flight places less strain on the remaining rotors. Immediately transition into forward flight by pushing the Left-Hand Inceptor (LHI) to full forward deflection.
3. **Controlled Descent**: Begin planning for an emergency landing, and prioritize transitioning to hover mode at the lowest possible altitude.
4. **Complete Emergency Landing**: Use the Right-Hand Inceptor (RHI) to control your descent and perform an emergency landing as smoothly as possible.

Prevention:

- Ensure that the aircraft's systems are in optimal condition before takeoff by reviewing the pre-flight checklists.
- Simulate motor failures to practice emergency procedures in non-critical environments.

TROUBLESHOOTING

The troubleshooting section addresses common issues that may arise during simulation flights with the Joby S4. This guide will help you quickly diagnose and resolve problems to ensure smooth operations.

Aircraft Does Not Respond to Inceptor Inputs

Problem: The aircraft does not respond to the Left-Hand Inceptor (LHI) or Right-Hand Inceptor (RHI), either during startup or in-flight.

Solution:

1. **Check Flight Mode**: Ensure the aircraft is in FLY mode. If the aircraft is in LOAD mode, it will not respond to inceptor inputs.
2. **Control Mapping**: Verify that your control mappings in Microsoft Flight Simulator are correct. The LHI should be mapped to throttle controls, and the RHI should be mapped to pitch, roll, and yaw axes.
3. **DISENGAGE**: Try pressing the DISENGAGE button (#12) to reset the control system and return to manual control.
4. **Restart Systems**: If the aircraft is unresponsive, restart the simulator or reset the aircraft to its initial state.

TRC Does Not Activate in Hover Mode

Problem: TRC (Translational Rate Command) does not engage during hover, leading to difficulty controlling the aircraft's position.

Solution:

1. **Check TRC Status**: Confirm that TRC is armed. It should display as "TRC" on the Flight Mode Annunciator (FMA). If TRC is not armed, press the Deceleration button (#11) to toggle TRC mode.
2. **Speed Check**: TRC only activates in hover mode when the indicated airspeed is below 40 KIAS. Ensure the aircraft has fully decelerated into hover mode.
3. **Manual Mode:** If TRC still fails to engage, manually control the aircraft's vertical speed and position using the Right-Hand Inceptor (RHI).

Aircraft Drifts During Hover

Problem: The aircraft drifts in hover mode, even with TRC engaged, making it difficult to hold position.

Solution:

1. **Recalibrate Controls**: Check the calibration of your joystick or throttle. Drift may occur due to unintentional inputs from hardware. Recalibrate your hardware through the simulator's settings.
2. **Wind Conditions**: Strong winds may cause the aircraft to drift even with TRC engaged. Use manual inputs on the Right-Hand Inceptor (RHI) to counteract drift or reposition the aircraft.
3. **Review Power Settings**: Ensure the aircraft has sufficient power to maintain hover. Low power settings can result in reduced rotor efficiency, making position-holding difficult.

Aircraft Consumes Battery Too Quickly

Problem: The aircraft's battery depletes faster than expected, limiting flight duration.

Solution:

1. **Forward Flight Transition**: Minimize time spent hovering. Hovering consumes significantly more power than forward flight. Transition into forward flight as soon as possible to conserve energy.
2. **Monitor Energy Draw**: Use the energy display on the MFD to keep track of energy draw during different phases of flight. Reduce speed during cruise to lower energy consumption.
3. **Flight Plan Review**: Ensure that you are flying the most direct route to your destination to avoid unnecessary maneuvers that increase power consumption.
4. **System Load**: Check if any unnecessary systems are drawing power. Reducing the load on non-critical systems can help extend flight time.

Nacelles Fail to Transition

Problem: The nacelles do not transition between vertical and horizontal positions during the hover-to-forward flight transition or vice versa.

Solution:

1. **Check Airspeed**: Ensure that the airspeed is appropriate for the transition. Nacelles will begin tilting forward once the airspeed exceeds 40 KIAS. If the airspeed is too low, the nacelles will not transition.
2. **Flight Mode Check**: Ensure the aircraft is operating in the appropriate flight mode, the FLY mode.
3. **Reset the System**: If the nacelles still do not transition, reset the aircraft's systems by toggling between FLY and LOAD mode and restarting the transition process.

Flight Mode Annunciator Fails to Update

Problem: The Flight Mode Annunciator (FMA) does not correctly display the current flight mode, such as hover, forward flight, or transition.

Solution:

1. **Recheck Flight Status**: Verify the aircraft's actual flight phase by observing speed and altitude on the PFD. The FMA should update accordingly once the aircraft reaches the appropriate airspeed for each flight mode.
2. **Manual Reset**: Toggle flight modes manually using the softkeys on the MFD. If the FMA remains inaccurate, reset the aircraft's systems by reselecting FLY mode.
3. **Restart the Simulator**: If the problem persists, restart the flight within Microsoft Flight Simulator to reset all avionics systems.

Glossary of Technical Terms

1. FBW (Fly-By-Wire):
   - A flight control system that replaces conventional manual flight controls with an electronic interface. The pilot's inputs are interpreted by a computer system that then controls the actuators that move the aircraft's control surfaces.
2. GTC (Garmin Touchscreen Controller):
   - A touch-sensitive device used to manage various functions of the aircraft, including flight planning, navigation, and system monitoring.
3. KIAS (Knots Indicated Airspeed):
   - The speed of an aircraft as shown on the airspeed indicator, measured in knots. This value is not corrected for errors such as instrument, position, or calibration errors.
4. LHI (Left-Hand Inceptor):
   - The control device located on the left side of the pilot, used to control the aircraft's speed, acceleration, and deceleration.
5. RHI (Right-Hand Inceptor):
   - The control device located on the right side of the pilot, used to control the aircraft's altitude, pitch, bank, and yaw.
6. TRC (Translational Rate Command):
   - A mode that allows the pilot to set a target lateral speed for the aircraft to maintain. TRC is used primarily during hover and thrust-borne operations to stabilize the aircraft against external forces like wind or turbulence.
7. DCL TO WP (Deceleration to Waypoint):
   - A mode that automatically commands the aircraft to decelerate to a hover state above a specified destination waypoint, based on current speed and distance to the waypoint.
8. VTO (Vertical Takeoff):
   - A mode of aircraft takeoff where the aircraft ascends vertically without needing a runway. This is enabled by the aircraft's vertical thrust capability.
9. FMA (Flight Mode Annunciator):
   - A display panel in the cockpit that shows the active flight mode and other flight-related information.
10. MFD (Multi-Function Display):
    - A screen in the cockpit that displays flight information, navigation data, and aircraft system statuses.
11. PFD (Primary Flight Display):
    - The primary screen in the cockpit that shows crucial flight information such as altitude, airspeed, attitude, and heading.
12. IAS (Indicated Airspeed):

- The airspeed of an aircraft as measured by the pitot-static system and displayed on the airspeed indicator, uncorrected for altitude or temperature variations.

13. V-Tail:
    - A tail design on an aircraft where two slanted tail surfaces combine the functions of a horizontal and vertical stabilizer.
14. Nacelle:
    - A housing, separate from the fuselage, that holds motors, or equipment on the aircraft.
15. KWh (Kilowatt-hour):
    - A unit of energy measurement that represents the power consumption of one kilowatt over the span of one hour.
16. RPM (Revolutions Per Minute):
    - A measure of the frequency of rotation, specifying the number of complete turns a rotor makes in one minute.
17. G-Force:
    - A measure of acceleration felt as weight. In aviation, G-force is often used to describe the stress on an aircraft structure or the force experienced by the occupants during maneuvers.
18. Load Mode:
    - A mode where the power to the motors is cut, and the motor angles are fixed upright, disabling all control responses. This mode is used for safe egress and ingress to the aircraft.
19. FLY Mode:
    - The operational mode of the aircraft where the motors are powered, and control responses are enabled, allowing for normal flight operations.
20. Envelope Protection:
    - A safety feature that limits the aircraft's bank and pitch angles to prevent the aircraft from entering unsafe attitudes.
21. Energy Draw:
    - The amount of power consumed by the aircraft's systems and motors, typically measured in kilowatts (kW).
22. Hover State:
    - The state in which the aircraft maintains a stable altitude while stationary or moving laterally at a very low speed, supported entirely by vertical thrust.
23. VMC (Visual Meteorological Conditions):
    - Weather conditions in which pilots can operate the aircraft with visual reference to the horizon and other landmarks.
24. Waypoint:
    - A predetermined geographical location used for navigation purposes, typically defined by coordinates and used to guide the aircraft along a flight route.
25. Pitch:
    - The up or down angle of the aircraft's nose, controlled by the right-hand inceptor.
26. Bank:

- The tilt of the aircraft to the left or right, controlled by the right-hand inceptor, influencing the aircraft’s turn.

27. Yaw:
    - The left or right rotation of the aircraft's nose, controlled by twisting the right-hand inceptor.