Gulfstream Aerospace Corporation (GAC) Document No.: GIV-GER-0016, GIV Gust Lock & Autothrottle Systems Ground Test Plan follows this page and is included after appropriate authorization from GAC per a redacted Proprietary Notice Restriction contained on the cover page of the report.

Gulfstream

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Ground Test Plan

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1.0 PURPOSE

This document presents the plan for gathering Gulfstream IV engine data and testing of the Gulfstream IV flight control system's gust lock operations during simulated take-off.

The purpose of this test is to exercise GIV flight control systems in different configurations in support of the NTSB accident investigation of Gulfstream aircraft serial number 1399 (ERA14MA271). To achieve this, some of the test configurations conflict with the requirements of the GIV Airplane Flight Manual (AFM). The focus of the tests revolves around gust lock (GL) system operations and interactions with throttle movement. The tests will simulate different configurations that may affect GL functionality under static and dynamic conditions. Video, audio, and FDR data will be recorded for analysis.

The tests will be conducted on a Gulfstream model GIV aircraft.

2.0 CONFIGURATION AND SYSTEM DESCRIPTION

2.1 Configuration

Testing will be performed on Gulfstream GIV aircraft. The aircraft will have all standard systems installed. Aircraft level configuration shall be documented prior to starting the test. A review of all open items will ensure that all test critical items are installed. Depending on the specific test case, the aircraft will be modified as follows:

- Instrumentation and equipment will be installed, as described in Section 5.0.

2.2 System Description

2.2.1 Gust Lock System

The gust lock system is a ground safety system that protects the ailerons, elevators, and rudder from wind gusts via mechanical latches which hold the surface in a stationary position. The system is completely mechanical, consisting of pushrods, cables, cranks, and pulleys. The system is engaged and disengaged via the gust lock handle located in the cockpit center pedestal.

The gust lock handle is a two-position lever located on the right hand side of the control center pedestal. Moving the handle forward to the OFF position releases the gust locks and unlocks the control surfaces. Moving the handle aft to the ON position locks the ailerons and the rudder in the neutral position and the elevators in the 13 degrees trailing edge down position. The gust lock handle locks in the forward and aft positions. A spring latch at the lever knob must be unlocked before the gust lock handle can be moved in either direction.

A disengaged gust lock system neither affects the flight performance of the aircraft, nor receives any flight loads. An engaged gust lock system locks the control surfaces capable of withstanding wind gust of 60 mph.

Each gust lock consists of a mechanical latch, springs, and a bungee rod. The aileron gust lock mechanism is located at Fuselage Station 283 below the cabin flooring. The elevator and rudder gust lock mechanisms are located at Fuselage Station 775 in the tail compartment. Moving the gust lock

handle to the aft position transmits motion to the gust locks through a 3/32-inch diameter 7 x 7 cable. Final input to the locks is made through a spring bungee. The aileron and rudder gust locks engage the flight control system linkage when they are in the neutral position. If a surface is not in the neutral position when the gust lock handle is engaged, a cammed lead-in at the gust lock will guide the control linkage into the lock as the control reaches neutral position. (This action occurs when the controls in the cockpit initially attempt to pass through neutral with the gust lock handle in the ON position.) As the surface reaches neutral, the control linkage progresses along the cam, deflecting the spring bungee to engage the gust lock. The elevator lock detent is at the upper end of the mechanical latch and engages when the control columns are moved forward, deflecting a spring bungee. With the gust lock handle in the OFF position, the bungee acts as a fixed rod to minimize any possibility of the locks being engaged or jammed. An additional safety feature is a set of two springs at each gust lock which will unlock the surfaces in the event of a failure in the system.

2.2.2 Gust Lock/Throttle Interlock

The Gust Lock contains a safety mechanism that restricts the movement of the throttle levers with the gust lock system engaged / locked. The function of the mechanism is to restrict throttle movement with locked flight controls. The gust lock sector assembly inside the pedestal housing mounted to the cockpit floor contains a stop which interfaces with corresponding stops on the left and right power lever sectors. These stops are positioned on the sectors to allow full throttle movement with the gust lock handle stowed, and 6 degrees of rotation above idle at the throttle sectors with gust lock handle in the up and latched position.

2.2.3 Autothrottle System

When the autothrottle is engaged and takeoff is initiated (requires cockpit input, minimum engine power setting, and satisfaction of enabling conditions), the throttles are automatically advanced to required takeoff engine setting based on a full-thrust (Rated EPR) takeoff or a reduced-thrust (FLEX EPR) takeoff. A minimum EPR of 1.17 is required to engage the autothrottle system. A FLEX EPR takeoff requires either an operating performance function and a CDU selection by the pilot during performance initialization, or a pilot input of engine pressure ratio (EPR) command on the manual thrust reference page of the display controller. At 60 knots the autothrottle servos are depowered with the clutches remaining engaged (throttle hold) and remain depowered until the aircraft has climbed to at least 400 feet above ground level. An indication of the throttle hold condition is displayed to the pilot.

The autothrottles are disengaged by any of the following:

- Moving either power lever mounted A/T ENG/DISENG switch
- Pressing either power lever mounted A/T disconnect switch
- Manually moving the power levers
- Deselecting A/T ARM button on the GP-280 Flight Guidance Computer
- Selecting the cross-side A/T via the DC

- Deselecting the EPR limit rating on the DC
- LP (N1) split of [redacted] percent
- Engine out (N2 < [redacted] percent)
- Bleed air isolation valve open
- FGC 1 and 2 fail
- A/T fail
- A/T moved more than [redacted] in the hold mode

3.0 TEST OBJECTIVES

This test plan was developed to inform both GAC and the NTSB regarding the events leading to the A/C 1399 accident. Specifically, these tests will simulate abnormal operations and are intended to validate the engine EPR model, characterize the aircraft power lever angle and engine EPR response during acceleration, and, validate the presence of an aerodynamic hold on the gust lock. The test objectives were developed during team meetings to address NTSB action items as recorded in the investigation action item list.

- Engine data gathering
- Autothrottle disengage force tests
- Autothrottle/Interlock disengage test
- High speed taxi tests to characterize air load impact on elevator gust lock release
- Autothrottle hold characterization

These tests will be categorized into ground stationary and dynamic taxi tests.

3.1 Engine Runs

This test is to characterize engine performance relative to power lever angle (PLA) position and EPR values. Data from the FDR will be used to supplement the existing Rolls Royce engine deck model. Each engine will be operated from idle to maximum power at 5% HP increments, allowing the engine to stabilize in between each test. In addition, this test will characterize the relationship between throttle lever angle (TLA) on the pedestal and PLA at the engine transducer.

3.2 Autothrottle Disconnect Force

This test will characterize the autothrottle disconnect force required for disengagement. Autothrottles will be engaged and a force measuring device will be used to measure the force required to disconnect the autothrottle servos at the throttle levers.

3.3 Autothrottle/Throttle Interlock Disengage Test

This test is to characterize autothrottle engagement and disengagement with the gust lock set to ON. A manual EPR target will be used and will be increased until the autothrottle disengages due to throttle movement restriction caused by the gust lock/throttle interlock.

3.4 Elevator Air Load High Speed Taxi Tests

This test is to characterize the aircraft speed at which air loads on the elevators will prevent the gust lock hook from releasing when the gust lock handle is unlatched.

This test will be conducted as a single high speed taxi. At a predetermined speed, the gust lock handle will be unlatched. The aircraft will decelerate and the speed at which the gust lock handle falls completely forward (OFF) will be recorded.

3.5 Autothrottle Hold Characterization

This test will be performed concurrently with the test in Section 3.4 to determine the effects of the autothrottle hold function on the throttle position with the gust lock set to ON.

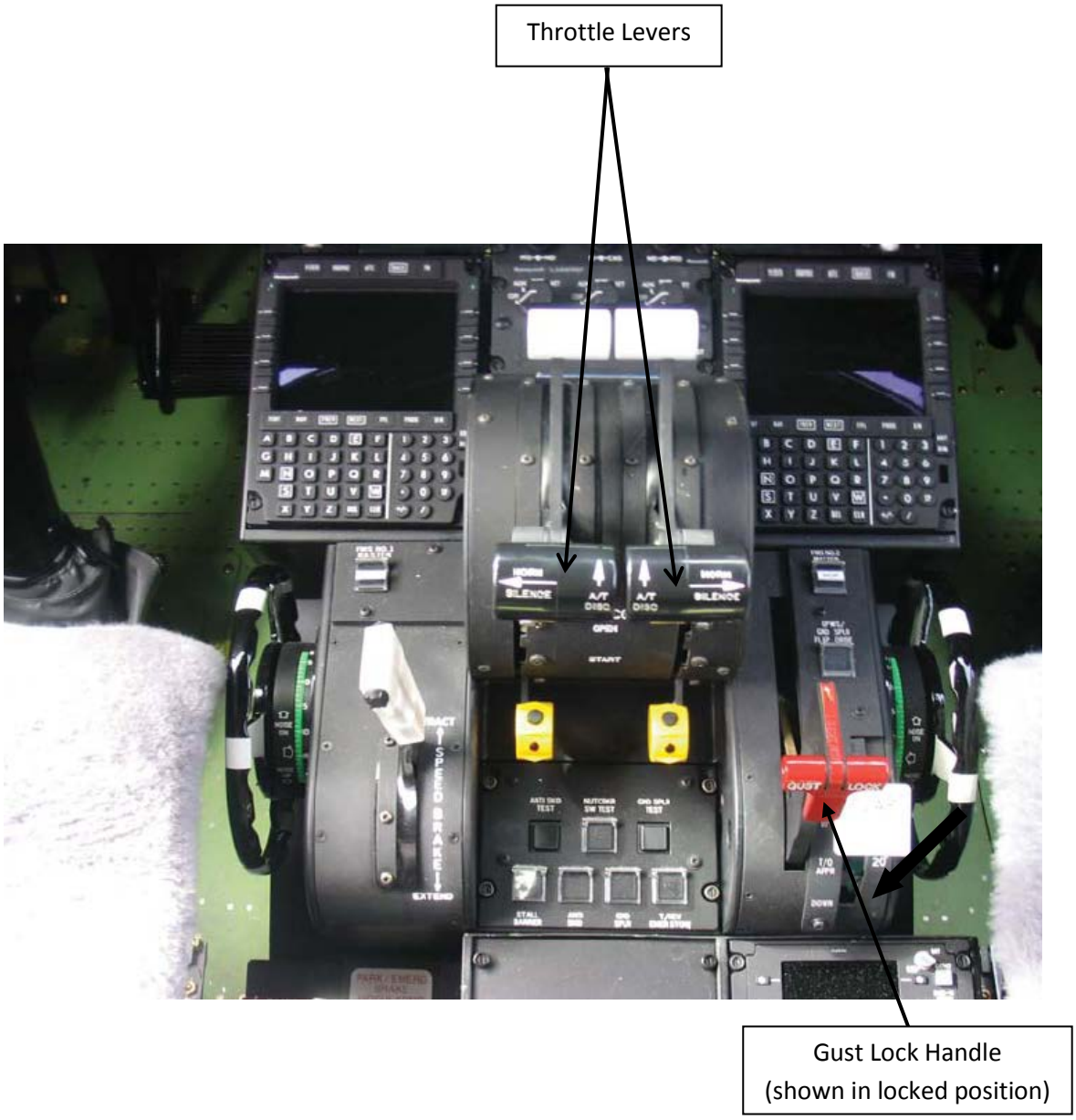

FIGURE 1 GIV COCKPIT PEDESTAL

4.0 INSTRUMENTATION AND FIXTURING

The instrumentation and fixturing required for testing will include the following:

- The cockpit shall be equipped with video and audio recording devices to record pilot inputs and handle/lever positions for all tests (mounted, not held by flight crew)
- The standard TC flight data recorder is required for all tests
- In addition to the FDR PLA position recordings, a protractor shall be installed on the pedestal to measure the throttle lever angle. (1159SEM20271-15)
- A Calibrated Force Gage – GSE5100758 or equivalent

5.0 SUPPORT EQUIPMENT AND PERSONNEL

5.1 Equipment

In addition to the standard power supplies and equipment found on the aircraft, the following support equipment is required for certain tests:

- None

5.2 Personnel

The following personnel shall witness the test:

- NTSB (as required)

The following personnel are required to conduct the test:

- Test Pilots
- Flight Test Engineer
- Aircraft maintenance personnel as required

6.0 TEST TERMINOLOGY

- The gust lock handle shall be considered unlatched when the spring-loaded handle is rotated towards the aft position such that the entire handle is capable of being moved slightly forward, out of its detent position but not fully stowed/down.
- The gust lock system will be considered OFF and unlocked when the aileron, rudder and elevator systems are able to move freely and the gust lock handle is fully stowed/down.
- The gust lock system will be considered ON and locked when the handle is in the full aft position (in the detent, with handle latched) and the flight control systems are locked in place.
-

7.0 GROUND STATIONARY TESTS

7.1 Aircraft Preparation

1. The following preparation is required for Sections 8.0 thru 11.
2. Inspect the aircraft to ensure all standard TC components are installed and functioning correctly:
   -Gust Lock System
   -Flight Data Recorder
   -Cockpit Voice Recorder
3. Install cockpit video/audio recorder (camera)
4. Install throttle lever protractor
5. Ensure sufficient fuel load: 10,000 – 14,000 Lbs.

8.0 ENGINE RUNS

1. Initial A/C Configuration:
   -Verify Gust Lock is OFF
   -Start both engines
   -Select both converters to ON
   -Select APU bleed air OFF and both engine bleeds to ON
   -Select both air conditioning packs to ON
   -Position aircraft heading into wind
2. Record the following information from airport weather report:
   Wind Speed & Direction:_____
3. Run each engine individually to a HP value of 60%, 65%, 70%, 75%, 80%, 85%, 90%, and maximum EPR value for the day, for each engine setting. Allow engine to stabilize at each setting before recording EPR and TLA data in the table below. Do not overshoot the throttle position. Repeat for opposite engine. See Table 1

TABLE 1 – STABILIZED ENGINE/EPR DATA

Engine	Left Engine		Right Engine	
% HP	TLA	EPR	TLA	EPR
60		1.		1.
65		1.		1.
70		1.		1.
75		1.		1.
80		1.		1.
85		1.		1.
90		1.		1.
Max EPR		1.		1.
90		1.		1.
85		1.		1.
80		1.		1.
75		1.		1.
70		1.		1.
65		1.		1.
60		1.		1.

4. Bring throttles to idle and proceed to next test.

9.0 AUTOTHROTTLE FORCE TEST

1. Initial A/C Configuration:
   -Verify Gust Lock is OFF
   -Start both engines
   -Select both converters to ON
   -Select APU bleed air OFF and both engine bleeds to ON
   -Select both air conditioning packs to ON
2. Set manual target EPR of 1.30
3. Advance throttles to EPR of 1.20
4. Engage autothrottles
5. Allow throttles to reach stabilized position
6. Install force measuring device to throttle lever and mark location for measurement.
7. Pull one throttle lever back until AT disengages, record max force value

   LH Throttle _____ RH Throttle _____
8. Repeat Steps 3 thru 7 for opposite engine.

9. Pull throttles to idle.

10.0 AUTOTHROTTLE/THROTTLE INTERLOCK DISENGAGE TEST

10.1 Throttle Test with Gust Lock Engaged

1. Initial A/C Configuration:
   -Verify Gust Lock is OFF
   -Start both engines
   -Select both converters to ON
   -Select APU bleed air Off and both engine bleeds to ON
   -Select both air conditioning packs to ON
2. Set gust lock to ON and advance both throttles until the throttles are against the gust lock. Allow engines to stabilize.
3. Record The following:
   A) EPR readings for each engine. LH 1.___ RH 1.___
   B) Throttle lever angle LH _____ RH _____
4. With firm pressure (gust lock set to ON), advance the throttles as much as possible and allow engines to stabilize
5. Record the following
   A) EPR readings for each engine. LH 1.___ RH 1.___
   B) Throttle lever angle LH _____ RH _____
6. Reduce throttles to idle, allow engines to stabilize

10.2 Autothrottle Test with Gust Lock Engaged

1. Initialize performance computers for autothrottle engagement.
2. Arm ground spoilers
3. Verify gust lock is ON.
4. Set manual EPR target from Section 10.1.3.A.
5. Advance both throttles to 1.18 EPR.
6. Engage autothrottle switch and verify the throttles move to the selected EPR value, allow engines to stabilize.

   Note: If autothrottles disengage, repeat test one additional time
7. Disengage autothrottles and reduce throttles to idle
8. Repeat Steps 4-7 adding 0.01 EPR to previous target EPR each time. Repeat until autothrottle disengages. Do not exceed target EPR of 1.60.

11.0 HIGH SPEED TAXI TESTS

11.1 Aircraft Preparation

1. The winds must be less than 10 knots.
2. Prepare aircraft for flight.
3. Select both converters to ON
4. Select APU bleed air Off and both engine bleeds to ON
5. Verify both air conditioning packs are selected ON
6. Verify Yaw Damper is OFF
7. Verify a total fuel load of 10,000 Lbs minimum
8. Set flaps to 20 degrees
9. Verify elevator trim is set to the correct setting. Record trim setting. _____

11.2 EPR Baseline Test

1. Set gust lock to ON
2. With firm pressure, advance the throttles as much as possible and hold until engines are stabilized.
3. Record the following
   A) EPR readings for each engine. LH 1.___ RH 1.___
   B) Throttle lever angle LH _____ RH _____
4. Return throttles to idle
5. Release gust lock

11.3 Baseline Taxi Test with Gust Lock Off

Note: This is a buildup test to verify aircraft operations

1. Prior to starting this test run, verify brake temperatures are below 200 degrees C.
2. Using the EPR value from step 11.2.3.A, set a manual EPR target of this value.
3. On the active runway with both engines running, verify gust lock is OFF.
4. Verify Yaw Damper is OFF
5. Arm the ground spoilers

   Note: During the take-off and rollout, avoid touching the rudder pedals or control columns. Use nose wheel steering to maintain directional control
6. Advance throttles to an EPR value of 1.20.
7. Release brakes and let the aircraft accelerate to 40 knots.

8. At 40 Knots, engage autothrottle system and verify the throttles move to the selected EPR value.
9. Record speed at which the control column starts to move aft._____
10. At 60 knots, verify AT HOLD illuminates on the PFD
11. At 80 Knots, abort the take-off and decelerate to 40 knots without using brakes or thrust reversers (unless required). Do not use the rudder for directional control.

11.4 Taxi Test with Gust Lock Engaged

WARNING: Test configuration has gust lock set ON, aircraft will not fly. Takeoff must be aborted

1. Prior to starting this test run, verify brake temperatures are below 200 degrees C.
2. Using the EPR value from step 11.2.3.A, set a manual EPR target of this value. If a different EPR value is used, record value. LH 1.____ RH 1.____.
3. On the active runway with both engines running, set gust lock to ON.
4. Verify Yaw Damper is OFF
5. Verify ground spoilers are armed

   Note: During the take-off and rollout, avoid touching the rudder pedals or control columns. Use nose wheel steering to maintain directional control. Make verbal callouts for the AT hold being ON (airspeed), 70 Knots (GL selected OFF) , 80 Knots (abort), and the airspeed where the GL goes to the OFF position.
6. Advance both throttles until they are restricted by the gust lock. Do not force throttles forward.
7. Release brakes and let the aircraft accelerate to 40 knots.
8. At 40 Knots, engage autothrottle system and verify the throttles move to the selected EPR value.

   Note: If autothrottle disengages, reduce the EPR value by 0.01 and repeat test
9. At 70 knots, release gust lock and note gust lock handle position
10. At 80 Knots, abort the take-off and decelerate until the gust lock handle goes to the OFF position without using brakes or TR's . Do not use the rudder or brakes for directional control.
11. During deceleration, record the airspeed at which the gust lock handle goes from the unlatched position to the down and locked position (OFF). Use normal brakes and TR's after this occurs. Airspeed _____

11.5 Taxi Test with Gust Lock Handle in the Unlatched Position

WARNING: Test configuration has gust lock hooks latched/engaged. Control surfaces will NOT move. Aircraft will not fly. Takeoff must be aborted

1. Prior to starting this test run, verify brake temperatures are below 200 degrees C.
2. Set the performance computer for a flex EPR take-off of 1.59.
3. Verify Yaw Damper is ON
4. Verify ground spoilers are armed

   Note: During this test run, use nose wheel steering to maintain directional control. Make verbal callout for 40 Knots (engage AT system), 60 Knots (pull gust lock handle aft), and 80 Knots (abort).
5. On the active runway with both engines running, set gust lock to ON.
6. Apply right rudder until the rudder limit CAS message comes on, reduce rudder pressure slowly until the rudder limit CAS message goes out, and hold this pressure until the AT system is engaged at 40 Knots during the test run.
7. Release the gust lock handle. Gust lock handle should go to the unlatched position. If the gust lock handle goes to the OFF position, engage gust lock and try again.
8. Advance both throttles to an EPR target of 1.40.
9. Release brakes and let the aircraft accelerate to 40 knots. It is acceptable for the rudder limit light to come on during this test run.
10. At 40 Knots, engage autothrottle system and remove pressure from the rudder pedals. Verify the gust lock handle remains in unlatched intermediate position.

    NOTE: If handle goes to the OFF position, abort the test and repeat but release rudder pedal pressure at speed recorded in Section 11.4 Step 11.
11. At not less than 60 knots, pull the gust lock handle towards the locked position once and release back to the unlatched position. Do not latch the gust lock handle.
12. At 80 Knots, abort the take-off and decelerate until the gust lock handle goes to the OFF position without using brakes or TR's . Do not use the rudder or brakes for directional control.
13. During deceleration, record the airspeed at which the gust lock handle goes from the unlatched position to the down and locked position (OFF). Use normal brakes and TR's after this occurs. Airspeed _____
14. End of testing.

12.0 RISK ASSESSMENT

Utilizing Gulfstream flight test experience on prior programs along with guidance provided in FAA Order 4040.26B, all of the testing prescribed in this test plan has been determined to be LOW risk with the

exception of the high speed taxi tests which are determined to be MEDIUM risk. The identified hazard during the high speed taxi tests is Loss of Control with a probability of Remote and a severity of Hazardous. Having the gust lock set presents the potential for unexpected control characteristics and the dynamic effect of gust lock release upon the control system are unknown.

13.0 RISK MANAGEMENT

Mitigation against the risk of conducting the high speed taxi test will be:

- Planning, briefing and acknowledgement that the aircraft will not fly in the gust lock ON configuration. Test location will be selected to allow acceleration and an abort from 80kts.
- A high speed taxi test with gust lock released to verify acceptable control with just NWS to maintain centerline (differential braking and rudder as backup). This configuration mimics the test configuration in which the gust lock will be set and the rudder will not be available.
- The runway required for an emergency stop from 90 kts will be calculated and briefed prior to test conduct. Testing will cease upon reaching that point and an emergency stop will be completed using spoilers, brakes, and reverse thrust.

For all testing, as noted throughout this test plan, anytime the FCS is operated with the gust lock engaged AND hydraulic power applied, there is potential for aircraft structural damage. Caution must be used while exercising the FCS in these configurations.

14.0 FOLLOW-ON ACTIONS

1. Download the flight data recorder
2. Perform thorough inspection per AMM of all gust lock system components and structural interfaces.
3. Ensure GL system is operating correctly per AMM.
4. Perform operational checks of the FCS per AMM.
5. Check work areas for tools and foreign objects.
6. Record completed maintenance actions.