June 22, 2015

VIA OVERNIGHT COURIER

National Transportation Safety Board

[redacted]

Attn: Mr. Luke Schiada

SUBJ: Gulfstream G-IV (N121JM) Accident at Bedford, MA on May 31, 2014
NTSB Accident ID: ERA14MA271
SK Travel LLC Submission Pursuant to 49 C.F.R. §831.14

Dear Mr. Schiada,

Pursuant to 49 C.F.R. §831.14, SK Travel LLC ("SK Travel"), as owner of the Accident Aircraft (N121JM), based upon on the information currently contained within the NTSB's Public Docket, submits for consideration its: (1) Proposed Findings, drawn from the factual information and data included in the Public Docket to date; (2) Proposed Probable Cause statement; and (3) Proposed Safety Recommendations.

We note that the NTSB did not convene a Human Factors/Human Performance Group for this investigation. SK Travel believes that issues regarding flightdeck design, operation and integration; human biomechanics; cockpit automation; information processing/decision making; human error; and crew resource management should be evaluated and considered by the NTSB as part of its investigation and Probable Cause determination. Further, as evident from the factual information contained in the Public Docket, there are also significant issues regarding the design of the Gulfstream G-IV Gust Lock system and pitch control system and whether they were/are properly certified under the applicable FAA regulations. Therefore, SK Travel's submission focuses primarily on these important issues.

I. Proposed Findings

1. The accident flight crew was properly certificated and qualified in accordance with all applicable Federal Aviation Regulations.

2. The airplane was properly maintained in accordance with all applicable Federal Aviation Regulations.

3. It cannot be determined whether the Gust Lock handle was in the UP/ON, DOWN/OFF, or an intermediate position when the accident flight crew started the engines.

4. It cannot be determined whether the Gust Lock handle was in the UP/ON, DOWN/OFF, or an intermediate position when the accident flight crew lowered the flaps to 20 degrees.

5. It cannot be determined whether the Gust Lock handle was in the UP/ON, DOWN/OFF, or an intermediate position when the accident flight crew began their takeoff roll.

6. The G-IV Gust Lock system incorporates a mechanical interlock in the sector assembly that is intended to limit throttle movement to prevent aircraft takeoff with the Gust Lock Handle in the UP/ON position. With the Gust Lock in the locked position, the throttle levers should not be able to advance beyond 6° +/- 1° from the idle position.

7. The accident flight crew was able to achieve takeoff speed with the Gust Lock engaged despite the G-IV's Mechanical Power Lever Interlock.

8. The Federal Aviation Administration's (FAA) general definition of V_1 is "the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance" and is specifically defined in 14 CFR §25.107(a)(2) for G-IV certification purposes.

9. FAA-published guidance recommends "that pilots consider V_1 to be a limit speed: Do not attempt an RTO [Rejected Take OFF] once the airplane has passed V_1 unless the pilot has reason to conclude the airplane is unsafe or unable to fly. **This recommendation should prevail no matter what runway length appears to remain after V_1.**" (*see* FAA Takeoff Safety Training Aid, Section 2) [emphasis in the original]

10. The Gulfstream G-IV Operating Manual, Ground/Flight Characteristics and Procedures, 06-02-10 (Normal Takeoff) does not include any guidance or procedure that at 60kts the flight crew is to confirm that the elevators are free and that the yoke has reached the neutral position.

11. The Gulfstream G-IV Operating Manual, Ground/Flight Characteristics and Procedures, 06-02-10 (Normal Takeoff) states that "[a]t V_1, the decision is made to continue the takeoff. If the decision is to continue, the PF transitions [his hand] from the power levers to control yoke."

12. Prior to reaching V_1, there is no indication that the accident flight crew was aware that the Gust Lock was "engaged" (i.e., the elevator mechanical latch was engaged).

13. There is no indication that the accident flight crew was aware that the Gust Lock was "engaged" (i.e., the elevator mechanical latch was engaged) until approximately 1 second after the aircraft reached rotation speed (V_R), which was approximately 6kts higher than V_1(and occurred less than 2 seconds after reaching V_1).

14. At no time after electrical power was supplied to the aircraft or after the engines were started was there any form of Crew Alerting System (CAS) aural warning or any form of warning, caution, or advisory messages provided to the accident flight crew that the Gust Lock System was engaged.

15. The accident flight crew encountered multiple complex, confusing, and conflicting cues/indications when they attempted to rotate the aircraft at V_R, including the inability to rotate the aircraft to takeoff attitude, the possible realization that the Gust Lock system was "engaged" with the Gust Lock Handle in an intermediate position, and the aircraft being at or above V_R with the gust lock "engaged" (which is not supposed to be possible in the G-IV aircraft). All of these cues/indications occurred in rapid succession and above V_1 speed, which would increase the flight crew's reaction/decision-making response time.

16. The Gulfstream G-IV Airplane Flight Manual (AFM), Emergency Procedures, Section 4-15-30, states that the proper procedure for an Immovable Flight Control, Elevator Control (Pitch) is to "PULL Flight Power Shutoff Handle." This Emergency Procedure does not discuss any limitations on when it should be used (i.e., only prior to V_1 or V_R, only prior to 60kts or 80kts on the takeoff roll, only during flight, not to be used in the event of inadvertent gust lock engagement, etc.) and does not define what constitutes an "Immovable Flight Control."

17. The Gulfstream G-IV AFM, Normal Procedures, Line Up checklist also notes that "If the Flight Power Shutoff Handle is pulled at rotation due to a flight control problem, high pull forces will be required to achieve the takeoff attitude. There will be a delay in airplane rotation and, once airborne, a push force will be necessary to maintain the climb."

18. After reaching V_R and possibly recognizing that the Gust Lock was engaged, the accident flight crew followed Gulfstream's AFM "Emergency Procedures" when they responded to the locked and "immovable" flight controls by pulling the Flight Power Shut-Off Valve Handle.

19. Due to the aerodynamic load on the elevator (and aerodynamic loads on the other flight control surfaces) and the forces acting on the elevator gust lock mechanism (and the other flight control gust lock mechanisms) at V_R , it was likely impossible for the accident flight crew to disengage the elevator gust lock mechanism through the use of the cockpit Gust Lock Lever with or without the Flight Power Shutoff Value being pulled.

20. After allowing for the expected delay in rotation with the Flight Power Shutoff Handle pulled (as noted in the G-IV AFM Line Up Checklist) and realizing that the AFM's Emergency Procedure for an Immovable Flight Control was ineffective, the accident flight crew was forced to attempt a rejected takeoff with insufficient runway remaining at a speed well above V_1.

21. It has not been determined whether the Serengeti brand sunglasses that were recovered post-accident on the Pedestal Assembly floor had any effect on the operation of the Gust Lock/Throttle Lever Interlock Mechanism during the accident sequence.

22. The Gulfstream G-IV Pilot's Checklist does not include, as part of the Line Up checklist, the "Note" (defined by Gulfstream as "Information which calls attention to special conditions or procedures") that "at 60kts the pilot shall confirm that the elevators are free and that the yoke has reached the neutral position" that is found in the G-IV AFM and Quick Reference Handbook (QRH) Line Up Checklist.

23. Due to the unique design characteristics of the G-IV flight control systems, a 13 pound pull force on the control column is always present. During takeoff, control column springs keep the elevators full trailing edge down (i.e., the control column is in the full forward position), the same position that the elevators are in if the Gust Lock is engaged, until airspeed increases enough for aerodynamic loads to drive the elevators to a neutral position and bring the control columns aft.

24. According to the G-IV-SP AFM performance data, the target EPRs for a FLEX takeoff and a maximum thrust (MIN EPR) takeoff for the Accident Aircraft configuration, runway length, and environmental conditions would have been 1.59 and 1.70, respectively. According to the FDR, at time 21:39:46, a maximum EPR value of 1.617 for the left engine and 1.614 for the right engine was achieved with the autothrottle engaged and the aircraft at 63kts.

25. Unlike the predecessor G-II and G-III fail safe design of the Gust Lock systems, manual force applied to advance either or both throttle levers cannot override the interlocks on the G-IV Gust Lock system.

26. The reason(s) for Gulfstream eliminating the fail safe design of the predecessor G-II and G-III Gust Lock system manual interlock override design on the G-IV is not known.

27. It is unknown what tests/analysis was performed by Gulfstream as a result of the design change to the Gust Lock mechanical interlock system on the G-IV.

28. Despite the FAA certification requirements and the Gulfstream G-IV design intent that the G-IV Gust Lock mechanical throttle lever interlock will limit power lever movement beyond 6° +/- 1° from the idle position, power lever movement ranging from approximately 18° - 24° from the idle position is possible due to the design of the G-IV Gust Lock system and interlock design, as well as other factors such as the throttle interlock rigging.

29. On the Accident Aircraft, post-accident testing revealed that the power levers could be advanced at least 22°, and possibly as much as 27°, above the idle position before the Gust Lock interlock mechanism restricted further movement. This restriction in power lever position (which should have been limited to 6° from ground idle) constrained the Accident Aircraft's autothrottle system from achieving the expected EPR, thereby increasing takeoff distance, invalidating the calculated V_1 speed, and decreasing the runway available for an aborted takeoff.

30. In order to achieve EPR values in excess of 1.6 EPR, the power lever angles would have to be in excess of at least 10°.

31. The Gust Lock Handle on a G-IV aircraft can be placed in a previously unknown, intermediate position that is between the UP/ON and DOWN/OFF position, with the gust lock mechanisms remaining locked (i.e., the primary flight control surfaces are mechanically locked, but the Gust Lock Handle is not in the UP/ON position).

32. With the Gust Lock Handle in the intermediate position, the mechanical throttle interlock allows greater movement the further forward the Gust Lock Handle is from the UP/ON position.

33. Even with the Gust Lock ON, it is possible to move the rudder pedals several inches under force against the rudder artificial-feel bungee. (*See* G-IV AMM, Section 27-05-00, Step 2.A.(5)).

34. The Gulfstream G-IV AFM states that the RUDDER LIMIT Blue Advisory Message on the Crew Alerting System (CAS) indicates that "Rudder actuator torque limiter is in operation" and that there is no Corrective Action needed when the RUDDER LIMIT Blue Advisory Message is displayed.

35. Neither the Gulfstream G-IV Operating Manual (OM) or AFM discusses that the RUDDER LIMIT Blue Advisory Message could be an indication that the Gust Lock system is "engaged" or requires the flight crew to verify the position of the Gust Lock Lever.

36. The last documented inspection on the Accident Aircraft was performed on September 20, 2013 by Gulfstream in Savannah, GA. The inspection included hourly, 12 month, 24 month, and 72 month maintenance inspections.

37. The last documented Gust Lock System operation test was performed on September 12, 2012 by Gulfstream in Savannah, Georgia.

38. The last documented engine control operational test for the No. 1 and No. 2 engine was performed on September 10, 2012 by Gulfstream in Savannah, Georgia.

39. The G-IV Gust Lock system was required to comply with 14 CFR §25.679 (Control System Gust Locks), which mandates that, if the Gust Lock system, when engaged, prevents normal operation of the control surfaces by the pilot, then it must either "Automatically disengage when the pilot operates the primary flight controls in a normal manner" (§25.679(a)), or "limit the operation of the airplane so that the pilot receives **unmistakable warning at the start of the takeoff**." (§25.679(b)) (emphasis added)

40. The accident aircraft did not either automatically disengage the Gust Lock system when the accident flight crew moved the primary flight controls or provide the accident flight crew "unmistakable warning at the start of the takeoff" that the Gust Lock system was engaged.

41. The accident aircraft did not comply with the requirements of 14 CFR §25.679.

42. As a means of compliance with 14 CFR §25.679, Gulfstream's certification documents required that the G-IV pedestal design limit Power Lever movement to no greater than 6° +/- 1° from the idle position during operation with the Gust Lock engaged, including system design tolerances. Additionally, it was required that a

sufficient force applied to advance either or both Power Levers could override the interlocks.

43. The Gulfstream design requirements pertaining to the Gust Lock throttle interlocking mechanism were contained within two drawings (GAC Drawings 1159SCF450 [Control Pedestal ASSY- Cockpit] and 1159SCF451 [Controls Sectors & support ASSY]), which were both approved by a Gulfstream-employed Designated Engineering Representative (DER) as a finding of compliance with 14 CFR §25.679.

44. The production rigging instructions (GAC Drawing 1159F40300) for the pedal assembly (Gulfstream 1159SCF450, Rockwell Collins 43083) and the floor sector assembly (Gulfstream 1159SCF451, Rockwell Collins 43084) did not contain specific instructions on allowable Power Lever movement with the Gust Lock On.

45. Gulfstream Quality Assurance Procedure 9.2, "Gulfstream G-IV Acceptance Flight Test," required a production flight test card to check the Gust Lock operation, but the production flight test card did not contain specific instructions on allowable Power Lever movement with the Gust Lock ON.

46. The "design and construction requirements" section of GAC Drawing 1159SCF451 "Controls Sectors & Support ASSY", which is a specification control drawing that contains design, engineering, and performance requirements and standards for the sector assembly containing Rockwell Collins part number 43084, states that "an interlocking device operated by the gust lock in the locked position shall prevent advancing of either throttle beyond 6° +/- 1° from the idle position."

47. The "quality assurance provisions" of GAC Drawing 1159SCF451 "Controls Sectors & Support ASSY" contained the production tests for the sector assembly. The production tests are performed to ensure that design and performance are being maintained according to established standards.

48. According to GAC Drawing 1159SCF451 "Controls Sectors & Support ASSY," the vendor [Rockwell] shall conduct in-process and final assembly inspection tests on each assembly offered for GAC acceptance and that such tests shall be adequate to assure continued compliance with all the requirements of the Drawing.

49. GAC Drawing 1159SCF450 "Control Pedestal ASSY – Cockpit" is a specification control drawing that contains design, engineering, and performance requirements and standards for the construction of the cockpit control pedestal assembly of the G-IV, including the Gust Lock Lever.

50. The "design and construction" section of GAC Drawing 1159SCF450 includes the following two requirements for the Gust Lock Lever: (1) "the gust lock lever shall have a locked position in both the up (ON) and down (OFF) positions. The handle and locking shall be similar to existing Gulfstream III design;" and (2) "The gust lock lever shall be mechanically connected to its lower sector assembly by means of push rods and a bellcrank." According to the Drawing, when the Gust Lock is ON, the operating range requirements should be "6° max movement from 'idle' W/GL on."

51. According to the "quality assurance provisions" section of GAC Drawing 1159SCF450, the following tests were to be performed on the pedestal assembly: (1) Qualification Tests, (2) Production Tests, and (3) Inspection Tests. The Qualification Tests were to be performed by the vendor [Rockwell Collins] and performed in accordance with Gulfstream's approved procedures at a Gulfstream-approved testing laboratory.

52. In 1985, Sargent Industries prepared and Gulfstream approved a Qualification Test Plan (QTP) for the sector assembly, control head and pedestal assembly to be installed in the G-IV aircraft and ensure compliance with the requirements of GAC Drawings 1159SCF450 and 1159SCF451. However, the QTP did not include any testing to ensure compliance with the design and construction requirements for the sector assembly as detailed in GAC Drawing 1159SCF451.

53. Sargent Industries prepared and Gulfstream approved a Qualification Test Report titled "Gulfstream IV Sector, control head and pedestal assemblies" dated December 2, 1986 that stated "from the results of the qualification and post-qualification tests, it is determined that the G-IV control quadrant fully conformed to the requirements of the Gulfstream control specification documents 1159SCF450, rev. F and 1159SCF451, rev. D", despite the fact that the Qualification Test Plan did not include any testing to ensure compliance with the design and construction requirements for the sector assembly as detailed in GAC Drawing 1159SCF451.

54. An informal technical inspection on 9 in-service G-IV aircraft found that with the Gust Lock in the UP/ON position, the forward throttle lever movement varied from 18.2° to 24.2° from the throttle levers' full aft position.

55. The G-IV provides no aural warning or Crew Alerting System (CAS) caution or warning to the flight crew that the Gust Lock Lever is in the UP/ON position (or that the mechanical gust locks are engaged) with the engines running, despite that the aircraft cannot be safely operated with the Gust Locks engaged and there is no mechanical override system for the Gust Locks.

56. The current G-IV pedestal design does not meet Gulfstream's chosen method of compliance with applicable FAA certification requirements, specifically that "an interlocking device operated by the gust lock in the locked position shall prevent advancing of either power lever beyond 6° +/- 1° from the idle position."

II. Proposed Probable Cause

The probable cause of the accident was the failure of the Gust Lock Mechanical Power Lever Interlock to restrict the movement of the power levers to a maximum 6° +/- 1° above ground idle with the Gust Lock system engaged, which allowed the engines to produce enough power to accelerate the aircraft to rotation speed (V_R) without "unmistakable warning" to the flight crew that the Gust Lock was engaged. Contributing factors include: (1) the lack of any G-IV Crew Alerting System indications (warning or caution lights or aural warnings) that the Gust Lock was ON with the engines running); (2) the failure of the accident flight crew to perform a proper flight control check after engine start, (3) the lack of a Gust Lock mechanical interlock override system (similar to the G-II and G-III systems); and (4) the flight crew's attempt to abort the takeoff with insufficient runway remaining after following the G-IV AFM emergency procedure for an Immovable Flight Control, Elevator Control (Pitch) and guidance in the G-IV AFM's Line Up Checklist regarding the expected delay in rotation if the Flight Power Shutoff Handle is pulled at rotation due to a flight control problem.

III. Proposed Recommendations

1. The FAA should issue an immediate Airworthiness Directive for the Gulfstream G-IV to address and correct the deficiencies in the Gust Lock mechanical throttle interlock system.

2. Gulfstream and the FAA should determine if the G-II, G-III, and any other Gulfstream model aircraft with a Gust Lock system that incorporates a mechanical throttle interlock system comply with all certification requirements both as designed and as manufactured.

3. Gulfstream should perform new FAA certification testing for a redesigned G-IV Gust Lock System that ensures compliance with 14 CFR §25.679.

4. Gulfstream should incorporate a G-II/G-III-style fail safe Gust Lock manual override system into the G-IV Gust Lock system.

5. Gulfstream should revise the G-IV Operating Manual, Aircraft Flight Manual and related documentation to ensure that flight crews are made aware that the current design of the Gust Lock system will not prevent the advancement of either power

lever beyond 6° +/- 1° from the idle position when the Gust Lock lever is the UP/ON position or in an intermediate position.

6. Gulfstream should revise the G-IV Operating Manual, Aircraft Flight Manual and related documentation to ensure that flight crews are made aware that the Gust Lock Lever can be in an intermediate position between the UP/ON and DOWN/OFF positions with the Gust Lock engaged and include a thorough discussion of the conditions under which this intermediate position can occur.

7. Gulfstream should revise the G-IV Operating Manual, Aircraft Flight Manual and related documentation to ensure that the "Starting Engines" Checklist contains a Warning (or Caution) to ensure that the flight crew are made aware that the Gust Lock Lever must be in the DOWN/OFF position prior to engine start; if not, the gust locks may not disengage even if the Gust Lock Lever is not in the UP/ON position.

8. Gulfstream should revise the G-IV "Line Up" checklist in the Operating Manual, AFM, QRH and related documentation to elevate the status of the "Note" under Item #4 (Ground Spoilers) regarding the flight crew actions to be taken at 60kts during the takeoff roll to a line item check of the "Line Up" Checklist or as otherwise found appropriate.

9. Gulfstream should revise the G-IV "Line Up" checklist in the Operating Manual, AFM, QRH and related documentation to remove the "Note" under Item #4 (Ground Spoilers) regarding the use of the Flight Power Shut Handle after rotation due to a flight control problem. This "Note" mandates that a flight crew troubleshoot an undefined "flight control problem" after reaching V_R without regard to external conditions/circumstances (including runway remaining) in lieu of performing a high speed aborted takeoff.

10. Gulfstream should revise the G-IV Operating Manual, Aircraft Flight Manual and related documentation to include a discussion and procedures for high speed aborted take-offs after V_1.

11. Gulfstream should revise the Gulfstream G-IV Operating Manual, Ground/Flight Characteristics and Procedures, 06-02-10 (Normal Takeoff) (and accompanying Figures 1 and 2) to include the content of the Note currently found only in the G-IV AFM and QRH "Line Up" Checklist, Item 4, Ground Spoilers, that "At sixty (60) knots, the pilot shall confirm that the elevators are free and the yoke has reached the neutral position."

12. Gulfstream should add a Crew Alerting System (CAS) warning (warning or caution light and/or aural warning) when the Gust Lock Lever is in the UP/ON position with the engines running.

13. Gulfstream should revise the G-IV Operating Manual and AFM to ensure that flight crews are aware that illumination of the RUDDER LIMIT Blue Advisory Message on the Crew Alerting System (CAS) may indicate that the Gust Lock System is "engaged" and revise the Correction Action to require pilots to verify the position of the Gust Lock Lever.

14. The NTSB Performance Group should conduct testing and analysis to determine stopping distances at Hanscom Field associated with an assumed decision to abort the take-off at time 21:39:59.9, or 1 second after the "rotate" call.

15. The NTSB Performance Group should conduct testing and analysis to determine stopping distances at Hanscom Field associated with an assumed decision to abort the take-off at time 21:40:05 when it is believed that the accident flight crew pulled the Flight Power Shutoff Value.

16. The NTSB should investigate if there is any connection between this accident and the February 7, 2015 G-IV incident at Eagle, Colorado.

Sincerely,

S/ [redacted]
Carl Poplar
Manager, SK Travel LLC

S/ [redacted]
Emil W. Solimine
Manager, SK Travel LLC

cc: James Rodriguez, NTSB