NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 8, 2015

Attachment 1 – Interview Summaries

OPERATIONAL FACTORS

DCA15MA019

Contents

A. INTERVIEW SUMMARIES

1.0 Interview: Ed Springer, Federal Aviation Administration

Date: November 1, 2014
Location: Scaled Composites
Time: 1230 PDT

Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach - Federal Aviation Administration (FAA), David Mackay - Virgin Galactic.

He had a briefing by Mr. Brad Preamble, but was not represented.

His name was Edward Payson Springer, IV, and he was 37 years old. His title was Aerospace Engineer Safety Inspector for FAA AST-400. He had been in that position for about 8 years. He was hired by the FAA in 2002 in licensing and safety division. He got into astronomy during college, and was always interested in rockets. This career appealed to him.

He was in mission control at the Scaled facility because it was an FAA permitted activity. He was the Assistant Safety Inspector. It was purely a compliance monitoring of the launch and operation.

During powered flight 2, he was also present as compliance inspector. He had only observed powered flight 2 prior to this powered flight.

His scope was limited to ensuring compliance with the permit; he sat in on the "delta readiness" review to check on changes to the flight from the previous day. The day of launch status was checked, weather experts briefed current and expected weather conditions. Mr. Mackay briefed the profile he would fly in White Knight2, and crosswind limits were briefed. When asked if there were any concerns expressed prior to the flight, there was a concern about the N2O load, and warming was required, so they were talking about the predictions, and it was left as an interest item. The performance of the engine was discussed that they were on the cold side but trending towards being within limits, (b) (4) . It was not within the limits at the brief, and later, in the control room, it was within limits.

After briefing, he sat down at console, sat at computer, and established communication with the FAA duty officer. Then there were the preflight activities, and monitoring the video displays in the control room. When asked if there were any concerns prior to flight, he said they were still evaluating the nitrous temps. Also during the preflight there was a rocket motor sensor that had signaled. He did not recall which one, but it sensed warm air blowing on the sensor. He was not sure what the sensor did. Another issue was the PSC indicator, which had to do with pressurization. There was an issue noted that they were getting errors or an alarm. They did a reset of the system, and it seemed to clear and they reported it clear. They felt it was not an issue with the system but a sensor. They were also concerned about wind at takeoff, however at release they were below the 10 knots crosswind limit.

He had no concerns for public safety from a compliance perspective, and was not in a position to have knowledge of any other concerns.

They were a little delayed in the takeoff since the preflight activities took a little longer than normal. White Knight2 followed flight plan, gained altitude, and everything seemed nominal. When they were in position for release everyone was go, the release mechanism was armed, it released, and it was a nominal time for ignition. During ignition, he was focused on a camera looking at ignition, and he was reporting the events back to the FAA duty officer providing real time updates.

There was a thumb up for release call, they released as expected, fire was observed, and within about 10 seconds, he heard an abort call, and all the data that was being viewed was lost within a second or two. He heard the abort call through the headset and did not know who called the abort.

In between fire and loss of data, it appeared there was ignition and a few seconds of level flight and then an abrupt pitch up. The flight plan that was briefed was 7-8 degrees, it appeared so initially. He expected a gradual pitch up, and this one was abrupt.

Activities after loss of data included Mark Stucky opening the hatch on the roof to try and visually see what happened. People were hoping the data would come back. The chase plane then called and said he had a visual on the parachute. Edwards called and it was reported they had a visual and they said the vehicle was upside down in a flat spin.

Next call was the impact on the west side of Koehn Lake, but it was not clear which impact. Someone called "everyone in the control center hold your positions." Then it was announced that they were going to preserve the data, and lock down the data.

When asked if the emergency response plan was initiated, he said yes, and Michelle indicated they were executing their "(b) (4) plan." He did not know what that meant.

The difference between the lead safety inspector and an assistant safety inspector was to have a two inspector construct. They split up responsibilities, and his role was to keep the duty officer informed. Jeff was more focused on having eyes on the data. They had a checklist, and he executed our mishap checklist. They got word early there was a casualty and it was defined as an accident.

He described the pitch up as "abruptly". It was brief and abrupt, only a matter of seconds. It looked more vertical than what he expected. After the anomaly, there was not much going on the consoles. Once there was confirmation that there was debris on the ground, they locked down all data. There were folks like Mark Stucky making phone calls. They brought in white folders and everyone put their notes in there.

He was watching the video on the big screen of the cockpit, and the rate at which the horizon moved was abrupt.

At 0900, they got (b) (4) for the N2O tank temperature for a 0900 liftoff, but it was trending toward acceptable. They left a little later than expected so it would be warmer.

They did not talk about why they had concerns about the nitrogen temps.

It was reported a day earlier that they had an issue with the DAU. Prior to launch, the DAU failure was being carried as a possible risk.

Going back to the sensor, the aft breech detection sensor was the one they were having problems as a result of warming air.

Scaled had a standing waiver for a hazard analysis. He said public safety was intact and not jeopardized during the activity. When asked if anyone of the FAA personnel had the authority to abort the launch, he said no, their role was only to ensure compliance.

He could hear the dialogue to the pilots and some individual stations.

Interview concluded at 1320.

2.0 Interview: Jeff Claxton, FAA Safety Inspector
Date: November 1, 2014
Location: Scaled Composites
Time: 1330 PDT.
Present: David Lawrence, – National Transportation Safety Board (NTSB); David Gerlach – Federal Aviation Administration (FAA); David Mackay – Virgin Galactic

He had a briefing by Mr. Brad Preamble, but was not represented.

Mr. Jeff Claxton stated his age 54. His title with the Federal Aviation Administration was a Safety Inspector for the Office of Commercial Space Transportation and had been in this position for two years. Prior to working with the FAA, Mr. Claxton was employed with the USAF VAFB 30th Space Wing Safety office as the Mission Flight Control Office and Range Safety Systems Analyst. His position on the day of the launch accident was that of a Lead Safety Inspector. Mr. Claxton stated this entailed monitoring the operator for compliance with the pertinent code of federal regulations and "that was their only role". Asked what he would do if he observed a noncompliance, Mr. Claxton indicated that he would notify the operator that they were proceeding into non-compliance territory and further continuance would result in a fine. Asked if he had the ability to declare an abort, Mr. Claxton said "no".

Mr. Claxton was asked to discuss his observations of the launch operation starting with the preflight. Mr. Claxton stated that he had attended the pre-mission brief on the day of the flight and the concerns for the morning were crosswind for landing on runway 30. He also noted that there was a Digital Acquisition Unit (DAU) problem that was in work. Asked if the DAU anomaly was resolved, Mr. Claxton said, "I don't recall".

Mr. Claxton was asked who gave the weather briefing and he indicated it was presented by an Edwards (AFB) person. Asked if anybody else briefed the weather and he said no.

Mr. Claxton was asked if anything in the pre-mission brief was of concern and he said "no, not that I recall."

Mr. Claxton stated that after the pre-mission briefing was complete, he walked to the control center and began configuring his audio system, set up his work computer to communicate with the duty officer for the mission. Mr. Claxton noted that they used a chat system like twitter to send status on key phases in the process.

Mr. Claxton was asked what he was looking at during the mission. He stated he was concentrating on the boards, ground track, altitude, and different things that are taking place on the SpaceShip such as engine displays and airspeed. He also noted that he listened to the flow of conversation in the control room.

Mr. Claxton was asked if he could listen to cockpit communications and he stated that he could only hear those that were broadcast.

Mr. Claxton was asked to go through the launch sequence. He stated that they (flight crew and launch team) went through the launch checklist. They performed the countdown to release and that the release looked normal. Following release, Mr. Claxton noted arm and ignition and commented that the plume looked normal for about three seconds.

Mr. Claxton stated that while watching the downlink video he observed a violent pitch up and loss of telemetry. Asked what he was looking at to observe the pitch up, he stated he was watching the SpaceShip video that showed the rocket motor and the in cockpit view. Mr. Claxton was asked how many powered flight he had observed and he stated that this was his second powered flight. He saw powered flight 3.

Mr. Claxton was asked what occurred after the violent pitch up and he stated that he observed the team members performing their emergency procedures, checklists, and contacting emergency authorities. He also noted that Mr. Mark Stucky went to the roof to look for the vehicle. Mr. Claxton also indicated he heard the Test Conductor (TC) contact the chase and WhiteKnightTwo aircraft to determine if they had visually spotted the SpaceShip Two vehicle. Mr. Claxton stated that during this period he was following his emergency procedures.

Mr. Claxton noted that he heard what was reported by the chase plan that the vehicle was in a flat spin and that someone reported seeing a chute. Following this, Mr. Claxton heard someone report the latitude and longitude of the impact site and reported this to his duty officer.

Mr. Claxton was asked if there was any difference between the preparations to the previous launch operations he observed and he indicated that he didn't think so.

Mr. Claxton was asked if he was aware that there was a previous launch attempt and why it was scrubbed. Mr. Claxton stated that he "was told that they had something to investigate and wasn't given the information

Mr. Claxton was asked how he would characterize the compliance with the CFRs and he indicated that they (Scaled Composites) were compliant.

Mr. Claxton was asked what channels/loops he was listening too and he indicated that they were open cockpit microphone, Test Conductor and that he could hear many of the stations, which included air traffic control.

Mr. Claxton discussed the rocket motor plume as having widened out and changed colors. He noted that plumes in his experience was generally orange and this one was opaque. He noted that in the initial start-up of the rocket motor that there was some black in the middle and that this plume was different.

Mr. Claxton was asked to discuss what happened in the control center when data was lost. He said he heard the Test Conductor ask everyone to stay on the consoles and noted that he was continuing to work through his notification checklist. Asked why he started his mishap notification checklist, he stated it was obvious that something was wrong because they lost contact with the vehicle.

Mr. Claxton noted that he heard the call abort, abort, abort as well as hearing somebody say he had "RMC shutdown."

The rate of the pitch up was much higher than anticipated. He compared this to his observation of powered flight 3. He was looking at the video on the left board, and also some telemetry. He observed the crew doing their tasks, saw them push the release button, but nothing else. His eyes were on the crew. Their head movements looked normal. He did not recall watching the hand actions of the pilots.

In the flight readiness review, they described the new rocket motor, how it was tested, and showed some thrust plots. They went into pretty good detail. He had not been involved in the engine testing. He believed the license group was involved because it was a permit modification. He did not notice any concerns. The licensing group, AST 200, he was not sure what teams they had.

MRR described the new rocket motor, and described how it was tested, and showed some thrust plots in pretty good detail on what they did for the new rocket motor. He was not part of the change over to the new engine. The FAA license group was involved.

Interview concluded at 1415.

3.0 Interview: Frederick Sturckow, Virgin Galactic Pilot (VG)

Date: November 1, 2014
Location: Scaled Composites

Time: 1415PT
Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach – Federal Aviation Administration (FAA); David Mackay – Virgin Galactic (VG)

Mr. Sturckow declined representation.

During the interview, Mr. Sturckow stated the following:

His name was Frederick Sturckow and he was 53 years old. His current title was Pilot for Virgin Galactic. He was hired May 2013. Prior to working for VG he was a pilot for another operator and prior to that was a pilot in the Marine Corps, flying F-18 Hornets principally. He completed test pilot training at USAF TPS. He had around 6,000 hours of which about 5,800 hours were as PIC. His previous SS2 experience was during GF30 which was a FCF where the feather functionality was verified. All Virgin Galactic pilots have test pilot training.

His duty on October 31, 2014 was as Safety Chase pilot in an Extra 300. The pre-brief was given using the Scaled Standard Briefing Guide in which all items were covered. All aircrew, the MCC team, management, and FAA representatives were present. The briefing covered the conduct of the mission, weather, NOTAMS and TFRs.

The concerns were weather - it was thought it would be worse than it turned out to be; there were also some electronic equipment delays, but no other concerns. It seemed like everything was progressing normally and it was expected to have full capability. Vehicle crosswind limits and window fogging were discussed. The window heating system had not been tested, but anti-fog film was fitted and was also discussed. The new engine configuration included new switches, but many sims had been done in this new configuration. The test was intended to be a 38 second burn and a supersonic feathered re-entry.

He waited until WK2 took off, monitored comms, and then knew when to take off in the Extra. He then flew to the holding point and climbed up to 12,000 feet. He saw WK2 coming about 10 minutes out. He monitored comms using countdowns to release to time his positioning for the launch. At launch it seemed to drop about the usual amount and the rocket ignition looked "beautiful." The motor ran for about 5-10 seconds and then shut down - he thought it was something to do with the (b) (4) looking from 14,000 feet looking up at 44,000 feet. He saw the clouds, pieces coming out of the cloud, and he flew in that direction. He put the vehicle in a 30 degree bank to stay away from the debris. He heard the "Knock it off" call from Ericson, but his impression was that it came after motor shutdown. He did not hear calls from the pilots. It continued on its upward trajectory and then a cloud appeared and it was obvious that something bad had happened. He next started looking for chutes. The SS2 tails were two distinct pieces that came down, one to the right and two to the left. He thought he saw two distinct objects falling out after about 5-10 seconds. One blossomed into a parachute and he followed it. The other did not.

It all happened in a blur. The photographer with him "locked up" after the loss of the vehicle. SS2 had looked good, the plume color also looked good. It burned for about 5 maybe 8 seconds. As he saw the pieces, he saw a little flame, an orange flash but he could not say where it came

from. The profile looked normal to him, although he was at 14,000ft. He thought the motor had shutdown then the vehicle broke up but the release looked nominal and the rocket lit at about the right amount of time. After shutdown everything was going uphill in a cloud, then the first thing he saw was the tails coming off.

He stayed with the chute that opened, and circled around the chute. They were drifting to the NE. The guy with the chute gave him a wave. When he landed, he crawled towards a bush, and gave him another wave. He then set up another orbit to look for the other objects.

He was surprised to see two objects at the same time. He said it was not easy to egress for the SpaceShip2. He flew a little further SW, saw the rest of cabin, and thought the cockpit was still there. He went back to check on the guy, who was sitting in the same place. WhiteKnight2 was orbiting overhead. He was trying to help the helicopters coming up to find the location. The first helo was Tiger 8 from the National Test Pilot School, and he led him over to the pilot. He started getting low on fuel, and another helo showed up, but he could not hear his call sign. He got it sorted out who was going to pick the pilot up, and then he headed back to Mojave to refuel. He went back to look for survivors, and then went back with a Scaled guy to document the wreckage.

There appeared to be a good wind drift – the accident has seemed to happen over Highway 14 and ended up north of Koehn Lake. He started looking for the other pilot. He was surprised that both bodies appeared to have come out together.

He went back to the west to find the tails and then the rest of the aircraft, the main wing structure and pieces of fuselage. WK2 orbited overhead and the Extra directed rescue helicopters to the site. The first was a Tiger 8 helo from NTPS, but the Extra was getting low on fuel at this time. Another helo arrived and he asked them to look for the other crew member. Then he headed back to Mojave, picked up another pilot and headed back out having obtained permission to enter the TFR. Another helo was already there and had already found the body. On the ground, he did not see the cockpit. All the debris he found was north west of the railway tracks. The distance from the bodies to the debris field was maybe one mile.

Sturckow also described the personal safety equipment. Prior to launch they go to 100% O2. There was an emergency bail-out bottle (the green apple). The chute had a static lanyard, which was tied to the seat. He had carried out emergency egress training in WK2 and had practiced SS2 approaches in the same aircraft, using gear down, inboard speedbrakes and 75% throttle. He was in the sim at least once a week. Sometimes on Mondays he was the sim operator. The sim belonged to VG but Scaled pilots also use it.

When he observed the release, it looked nominal to him. It dropped and was about the right amount of time before it lit.

Attitude of the ship was clear that something had happened, and he observed the tails coming out of the cloud. The two tails were separate as they came down. He was surprised the wing and tail structures came down close to each other. The two objects definitely came out of the wing section in flight during the breakup.

Egress procedures was the FO going back to open the door.

He was following two objects down, one with a chute and one without.

20k feet was their bailout procedure. In that situation, it depended on if they were still pressurized. The chute had a lanyard that auto deploys, and the red lanyard tied on to the corner of the seat. He could not tell if the tails came off symmetrically.

The time between seeing the plume and seeing the two objects coming was about 5-10 seconds. Practicing egress, it took a long time to get out, which included depressurizing the cabin, and the cabin does not climb rapidly. There were two buckles to undue, plus getting out of the seats. Operating the hatch was straight forward. With the chute on, it was hard to get through the seats. You are not going to get the hatch open without pulling the pull plugs. He saw a big cloud of nitrous and it did not look like a normal dump.

When the RMC shuts down it shuts down the MOV (main oxidizer valve).

The interview concluded at 1600.

4.0 Interview: Michael Masucci, Pilot, Virgin Galactic Pilot

Date: November 1, 2014
Location: Scaled Composites
Time: 1600PT

Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach – Federal Aviation Administration (FAA); David Mackay – Virgin Galactic (VG)

Mr. Masucci declined representation.

During the interview, Mr. Masucci stated the following:

His name was Michael Masucci and he was 51 years old. His current title was Pilot for Virgin Galactic. He was hired in March 2013. Prior to working for Virgin Galactic he was a captain and check airman for XOjet and prior to that spent 23 years in the USAF mainly flying U-2, F-16 and T-38. He had about 9,200-9,300 total hours, and ATP, multi, single glider ratings. He had an Experimental Authorization for WK2 and had flown two glide flights in SS2, one from the left seat.

His duty on Oct 31, 2014 was as WK2 tow pilot. He arrived at work at 0330 PT in preparation for the tow which was scheduled for 0430, however, some avionics issues caused a delay. Once the vehicles were ready Masucci followed the Tow Pilot Checklist procedures and carried out a dry motoring of engine number 2 to pressurize the brake system. The mated pair were then towed to the runway and positioned such that the adjacent roads and buildings were outside the safety zone and good telemetry reception was achieved. Having successfully positioned the mated pair, he then proceeded to the Mission Control Center in Faith (Oculus) and remained

there for the flight. Oculus was set up as a training environment with Scott Ostrem as Test Conductor (TC), and it shadowed the Scaled Control Room in building 78.

There was a short delay getting the N2O temperatures correct prior to take-off. After that the take-off, climb, enroute, L-10 [minutes], L-4, L-30 [seconds] checks were all nominal. For the SS2 flight Masucci's attention was focused on the video screens. He was surprised by how black the initial rocket motor exhaust was but, once lit, it was a very nice plume and the shock diamonds were very clear. It looked like a good light and burn.

Pete [Siebold] called, "Clean release" and made a noise like a "Whoopee", or something like that, as the motor lit. The transonic pitch bobble was called and it looked like Pete was working hard, there were lots of movements in the roll axis. After that there was a call of "Supersonic", or some words to that effect. Scott Ostrem who was following the calls from the building 78 Control Room repeated that call for Oculus training purposes and stepped on some other call from the cockpit.

Masucci was expecting to see a normal pitch up but instead the pitch up was very rapid and the video froze. It looked like the airplane had bent in half. The stabs station in Oculus was not manned but afterwards the aero station said they had seen massive AOA. The systems station said they saw the feather unlock, then go back to lock; aero said they saw something similar. On the motor everything had looked normal up to the point of an RMC-commanded shutdown. After the incident the VG/TSC emergency response plan was initiated in Oculus.

In the brief the day before there were no anomalies or concerns. Prior to the flight there had been a lot of FRRs, focused on the (b) (4) system and ground safety procedures. There had been some discussion that there would be a slightly longer delay in the time from fire to rocket motor ignition.

This engine involved more sequencing to get the engine to light, unlike the previous engine. They were expecting apogee at 125k-140k feet, and were trying to hit Mach 1.2 on reentry.

Masucci estimated that the time from light up to the violent pitch-up was about 8-10 seconds. He could not say whether the tail booms had risen symmetrically. The burn duration was scheduled for 38 seconds. Then next step would likely have been a 50 second burn.

For SS2 pilot training Masucci had two simulator sessions per week. One where the primary crew was from Scaled and another where it was from VG. Crews typically took turns as the simulator operator and as crew.

He was asked about the VG emergency response plan, and he indicated they had a joint ERP with TSC. They performed the (b) (4) ERP which was downstairs from the Faith control room. During that process, the IT personnel secured the control center and its data.

Asked about a risk analysis on the propulsion system, he indicated there was a qualification program that required 3 good burns on the motor. Asked if VG was kept in the loop on the RM developing and testing, and he said Mike Mosses was in the loop.

He did not consider the schedule rushed.

For WK2 training VG had its own simulator in which he typically spent a couple of hours a week training. He flew WK2 perhaps twice a month on average and typically also carried out simulated SS2 approaches in it. He said they also did aerobatic training.

A rocket motor risk analysis and qualification firings had been carried out, in which VG and TSC were included.

Masucci described the parachute equipment used on SS2. These were Butler, heavyweight round parachutes. They incorporated an 1800 psi O2 bottle, which provided around 15 minutes of breathing. A static lanyard was employed which attached to a hard point on the seat. On bail-out this armed the auto-parachute barostatic release which was activated when altitude and descent rate conditions were met. The nominal bail-out altitude was 20,000 feet. He said the right seater got out first, then the left seat. Normal bailout would be in the feather position. Chutes also had a D ring for manual pull.

The interview concluded at 1700.

5.0 Interview: Ryan Smith, The SpaceShip Company Engineer (TSC)

Date: November 2, 2014
Location: Scaled Composites
Time: 1600PT

Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach – Federal Aviation Administration (FAA); David Mackay – Virgin Galactic (VG); Mark Stucky – Scaled Composites.

During the interview, Mr. Smith was represented by Mr. Steve Avila, Legal Counsel, TSC. Mr. Smith stated the following:

His name was Ryan Smith and he was 31 years old. His current job title was Test and Analysis Engineer for TSC, essentially the engineering arm of VG, And he was sitting in the Melvill center for this flight. He had been at TSC for one and a half years and had worked hand-in-hand with Scaled. Prior to TSC he worked at Edwards Air Force Base for Lockheed Martin as a Test Conductor on the F35, including high AOA, loads and envelope expansion. At TSC he worked on simulation and initially observed glide flights from the Stabs Console.

Smith was also assigned to qualification testing of the SS2 feather actuator; he wrote the test plan and ran the test program. In preparation he looked at previous data from flights when the feather was deployed, on PF02 and 03, and the forces the actuators had to overcome, then drew up a test plan based on engineering best judgment and best practice, and used DO 160 as a guide. The test defined maximum and minimum operating temperatures and included an endurance test.

On Oct 31, 2014 his duty was sitting on the Stabs Console as Stabs Secondary, the Primary was Toby Sorenson. The Secondary position was an additional source to look at the data, essentially it was a

co-pilot role to Stabs Primary. The Primary was also responsible for the Stabs Console communications.

Smith reported at 0410 for the 0430 brief, which subsequently slid to 0500. The full brief had been given the day before. Following the brief he went to the control room.

In the control room he used the checklist to set up the console. Take-off was delayed for a couple of hours to allow the N2O to warm up so he waited in the vicinity until the Rocket Motor team decided it was ready. The team then began pressurizing the N2O and going through the NPs as written in the checklist.

There followed a normal take-off and climb up to altitude. Sorenson and Smith did their standard CRM calls review during this time, then went through their "Commit To" criteria. He said he was essentially in a co-pilot role to Toby. SS2 was released on condition at the drop point. There were two screens at the Stabs Console: Sorensen watched the stabs, pitch and roll, and roll boost; Smith was on the second screen, primarily the feather actuators, feather lock and the speedbrake, he also watched the flight conditions, including ADI, Mach and airspeed.

On release the g went to 0.5 g initially, as expected. The rocket motor lit and he heard a "Good light" call, the airspeed increased at roughly a constant altitude. He was not watching the 8 ball (attitude indicator). As SS2 accelerated the pilots made a couple of calls of "Yeeha", and there was a heavy breathing sound, as had been heard on previous flights. Smith watched the Mach number, and standard calls were made.

At about Mach 1 he heard an "unlocking" call from the vehicle which, he believed, came from Mike Alsbury. Smith's scan went from the Mach indication to the feather locks. He can't remember what lock indications he saw but it was enough to know they were moving, and he saw them moving.

That did not seem right so he went back to the Mach indicator to check it was correct and started to reach for the transmit switch but at the same time Sorensen already had his finger on transmit switch, about to make a "Check trim". Simultaneously someone called "Departure", the TC called "Knock it off, knock it off, knock it off", then TM was lost. Smith did a quick scan to check why TM had been lost, comms could not be re-established and he recognized that this was a bad day. He was not sure what the feather did, he was more concerned with the locks. He began to write notes and completed two pages before the aircraft impacted.

The SS2 procedures were written such that after the 0.8 Mach and the pitch bobble, the pilots started trimming. The locks should have remained engaged until after the gamma turn. They were unlocked at 1.4 Mach, and above 1.8 Mach the SS2 might not be capable of a feather down reentry. At less than 1.4 Mach, Smith's understanding was that the actuators would hold the feather down but the load path was altered, so SS2 needed to be through the gamma turn before unlocking. A lock cycle check had been carried out on the ground and in flight. Both had been normal.

Normally, they would come off the hooks, they accelerated, and through the transonic pitch bubble, they start trimming for the gamma turn. Once stable in the climb and around 1.2 Mach they were out of the pitch bobble and could unlock the feather. You need the locks engaged during the loaded turn.

For an unlock to occur without first moving the locks, the over-centering mechanism would have to be overcome as well as the pneumatic pressure holding the locks in place.

Test of the feather system in flight was done, including a ground preflight. There were two functional tests. He was watching and it was a standard check, and they got good indications, and he called good feather cycles. Asked about problems with the feather locks, he said he did not know the history of the program.

Listening into the hot mic, what was "normal" depended on the pilots. He was used to a litany of information coming through with other crews, and this crew was quieter than other flights he had observed, even compared to the simulator work.

He believed Pete would make the trimming call when he was trimming, Mike only made a call when actions were complete. This crew made calls as they were doing things, not pre-movement. He did not see this as a negative, just how this crew operated. He did not hear any trimming calls. He heard armed, fire call. He remembered briefly while under acceleration something like "yeehaw," or something like that, and then an "unlocking" call. He believed in the room there was a "Mach 1 energy" call. In the Alpha position at the console, Toby had his fingers on the comm switch to the TC as a technique to be ready to make any calls. During his debrief with Toby, Toby told him he remembered seeing something on the locks screens, but he saw the trims around -9, -10 degrees and not the -14 degree trim, and he should have been a mandatory trim call to the TC and he was about to make the call to the TC. He was not watching the big board, and relied on the pilots to fly the nominal trajectory and fly their procedures. He saw the unlock indications, but did not see what the actual the feather was doing on the big screens.

The actuators have a preload on the torque tube. Actuators were making about 30k pounds of force, and if they moved at those speeds they would see that indication.

The time frame from when he heard the unlock to loss of telemetry was about 3 seconds.

The interview concluded at 1700.

6.0 Interview: Mark Bassette, Scaled Design Engineer

Date: November 2, 2013
Location: Scaled Composites
Time: 1330 PDT

Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach - Federal Aviation Administration (FAA), David Mackay - Virgin Galactic, Mark Stucky – Scaled Composites

Representative: Gary Halbert – Counsel, Holland and Knight.

Mark Thomas Bassett was 29 years old and came to Scaled directly upon graduation from Wichita State in Aerospace Engineering.
Job Description: Design engineer for 7.5 years almost entirely on Tier 1B program (WK2 and SS2 program). Initially WK2, then SS2. Design engineers do lots of things at Scaled – design structures and systems, do analysis and test.

His role on day of accident was Primary Aero station in the control room. As a side function of the Aero console was weather monitoring.

Console station configuration was:

- Left display -- raw parameters (airspeed, altitude, attitude, control surface positions)
- Right display -- more processed info. At time of accident it was boost – time vs performance parameters

His role was to monitor the values for all parameters and communicate directly to the TC if they differed much from predictions.

On the day of the accident, he showed up a little before the flight briefing at about 0400. Received a radiosonde data file (weather balloon data from Edwards AFB) and processed it. Took that data along with the latest NOAA (National Oceanic and Atmospheric Administration) RUC (Rapid Update Cycle) forecast model and plotted them to see what the wind profile should be during the boost. He then made recommendation for corrected V_{NE} flight limit changes based on the corrected for winds. This is required because the INS mode no longer uses ADC (mode) data when supersonic and therefor loses the ability to compute the wind-corrected airspeed. During the climb to altitude he compared the INS winds aloft to validate the model. The important parameters are airspeed and mach.

The team had an issue where the nitrous was colder than expected and they had to wait for it to warm up, delaying the flight quite a bit. As the takeoff time was delayed, they became concerned with exceeding the crosswind limits.

For preflight checks, he ensured control surfaces and dampers functioned as expected. He did not have the Stabs Station role but double checks the stabs for expected movement. The feather locks functioned as expected both on the ground and during the inflight mated checks. Nothing unexpected happened during the climb to altitude. The winds aloft were slightly higher than expected at 30,000 feet but not an issue for a boost flight. He did the L-10 check, which included checking the dampers again, and the feather lock check was normal.

Ignition, everything looked as expected. Approaching Mach 1, there was an expected pitch bobble (wings and tails don't shock up at the same time and the vehicle pitches nose up then nose down). We saw the pitch up, it seemed to slow down and then I saw it roll inverted. I called the pitch up to the TC, saw the Nz was greater than 9 g's and the feather had moved. Nothing made sense after Mach 1, all the values displayed were not plausible.

When asked how he knew the feather moved, he said on the control surface position he displayed feather string pot position. The feather position had gone exponentially to beyond its 90% limit,

then discreetly to zero. Going to zero did not seem like real information. After the loss of TM he noted that the two lock LED were red (unlocked) when they should have been green (locked).
Did not see tail boom video because of where it was in the control room. He sat in the front row right side while the tail boom video was displayed on the left big board. After loss of TM he made an estimate of where SS2 was at the loss of contact and relayed the lat/long coordinates to the TC.

For quite a while there wasn't much of anything going on. Wes was monitoring LRO and he said he saw it in an inverted spin, then he lost view of cabin. CJ reported he saw one parachute. CJ relayed coordinates and I transferred them to decimal/minute/seconds format to Forger. That was about it.

He had not heard an emergency response plan initiated, but got the impression that it had based on who was arriving and what was going on.
He listens to TC loop audio, station loop, and Rocket Motor loop although he normally muted the RM loop. He also listened to the two radio channels (mission and Joshua Approach) frequencies, the hot mic that comes from the telemetry stream, and the phone line from the Edwards Range Control which is manned by Wes Persall of TSC. He did not believe anybody was talking on the station loop.

He heard the normal calls approaching release, the arm and fire calls, I think I heard a Mach 1 call and that's all I really remember. The Mach 1 call occurred just prior to data loss.

What is your control room experience. I've done all 3 powered flights. Only not present for 3 SS2 flights.

He was familiar with the callouts, and everything was as expected.

There was a discussion about a DAU problem. DAU#1 had a problem. We had a program history of DAUs being not as reliable as they should be. He was familiar with what a DAU did, and was able to describe its function. A DAU failure does not preclude safe operation of the SpaceShip but you lose redundancy and some of the signals. He could not remember a flight failure of the DAU. They do many sim sessions that include a DAU failure. The program had a history of DAUs not being as reliable as they should be. The flights were short but they often leave the DAUs on for hours and on the ground and they would frequently fail. They have had them fail on captive flight. It was usually remedied by cycling power to them. He thinks it's just a time-averaged statistical thing. I believe they swapped a spare on the accident DAU.

There was an intermittent PSC status bit that was toggling. They were going to accept it for the flight because even if it wasn't correct it would not impact the PSC's ability to perform its duty or impact the RM.

He believed the CMFD (Center Multi-Function Display) turned off without command, and thought they cycled power and it came back.

The new rocket motor was part of the brief, and his desk was adjacent to the RM2 team. He kept abreast of developments, was aware of the change of fuel, the implications that had on the nitrous (we reduced the levels), the addition of the (b) (4) – we were going to accept lower helium pressures because of the reduced nitrous. We had enough helium to meet the design goals for the flight. The first page of the test card had a weight and balance statement and list of objectives for the test.

They talked about the change in the nitrous level. There was a card objective that stated the new rocket. The objectives are not a rank hierarchy, more of an ad hoc summary. He did not hear anything or observe anybody else say something in the control room during the event, someone watching the video feed. He was very focused on his display and doing what I could to help the crew.

At release, stab primary position verified trim set to -9 degrees, after Mach 1, you trim to 14 degrees up for the gamma turn. At loss of data, the stab trim was still -.9. He did not hear a call from the pilots about trim position, and that was not normal, but things were happening quickly. Locks were unlocked during boost as a risk mitigation method to avoid having feathers remain locked down and reentering unfeathered. There was a risk to unlocking the feather because unlocking the feather reduced the load path which held the feather close when the tails are generating a large lifting force. By design, the tails create a large lifting force during the climb, which is the gamma turn going from level to vertical climb. Feather locks resist the lifting force of the tail's load during the gamma turn.

When asked why the pilot unlocks at 1.4M, he said a better parameter would be the Nz[1] because that was what was displayed to the pilot. In a normal boost, 1.4M should coincide with the Nz finishing of the turn, and vertical flight path unloads the wing. Feather actuators are capable of resisting the load during vertical flight. If the feather was unlocked below the 1.4 feather unlock, the vehicle would feather uncommanded. You would effectively trim up.

A headwind would not cause a higher indicated Mach at unlock. If you unlock at exactly 1.4, you would actually be at a higher Mach based on the winds that day.

[1] Nz is acceleration in the vertical axis.

Discuss the limit values that you changed -- [explained the reason for the change based on head or tail wind]. The forecast indicated significant headwinds. (b) (4)

He then gave more explanation about the flight profile stating it took about 10 seconds to Mach one and 20 seconds to max q.

He then explained in detail how when supersonic the INS computes airspeed based on groundspeed and standard day temperature and pressure.

He did not brief a change to the limit Mach because we were so far from that at that point in time. We do fly to near VNE as part of the design profile. INS used standard atmosphere to display airspeed, and it was mostly the winds that made the difference between ground speed and airspeed. It does not reference air data. How big of a delta could there be? -- the delta was 15 KEAS derived from 50 Kts of true wind.

All the parameters he saw were all off scale, some high, some low; beyond the range of the capability. He could not say if any he saw were normal.

Was there a sequence? I saw the ADI flip over, I saw a very high Nz, the control surfaces were not in reasonable positions, and the feather had deployed. The feather started to deploy at a reasonable rate about to about 20% and then exponentially full and then flat lined at a rate beyond anything reasonable.

I believed Pete Siebold made the Mach 1 call.

He then discussed the expected pitch up at Mach 1. He never saw the trim move from the release setting to the gamma turn setting (-14° NU). When questioned where it was he said "near 9".
Was there any call of Mach number or trim position? -- No, and he thought that was different from a normal mission.

At what point are the Mach's normally unlocked? -- above 1.4M.
Why -- the feather was unlocked during boost as a risk mitigation procedure to reduce the likelihood of having the feathers remain locked.

Is there any risk of unlocking the feather? -- yes the risk on the flip side is when you unlock the feather you drastically reduce the capability of the actuators to counter the lift of the horizontal tails. By design the tails have a large lifting force during the gamma turn for the duration of that gamma turn. We use 1.4 mach since that is what is displayed to the pilot. At 1.4 it takes much less force to keep feathers locked. There's a lot less load on the feather, and feather actuators can

ensure they are locked. If feather was locked below 1.4, the tail has enough force that you would backdrive the feather, and they could unlock. 1.4 should coincide with the finish of the turn.
He described the feather control surface aeromechanics.

When asked why not base feather unlock on attitude instead of Mach, he said he did not have a good answer for that.

Describe when the tail lifts and when it does not lift – the tail lifts during most of the flight regime. SS2 has a very unique way of attaining longitudinal stability, the center of gravity is aft of AC, a very unusual configuration, the tails balance it by lifting and the tails [being outboard of the wing tips] are also in upwash.

Is that true above 1.2 Mach? He believed so.

He then described how the feather actuator would be pulled open by the feather although the spring back to their closed position. The actuators were more powerful extended than retracting.
Can you describe how effective the dampers would be after departure of the tail boom? -- they would not [be effective], they are designed to fail in the open position so with loss of power they would unlock.

Could flutter damage occur after the departure? – It was entirely possible, only designed for normal flight regime.

There were bumpers inside the feather actuator, if extended or retracted quickly they would likely be damaged, probably not a lot of margin in the hinges. Damper system is design to fail in the open unlock position to minimize the risk of failure. Rudder locks have to be powered to stay lock. If the feather system was overloaded, you might see damage to the bumpers.

Is there anything you did not mention in this interview because of Stucky's presence? -- No
How did you know you were going to get the same transonic pitch bobble? -- We didn't know for sure that we would be we expected it. We didn't expect the (b) (4) fairings to have much of an effect.

He was unsure of Jim Tighe's analysis on the blisters.

Describe what would have to happen for the feather to extend with the feather locks engaged (closed). When the feather handle is in the closed position, the feather locks are actually driven further locked. He would expect the locks to stay engaged and the tusks to fail. The booms would fail before the hooks.

Interview concluded at 1500.

7.0 Interview: Peter Kalogiannis, Project Engineer – Avionics, Scaled Composites

Date: November 2, 2014
Location: Scaled Composites
Time: 1215PDT

Present: David Lawrence, – National Transportation Safety Board (NTSB); David Gerlach – Federal Aviation Administration (FAA); David Mackay – Virgin Galactic, Mark Stucky – Scaled Composites; Gary Halbert – (Attorney Representative) Law firm of Holland and Knight

Mr. Peter Kalogiannis was represented by Mr. Gary Halbert

During the interview, Mr. Kalogiannis stated the following:

His name was Peter Kalogiannis and he was 35 years old. His current title was Project Engineer – Avionics, Scaled Composites. He has been employed by Scaled Composites for approximately 7.5 years. Prior to working for Scaled Composites, he was employed by Avidyne Avionics for 1.5 years as an avionics engineer. As a project engineer, Mr. Kalogiannis works primarily on the Tier 1B avionics systems. He has designed and built the avionics system for the aircraft WhiteKnightTwo (WK2) and SpaceShip two (SS2), their simulators, and flight test data acquisition system.

Mr. Kalogiannis has supported powered flights one and three and can't remember if he worked flight 2. He also noted that he has worked on the majority of the glide flights as well.

On the day of the event, Mr. Kalogiannis was assigned role as the primary flight test engineer at the TM and avionics station. He arrived Scaled Composites for the test at 0400 hr. He was Informed that Data Acquisition Unit (DAU) 1 was malfunctioning. To resolve the DAU1 anomaly, Mr. Kalogiannis removed the DAU 1, tested the DAU, found the failure, replaced the anomalous component, retested the unit and reinstalled the DAU 1.

Mr. Kalogiannis attended the morning pre-mission briefing in building 78. Following the brief he went to the control room. Upon arrival he verified telemetry system was operating correctly and the data parameters made sense at his station.

Mr. Kalogiannis was asked if there were any concerns at the mission pre-brief. He noted that the issues were wind levels; specifically crosswind limitations for launch and landing times. Asked if they were resolved and he stated that the winds were below limits.

Mr. Kalogiannis was asked if the new hybrid motor was discussed and he said that nothing was discussed.

Once arriving on-console in the control center at the TM position, Mr. Kalogiannis remained until released by the Test Conductor (TC)

Mr. Kalogiannis was asked his role while working in the TM position and he stated that his role was to address any avionics issues that occurred during the flight as well as telemetry issues. He noted that there were no TM or avionics anomalies.

Mr. Kalogiannis stated that the center multifunction display (MFD) rebooted during climb and only had one failure and that the reboot spontaneously occurred when the Pilot was moving a right inner control knob. The center display was used by both crewmember for status monitoring of the health of systems on the vehicle and was configurable by the flight crew.

Mr. Kalogiannis stated the MFD failures happened infrequently and this failure did not occur again on the flight nor can these problems be duplicated on the ground. He suspected the problem was related to electrical discharge.

Mr. Kalogiannis stated that in his TM position another responsibility is to sequence the map display from boost mode to approach mode and that he makes the switch at some point after release.

Mr. Kalogiannis was asked what he witnessed during launch and he stated that on separation he saw separation through video feed on his station, observed motor ignition, then turned to keyboard and mouse and looked at map, he heard his partner selected INS for the display.

Asked what the INS switch was and he stated that they have to switch from using air data to inertial data at 0.8 Mach because there was a limitation to the data of 1.0 Mach. The switch of data was only for the control room.

Mr. Kalogiannis stated that he heard in his headset audio that seemed something was wrong and there was a loss of data on the vehicle. He looked at the TM receiver screen and they weren't detecting any energy from the vehicle for transmission. He turned back to the console and verified no valid parameter. At that point he heard a Broken Arrow call he believed from the TC; this is the term used for an unintentional release. However, this call was for a loss of control. He noted that there was background talk on the TC loop and that he had the impression the vehicle was no longer under control.

Mr. Kalogiannis was asked if he heard anything out of the ordinary and he stated he heard nothing unusual before loss of TM and that it was just like flights and simulation sessions.

Mr. Kalogiannis was asked how often do you sit in on simulations and he stated that they have multiple sessions which they conduct simulator session with full up console positions simulation sessions.

For powered flights, he had done PF03, 1, and was not sure about 2. He had done a majority of glide flights.

Mr. Kalogiannis was asked what happened after the loss of signal (LOS) of TM and he stated that he work with Edwards Air Force Base (EDW), Wes Persall, which had long range cameras. He stated that he queried EDW on status of the vehicle and that they reported it was in an

inverted flat spin. He passed along the information to TC. Asked how soon he passed the information on to the TC and he stated in the 15-30 second timeframe

Mr. Kalogiannis was asked what was occurring in the control center and he stated that he recalled reports from the chase aircraft which included a sighting of one parachute.

Mr. Kalogiannis stated that he continued to work with EDW and requested the latitude and longitude coordinates for the impact positions which was provided to the TC.

Mr. Kalogiannis was released by the TC via the TC loop ending his role through that phase. He stated he asked the TC permission to shut down the system to archive the data. He was granted permission and in doing so transferred the telemetry data to the network storage and to a stand-alone hard drive which meant there were two copies and also the original. Asked what they were named and he stated something like PF04.

Mr. Kalogiannis was asked if VG seeing the same data and he stated that they have their own receiver and see the same data. Asked if they have a similar control with similar displays and he stated that he did not know how different the displays. Asked did you call to see if they were getting telemetry and he said no.

Mr. Kalogiannis was asked if there was any type of emergency response plan (ERP) and he stated that Scaled Composites had an internal ERP. He noted that they follow the ERP for incidents and accidents. He noted that he observed Ben Diachun pick up the (b) (4) binder. He also heard multiple calls from TC & TA for emergency services. Asked if he had a roll in the process and he stated that he had No specific role for this operation.

Mr. Kalogiannis was asked if he archived data as part of the checklist and he stated that the data archiving process is not part of a written procedure. Asked if had any kind of checklist that you follow for an emergency checklist and he stated that he does not have a roll in an emergency. Asked if other people have a checklist and he stated that the (b) (4) procedure was being followed which involved both TA & TC.

Mr. Kalogiannis was asked did you happen to notice or seeing anything from cameras. He stated that when the loss of control occurred he was looking at the map display and he was not looking at a video display with the initial departure occurred. Asked did you hear anybody else in the room voice anything and he responded that he didn't remember anything other than a gasp.

Mr. Kalogiannis was asked are you looking at all data or the stream and he replied that he was just monitor health of the TM system, but also monitoring Inertial Navigation Units (INU). Asked if there were any anomalies with the IMU and he replied, no. Asked also was the data nominal and he replied it was consistent with prior flights until loss of all data. Asked if anyone mention data that looked wrong and he replied that no one did.

Center MFD was rebooted in the climb, it was information used by both crewmembers for status monitoring of the vehicle, the health of the systems on the vehicle, and included most all the systems. A portion that automatically switches phases. Can you see what they see? Only from

the video monitor. A MFD reboot was not common, but the pilot was the one who initiated the reboot. It reloaded after reboot so no additional action was needed. We have seen this happen before. It does not happen extremely frequently, and when it has happened before, all functions returned to normal. We have pulled the unit on the ground and tested it, primarily for electrical reboot but haven't been able to duplicate. It was built by Scaled. It is not an abort requirement.

A follow up question was asked about the avionics switch for the flight crew that transitions the pilot's airspeed indicator from air data to inertial. Mr. Kalogiannis stated that the avionics switches automatically above 0.8 Mach.

A follow up question was asked about a failed DAU and Mr. Kalogiannis noted that it would be a complete loss of data.

A follow up question was asked if a DAU could cause misleading air data and he replied he had never experienced this type of failure.

Mr. Kalogiannis noted that they practice MFD failures in the simulator and specifically sim center MFD failures. Asked about the outcomes of those failures and he replied that there is an EP for the failure, crews follow their procedure. A follow up question was asked if the MFD failure causes a problem in flight and he replied that the crew can successfully control the vehicle and manage an EP for the MFD

Mr. Kalogiannis was ask if the DAU can cause a loss of Mach number he replied that the pilot and copilot have separate DAU's.

Mr. Kalogiannis was asked what DAU drives the copilots MFD and he replied that he would have to report back with the information.

Mr. Kalogiannis was asked if there were any other indications of anomalies and he said no.

Mr. Kalogiannis was asked if the MCC gets a Caution Alert System (CAS) Message and he replied that they do on the big board display.

Winds aloft were computed based on INS and air data systems. ADC sources were no longer displayed during after transition above .8 mach.

Mr. Kalogiannis was asked what happens to the displayed data when a DAU fails and he replied that the pilots get a red X on invalid data.

Mr. Kalogiannis was asked about the auto mode for the airspeed and he stated that in this mode the avionics will automatically switch between air data and inertial data. He also noted that selecting the auto mode was part of the checklist.

Mr. Kalogiannis was asked what can vary for a non-standard day and he replied that there is typically a little variation, variation will occur based on winds aloft which are not detected by the INS and that winds aloft is computed based on both INS and standard atmospheric data. He

noted that the INS no longer uses air data and cannot properly correct for wind induced variations

Mr. Kalogiannis noted that if you had a DAU failure it would cause a CAS caution display based on the configuration of the MFD.

Mr. Kalogiannis noted MFD has two choices of display and that CAS messages only show up in MFD mode and the center display is the only MFD for CAS messages. He also noted that if the center MFD were inoperative there would be no audible CAS message and the control room would no longer received CAS messages.

Mr. Kalogiannis was asked if he could you characterize why the pilots need an operable Mach number. He stated that there were limits on Mach and there were procedures that have certain Mach numbers. These procedures were things like recovery from feather, feather unlocks above a certain Mach for boost phase, and he was not certain what the number is.

Mr. Kalogiannis was asked if he had anything more to add and he said he had nothing. Then it was noted that there was a backup airspeed indicator for verification of just air data. The pilot and copilot MFDs had separate Mach number input from the DAUs.

The interview concluded at 1330.

8.0 Interview: Clint Nichols, Scaled Test Pilot
Date: November 3, 2013
Location: Scaled Composites
Time: 0930 PDT
Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach - Federal Aviation Administration (FAA), David Mackay - Virgin Galactic, Mark Stucky – Scaled Composites
Representative: Gary Halbert

His name was Clint Thomas Nichols, and he was 40 years old. He was hired at Scaled in June 2000 as an engineer doing composite structural design but immediately became involved with flight test data analysis. Worked on a lot of flight test programs (approximately ten), including Adam aircraft, Toyota Budgie (designed the mechanical flight control system), worked with Matt Stinemetze who left for SS1 and Clint took over. Clint then went to SS1 program doing data analysis and working in the control room. [Did the] engine integration and performance verification and planning for the Global Flyer. Got involved with the Proteus, then in 2006 started working on WK2, working for Bob Morgan the PE. [Clint] did the engine installation, fuel system, and whatever else needed to be done. Bob left, then Mark Stucky became PE, then Clint took over as PE until it was transferred to VG. Also did a lot of flight test on it, [flew the] 1st flight with Pete Siebold. Has flown WK2 a lot.

Prior to Scaled he got a B.S. in Aerospace Engineering, from Embry Riddle University, Prescott, AZ.
Pilot Experience – ~ 1800 hours, most of his time as co-pilot in WK2, ~ 1500 hours PIC total, ~ 150 hours in WK2.

Specific to WK2 what are your roles and responsibilities? – mainly copilot but has flown a few times as the test engineer in the back.

Day of the accident –

- 0430 show, set alarm for 0330, on time arrival went to the briefing, it was delayed 30 minutes.
- Attended briefing, it was briefed that additional time was needed to warm the nitrous
- Went to FAITH and waited, had a breakfast burrito
- Manned up, and completed the checklists, took off, climb out (doing PM duties), took PF duties on the east leg until the inbound leg and then PM again. Did the L-10, L-4 checks, and all was ok. SS2 gave 30 second to release call and confirmed armed. Clint, as PM, dropped SS2 and the WK2 pitched up and over.
- Heard Ground Control call supersonic, then "Knock-it-Off, Knock-it-Off, Knock-it-Off" followed by a loss of telemetry call.
- TC requested they look for the vehicle, and we never saw any sign, no smoke trail, nothing, which is not a big surprise, since he had seen a lot of these flights and it's tough to see the vehicle.
- Chase called out the vehicle was in a spin
- Descended to see what we could do to help. They had a floor of 10K' for deconfliction with the Extra chase. Did left turns so he could never really see the ground but Dave and Matt , the flight test engineer could. So he ran the checklist and did PM duties, monitoring fuel, etc.
- They came back and landed.

Were you monitoring comms with the spaceship? – Yes, we had monitored hot mike just prior to release. Remembered them talking about the CMFD but nothing else specific.
Was there an issue with the CMFD? – I know they discussed what would happen if it failed.
He has flown as copilot on SS2 eleven times. Ten glides, including first feathered flight, speed expansions, and PF02 in Sep 2013.

Have you had an MFD failure airborne? Likely, probably.
Is it normal, regular? – seems pretty rare.

Have you flown with the pilots before? – Yes

How often have you flown with Pete? – A lot. Flew with him in Adam, WK1, WK2, SS2, Proteus, chase work with him in Duchess.
How would you characterize his cockpit style? – Professional.
Was he standard, did he follow the checklist, did he have his own techniques that were different? – all pilots are different, he was by the book, standard, as briefed.
Did you ever experience a non-normal with him, specifically SS2? I don't recall, nothing too far off nominal.
How was he to fly with in WK2? – Great
Any non-normals in wk2? – multiple speed brake failures, emergency landing in Williams Gateway.
How did he handle it? – Fine.
I think it was flight 35 that we had a landing gear failure in WK2. Pete was flying, Clint was copilot. Left main landing gear broke on touchdown which lead to loss of braking, skidded the length of the runway and made an emergency egress.
Did you do a follow up investigation at Scaled? Yes
What was the outcome? I don't specifically recall.
Was there any remedial training? – No it was a design problem. The FAA did not even declare it to be an incident.

Let's go to Mike, have you flown with him? – Yes.
Specifically with WK2 and SS2 – we have flown a number of Scaled aircraft. He checked Clint out in Proteus, Firebird, and ARES. I don't think we have ever flown together in SS2 or WK2.
How was his style? – Professional. Prepared.
Any special techniques, any non-standard? No, he definitely knew all the regs. By the book. Definitely enjoyed instructing.
What do you mean? – he was kind of in instructor mode a lot. Once we flew in a Duchess and he commented on one of Clint's techniques but he commented even though he it was not an instructional flight.
So did he have his own techniques on how to do things? – Pete was by the book.

Do you have a training program, something that says how many t/o's and landings? – Yes.
Do you know the manual, name? – No, but I can find it.
Do you have copies of it? – Hard copies, don't think so.
Regarding actions are they checklist driven or are there actions not called out? – they are either driven by the normal procedure or test card.
Is a test card a standard for every flight? – absolutely, it is mission specific. That's where the development and preparation comes into being. The cards for this flight had been in development for months. We were on Rev U. The cards are peer reviewed. The pilots have inputs. Anybody has inputs. I probably had inputs on this card based on what I saw in the sims.

So you practice this stuff in the simulator? – yes.
Tell me about them – we have all up sims where we have a ss2 crew in the sim, an instructor at the sim console that can inject failures, and we have a control room and test conductor, sometimes observers or people in training.
How often are these all done prior to a mission? – weekly or sometimes twice a week. He observed some of the PF04 sims and attended some briefs and debriefs. Was not specifically in the simulator for the PF04 sims.

During the development of the mission plan were there any identified concerns? – Primary concern was supersonic feather reentry. Lots of discussion about the length of the burn time and what was appropriate. The length of the burn affected the time spent supersonic. And of course, the new motor. But as far as the initial part of the maneuver there was not any real concern about the release or the pull-up or whatever.

Was there anything procedural about the trim that was different than flight 3? – the numbers may have been slightly different but they were very close -9 for release trim to -14 for the pull up. Same as before except for changes in the thrust profile due to the new motor.
Tell me about the unlocking of the feathering system. – it's on the cards. Copilot calls out mach information, monitors rocket, calls the stab settings to the pilot (he doesn't have eyes on that necessarily), at 1.4 Mach the co-pilot opens the feather locks. If they do not open they abort.
Does the captain call for unlocking? – I don't know how they were simming it, nor remember exactly how he did it on the 2nd PF but feels the copilot calls it out and does it.
Is this something that is a standard choreographed thing that occurs in the cockpit or does the copilot just do it? Does he call it out? – there is definitely a callout.
Is it a prepatory or that he's completing it? – It's a callout and then an action.
Do all the pilots do it the same way? – The glide process is different. I think it's more of a permission from the captain to do anything. The copilot generally asks for permission. The copilot should call out "OK to lock" message.
Why is there a difference between the PF and GF procedures? – more time to complete the action while gliding than on a powered flight.

Dave Mackay asking – can you describe why we unlock the feather and when? – yes , that's important. The feather is unlocked at 1.4 and if it does not unlock then you will not be able to use the feather for reentry. So at roughly 1.5 mach you have to abort because you can still make a successful feather down normal configuration reentry. If they do unlock then there is a good chance the feather will work and you can do a [subsequent] feather reentry.
If you forgot to unlock the feather at 1.4 what would happen? – you get a CAS message, at, I think 1.5 Mach.

If you were to unlock prior to 1.4 is that a problem? – long pause. To a point. You could safely unlock at 1.2 Mach. Below there you get into higher loads associated with it around Mach 1 the loads are the highest and at that speed the feather actuators do not have enough force to hold the feather closed but they do have enough at 1.2; maybe lower. There is a lot of counter-intuitive aerodynamics going on.

You did a powered flight, did you raise the feather? -- yes. Can you describe the procedures you used? – I don't know if I remember it's been awhile. It's all documented, all on [cockpit] video.
Obviously the feather is at the forefront of everyone's mind. Was this 1.4 Mach a fuzzy number or was it a hard number you wait to that point, was it well understood by the other pilots? – I do not think it was fuzzy it was a hard 1.4 Mach. All the pilots knew that number.
Did they all know why? – Yes.

Do you ever recall anyone getting that wrong? – Yes. Generically it was difficult not to be late. It's a busy time and personally I would be late on it if my workload was high.
Did you abort at 1.5? – No we would unlock the feather.
Wasn't standard procedure to abort at 1.5? No, I would probably have to check to know that number.
How far could you go above that before you would have a problem? – I don't think I have a good number off hand. If I was flying I would certainly have that number memorized.

Do you think that SS2 has a feather down reentry capability? – I think there are some design changes that were made to have it perhaps have that capability however I personally thing the chances of doing successfully are low, primarily driven, I think by flutter which most people don't understand.

Can you clarify what you mean by people not understanding SS2 flutter in general or just not in the feather down reentry case? – I think we understand the flutter it just gets more nebulous as you get out to speeds the aircraft was not really designed for.
Who knows the aerodynamics best on this vehicle? – Jim Tighe, then Mark Bassett. Flutter is Tim Bourgiois.

Was your workload high enough during a normal boost to often miss the 1.4 mach or did that tend to occur because an anomaly was being injected during that? without an anomaly you had to still be on your game to get it at the right time. That was part of the simulation process, developing that scan, that rhythm. Certainly when I flew it by myself it was easy to miss while trimming, doing the boost all by myself.

Do you fly with your hand on the feather handle if you're in the right seat ready to go? – I didn't. When I did the powered flight I was unsure where to put my hands. The locks are very stiff you

have to move the handle laterally and then down. I would not use it as a grab bar, the rocket switches are in the same area and I wouldn't want to inadvertently hit them.

At 0.8Mach do you start working your hand up or wait till 1.4 and reach up and do it? – I think 1.3 or so you are reaching for it. See it [1.4] do it.

Did you ever have an MFD failure that was more than an apparent reboot? – not that I recall. It does its own boot process and comes back sometimes. You can pull cb's to reset but it's not hard. And they are redundant MFDs.

Is there anything you've been hesitant to say because Stucky was in the room? – No

Described the MFD air data sources and the mechanization. At supersonic speed it is INS data that is mathematically corrected to an airspeed based on standard atmosphere and such.
Is there any reason not to be in auto? -- Generally no. You can force it. There was a flight where Forger and I specifically forced it to AIR DATA because we didn't want it switching back and forth. The display normally switches automatically depending upon phase of flight.
In the sim did you used to train at a higher speed rate? Yes, to simulate the time compression, but we hadn't done that in a while. Why? Time compression we would train at 1.4 speed which is what the X-15 did just to simulate the time compression. We didn't do it on powered flights.

Are the pilots on SS2 and WK2 involved in the go/no-go decision? – absolutely. That is the primary responsibility of the SS2 PIC, he is in charge of everything. We were not rushed, we were told by management, Stinemetze, Whitesides, if you're not ready don't go. It's been a consistent thing this was not a rushed operation.

Interview concluded at 1045.

9.0 Interview: Mark Stucky, Scaled Composites Test Pilot
Date: November 3, 2014
Location: Scaled Composites
Time: 1100 PDT
Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach - Federal Aviation Administration (FAA); David Mackay - Virgin Galactic.
Representative: Gary Halbert

His name was Mark Paul Stucky, and he was 55 years old. His title was Scaled Engineering Test Pilot. His date of hire with Scaled was April 2009.

His background included 8500 total hours flight time, having flown about 170 types of aircraft. He had about 5000 hours in fighters, and had been flight testing for at least 25 years. He had flown for the Marines, Air Force, NASA, and United Airlines.

When asked about his roles and responsibilities, he said "I do what is assigned to me by Pete Siebold," and was heavily involved in aircraft documentation on WhiteKnightTwo (WK2) and SpaceShipTwo (SS2), as well as other programs. Most of the other test pilots were hired with other primary duties, but his was primarily as a test pilot. He said "I like engineering work."

He flew both the WK2 and SS2. He said he and the accident pilot both flew on both WK2 and SS2, and they were the only two Scaled pilots authorized for both vehicles.

For SS2, he had flown 21 total flights, and 3 were powered flights

On the day of the accident, he was the Test Assistant (TA), which meant he was the TC's right hand man. He arrived at 0345, he went to the Faith hanger, checked on the status of the aircraft, then came over to Scaled for the delta brief. He was told at Faith they had a DAU issue, and would be delayed. They said it would be a minimum of half an hour delay. On SS2 flights, the mission commander was the WK2 pilot and Dave Mackay did the brief. There was an issue with the DAU1, but they were getting reports that it was getting fixed, and the nitrous oxide was colder than expected, which could delay the launch for several hours. Because of that, it appeared they had a small window to conduct the operations, and winds and visibility were an issue. When asked if this pressured them to decide to launch, he said if there was pressure, it was from himself because of the window, he wanted to make sure there was no wasted time. He wanted the crews to be at the planes ready for the next step.

In the command center, on all their previous flights Jim Tighe was their TC, and he said Jim was "unarguably the expert on the design of SS2." He departed the company recently, and they needed a different test conductor, and they did not have someone at Scaled for the next block of flights. They did not have the right person within Scaled due to their own constraints, so they relied on VG. They got Todd Ericson who was knowledgeable, but not on SS2. This decision was made because they had aggressive schedules. He said "we have to have aggressive schedules to do what we do, but it doesn't mean we cut corners." In this case, they had a date, and as it approached they were not ready based on a flight readiness review. They looked inward to see what could go wrong with their systems, and what questions needed to be answered. There were a number of people who needed a little more time. Because of the delay, they had more time to train in the command center. Todd got extremely proficient. His initial role was an instructor TC to Todd. He then made the decision to let Todd go and be the TC, and he decided to force himself to be the TA.

Ground ops were fine, the DAU was repaired, and the nitrous delayed them but only 2 hours instead of 4 hours. He was hoping to takeoff by 9, but it ended up around 0915. He thought they would be out of limits by 11 am. Everything was fine, and the MFD reboot was not an issue in flight. It happened when Pete was twirling a knob real fast, and has only happened 3 times in about 5 years. It was not something he was worried about.

They were within limits on everything, and proceeding to the drop, and everything was nominal. As TA he had two required callouts; first after ignition, he would call a good plume from the engine. He was looking at that visual. It looked like a beautiful ignition and plum. He expected

the 0.8 call, which he came up with after the first POF (Power on flight) to remind the pilots that they were going to have a pitch up during transonic flight. He said the flight was like a catapult shot that did not quit. He heard the 0.8 call. He thought normally that was the copilot's duty. He looked at the video of the pitch up then down. Then there was supposed to be the trimming call after the bobble, made by the pilot. After the pitch up, he looked at the big board, and immediately heard Mike say unlocking the feather, which totally surprised him. He looked at the Mach display and saw 0.94, and as he was thinking of hitting the comm the telemetry quit. It was his instant belief they pitched up.

The feathers unlocked and the aircraft disintegrated. He turned around, there was a lost telemetry call, and he got the (b) (4) book out. Ben said he had taken care of it, and he started making emergency calls. He heard about the parachute and an inverted spin. He was surprised to hear about the parachute, and they got the SAR going. About the time Ben asked him to go on the roof to see what he could see. It was obvious there was not anything to see with the clouds. He had his headset on and heard that they had an impact, went back into the control room. He called China Lake to get a helo. The crash was close enough to a previous crash, and 911 called him back to verify this was a different crash. Last he saw before they archived the data, was that both feathers were unlocked, and saw both pilots slumped forward.

He thought CJ in the Extra did an amazing job in their rescue.

When asked if the 0.8 Mach call was normally done by the copilot, he said "I believe so." It was a technique he came up with to prepare for the pitch up. From PF02 on, he briefed 0.8 Mach as a call.

He had flown with both pilots. He said Pete was "extremely professional." They only flew together a few times since they were both PICs. Pete was a quiet person in the cockpit, but approachable, and did not set up any walls or barriers in the cockpit.

He said Mike was as professional of a copilot you could have, and was 100% prepared for the mission. He was always looking for ways to do things better. No one knew FAA regulations like Pete and Mike. Nobody was better at procedures than Mike. In the simulator, he had seen Mike "off of his a game" before. It was always the result of having a busy plate. He would only improvise procedures when he was going in the simulator on his own to try and find ways to do things better.

When he flew, he briefed that the co-pilot was cleared to unlock the feather, but call it with a pause so he could have time to disagree if he chose to. He did not want someone to rest their hand on the feather locking lever.

That was what he briefed. He and Pete were only aware of what the other pilots did when they sat in the simulator and observed them. For instance, at release, he would have the copilot auto arm the rocket and call when it was armed, then he'd make the fire call when he felt so. The copilot hits the fire switch. Pete would say fire, and expect the copilot to both arm and fire the engine. Pilots and Command Center personnel all debriefed together, and he did not really remember anyone saying it would be nice if you'd say/do this.

The simulator replicated the bobble during transonic flight. He was not sure if it was modeled for an uncommanded feather prior to 1.2 Mach. They do not train for uncommanded feather at that point since it would be catastrophic.

In the simulator, you could unlock the feather anytime, however they modeled it where it was important. On dive pull out on PF02 or 03, they did see some minor gapping of the feather during the pull out, and he thought that was in the modeling of the simulator. That was also possible above 0.8 Mach when talking about Mach and you had to have that take into account the flight profile.

They had structured training was for any FAA training checkride, and it was in the manual.

For an SS2 PF flight, they did integrated simulators and were given emergencies and problems with flight controls. They could get sub-level failures and work with the TC. It was not scripted, and the instructor could come up with whatever he wanted, and the TC and others could come up with any event they'd like.

They had SOPs on WK2, and for SS2, they were still developing SOPs. They were standardized on the WK2, and for the SS2 the PIC had more leeway on how he runs his ship. Any SS2 flight had a least a handful of simulations to prepare for the flight.

They had standardized procedures on WK2, and since Virgin was the ultimate customer, they came up with their own procedures. SS2 was still Scaled procedures, but collaborative. He thought they had a great working relationship with the pilots. The pilots could all talk candidly.

He said he had multiple bosses, but considered his primary boss as Pete Siebold. Pete was ultimately responsible for SS2 training.

Asked if every crew got a set number of simulations, he said no, it depended on the time to prepare for the flight. If the flight was a month away, you could get more simulations.

He flew PF01 with Mike for a 16 second burn, and they did not feather, but they "simmed" [simulated] feather. Asked about the crew coordination, he said max Mach was at about 1.2 for that flight.

For PF02 and 03, they never got to 1.4 Mach. For those, they put in the cards to feather unlock at 1.3 Mach instead. PF04 was the first flight we were going to exceed 1.4 Mach, and planned to go to 1.8 Mach, where someone would be unlocking at 1.4 Mach.

In sims as TA, he did about 5-6 simulations with the accident crew. Regarding the crew coordination, he did not remember anything specifically on crew coordination and was concentrating on those issues that were non-nominal. Asked if Mike being busy on other projects was a factor running up to PF04, he said he had every reason to believe he would be fully prepared and adequately rested prior to PF04.

They only did informal risk assessments prior to flight. They went round the room, and anyone could speak up if they did not like something.

Scaled would also leave the simulator open just to practice the day before [flight] and Pete and Mike did the same thing and were in the simulator the day before the flight. There were a number of dives required for SS2, but he was not sure of the number, and they flew much more than the requirement. It was an excellent simulator. Approaches in WK2 simulated SS2 descent, and there are some obvious differences, like roll control, but it was a good simulation.

Interview concluded at 1215.

10.0 Interview: Tim Bourgiois, Scaled Composites Design Engineer
Date: November 3, 2014
Location: Scaled Composites
Time: 1345 PDT
Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach - Federal Aviation Administration (FAA); David Mackay - Virgin Galactic, Mark Stucky – Scaled Composites
Representative: Gary Halbert

His name was Timothy Bourgeois, and he was 27 years old. His title was mechanical design engineer and he had been with Scaled Composites since August 2011. Prior to that he had worked for two years at Pratt and Whitney on jet engine airfoil design. Before that he was in college.

His roles included designing modifications to the fuel system on WK2, he briefly worked on the rocket motor, and the majority of his time was spent on flutter prediction and flight test. He started on that about two years ago, at the end of glide testing and the beginning of powered flight testing.

He defined flutter as an aeroelastic phenomena that was a combination of structural vibration and aerodynamic forces; essentially when the airflow couples with the airframe vibration. They had a third party they contracted out for the analysis on the flutter.

They had seen no problems in flight test with flutter on the SS2. During flutter flight test they looked at damping subsonically and accelerometer trends when supersonic. They had seen no signs of flutter. They correlated the model as best they could and compared their test points to predict when flutter could occur.

He got to the delta brief at 0430, and they were delayed about a half-hour or so. It was a normal delta brief. There was a delay for the nitrous temps, and they got through the brief. He got to the control center, they had the man-up, and started the checks. His secondary, Chris Turk, was his beta position, and they went through the preflight checks; checked the accelerometers, rocket motor procedures, and checked to see if anything was abnormal.

They started the engines, went to drop, and went through the normal checks. He saw the drop, heard the 3,2,1 release calls, and saw the accelerometers response indicting a normal release. He heard the arm and fire calls, and saw a response on the tail that looked normal for rocket motor ignition. He did see a slight increase in lower frequency noise than they had seen before, and thought it could be the new fuel but everything was well within the normal range.

He followed up along the airspeed and accelerations. When they got to 0.8 Mach, the TM station selected the big board air data source to INS [as planned]. He thought he heard over the radio something about the feather lock, but he was focused on the accelerometers. At 0.8 Mach, he said to Chris "ok, transonic" since that was an area of concern. He saw an increase in tail acceleration, and thought it was a bobble, but it was well within their limits. Then all the accelerometers were completely saturated for about a ½ second with a band of noise that he had never seen before and then they lost TM. He thought there was a TM issue, and then heard multiple abort calls around the room, including from the TC. The TC was trying to get in touch with the crew. They talked to the chase airplane, and heard CJ say they were in an inverted spin, and someone said they had departed the vehicle. There was a discussion about chutes, and only seeing one. He then heard there were multiple pieces coming down, and they called the crash phone and 911. He did not have any specific instructions for his role in the ERT. The TC, TA, and TM were trying to figure out where they came down. He thought Mike seemed nervous, and thought they were having trouble talking; perhaps the g force. He was shaking afterwards but wrote down notes. He knew there wasn't anything he could do. He reviewed the last portion of the data, and nothing on that suggested anything like flutter.

There was a slight linear growth in signal right before loss of TM, and it looked like something similar when going through transonic. He was on mission and on the TC loop for communications, and he monitored the hot mic with the crew. There was something about a feather unlock. They normally do it at 1.4 mach.

He had worked all the flights since glide flight 16, except for the last glide flight where he had two TSC persons work it, and he had worked all three previous powered flights. He could not think of any communications that were different. Going through their checks, everything seemed normal. Mike said something about that he would be putting his head back on the headrest prior to ignition this time. Nothing was out of the ordinary. The feather unlock test occurred while mated. It was on the L-10 checks. They had indications to see if they were on or off.

He was familiar with 1.4 Mach unlock procedure. There were a lot of vertical g's going through that. There were significant changes in air flow. From a flutter perspective they had modeled it both with the feather locks on and off and there was only a slight change. It was not flight tested. They did not get above 1.4 Mach in previous powered flights, and he believed they got to 1.35 Mach on PF03, and did not see signs of flutter.

Everything on his monitor was completely saturated, meaning the accelerometers being a solid band of data after loss of TM. There was one of two with some frequency offsets, but it just appeared to be some big g input. For flutter, they had not done any wind tunnel testing. He thought if he had all the money in the world, he would like wind tunnel testing but stated there was not a specific area that he'd want to test. The area of concern was transonic and they'd been

there multiple times already. Anytime they expand the envelope they were subject to possible flutter. They saw buffeting during certain phases, but they were damped. Nothing that looked like flutter would be a problem.

For nominal profile, their concerns were transonic 0.9 to about 1.1 Mach. He thought he heard a 0.8 Mach call but was not sure. The transonic buzz was prevented by the dampers; there was one mode that was predicted at 1.05. If he saw that, he would call an abort. For the accident flight, he had never seen signals like that before toward the end of the TM.

They do not say anything at his station unless there was a problem. He heard a good release, armed, fire, and he thought he heard a Mach 0.8 call.

He felt it was better to accelerate though the transonic range before putting AOA on the vehicle, and that was being done now.

He had a switch that he could call an abort if he saw a flutter indication. He had not made that call in flight, but had to do it multiple times in the sim.

Until recently, Jim Tighe had been their aerodynamist. He was the head of the flight test effort for the program, and went through the flutter results with him. Since Jim left, he only did flight test support, and they now had a new TC from TSC. Jim had always presented the aero data during the data reviews.

When told that the outer elevons were separated from the booms and queried whether he would be inclined to think they were causal or an after effect, he said for that to occur it would be a high g loading that would normally be very visible on the display.

He clarified that he had an FRR presentation that concerned all the feather down flutter predictions, analysis, and conclusions. In that report there were a couple of spots of concern (hump modes). In his analysis he mentioned they were below the level of predicted flutter but felt it was prudent to state it as a concern since that was a region they would be flying through.

Interview concluded at 1500.

11.0 Interview: Toby Earl Sorenson, The Spaceship Company (TSC)
Date: November 3, 2014
Location: Scaled Composites
Time: 1530 PDT
Present: David Lawrence - National Transportation Safety Board (NTSB); David Gerlach - Federal Aviation Administration (FAA); David Mackay - Virgin Galactic; Mark Stucky – Scaled Composites.
Representative: Dane Jacques

His name was Toby Earl Sorensen, and he was 30 years old. His title was Test and Analysis Engineer at TSC, and he was hired in June 2013. Before TSC, he was a UTSI research graduate, and was also a flight ops intern at Insitu. His roles and responsibilities included mission control,

and was in charge of a large scale structures test, flight test data analysis, and general flight tasks on the WK2 and SS2.

On the day of the accident, he woke up about 0230, showered, ate breakfast, and arrived a bit early for the 0430 delta brief. After the delta brief, he waited upstairs for the Nitrous temps to rise in the MOT, a delay of about an hour or so.

He was sitting at the stabs station, which monitored the horizontal stabs and feather. The ground checks were uneventful and included each station conducting a comm check with SS2. The L-10 checks included an unlocking and relocking of the feathers, and the checks were good. They then checked the stab trim and set them for the release, and the trims were good. During the release, he was watching the stab screen to ensure the actual outputs met the commanded inputs, and the roll boost was working correctly. There were no split stabs or delta between the commanded and actual positions.

He heard the pilots grunting, and was waiting for them to trim since he knew that was going to come up really fast. As he was expecting them to trim he saw on the other screen from the corner of his eye the feather locks coming unlocked. Out of habit he called "good unlock". He felt something was out of sync and that he had gone through a phase of flight sooner than he thought. He looked back at the trim, saw they were not trimming, and knew they were in error and was about to call TC "Set trims, feather locks" but TM was lost.
The screen went to all red indications indicating loss of data. Right before that he heard Aero call 'departure' followed by KIO [knock it off] call from the TC. Things were hard to recall, but were written down on his notes.
He heard CJ call that the vehicle was a breakup and Edwards called that they were in an inverted spin. Then CJ called one chute visible. CJ saw one of the sites where they were, and the rest of [his] memory was fuzzy.
He had been in the control room for about six months, and was the primary Stabs position for GF29, GF30, & PF04, and the secondary position for GF26, 27, 28. He was an observer for PF03, and was not there for CF02.
He did not recall if he had worked with Pete and Mike before, and thought this was the first time. He had worked with Pete before and in the multiple sims.
He was monitoring the mission comms and hot mike. There was nothing unusual leading up to the event.
For the Delta brief, he wrote notes down on the test cards, and there were no concerns raised that pertained to his station. The only concern was the left stab string pot was giving funny readings, but they had backup indications. It was a small delta between the string pot and the derived position, but it was about a degree or so. They had already discussed how they were going to work with that. They were actually matching during the main phases of flight.

There was a feather unlock cycle during the L-10 checks. They checked the locks to verify they can be unlocked. For the check, the crew asks for permission, he would give the TC a thumbs up and the TC clears it. Nothing was abnormal during the feather unlock check. The crew would unlock the feathers at 1.4 Mach because aero forces will hold the feathers down after the gamma turn.

His understanding was if the locks do not come unlocked you need to abort the burn. A CAS message was inserted at Mach 1.5 indicating the feather is still locked. If not unlocked by 1.8 Mach, then you terminate the boost for reasons that you can fly back down without any adverse effects.

His backup was watching Mach and was going to readout Mach at 1.30, 1.35, and 1.40. If not unlocked at 1.45 Mach he would have told TC to "check locks", and at 1.5 Mach it would have been a command to unlock, and after that command they would have to abort. He considered this as another backup to the automated CAS message. The problem was if they wouldn't unlock you would have to do a feather down reentry. There was a procedure for an unfeathered reentry.

When asked which string-pot was indicating off-nominal, he said it was the left horizontal stab. They had briefed with it and were comfortable with it. It was squawked to be fixed. The derived was the primary, the string-pot was the backup.

When asked if they had that problem before, he said yes, sometimes it was just a little noisy. He would see the commanded, derived and string-pot positions. Normally there was a small delta, and this was just a little more.

They also checked the dampers on the L-10 check, but he did not monitor the dampers. He recalled them saying good indications.

When asked if he recalled anyone making the 0.8 Mach call, he said he did not know. He was waiting for it but did not recall it.

When asked if he remembered during the sims if the flight crew called out Mach numbers, he said yes, the copilot would call it and the pilot would call out the pitch up.

He did not remember the stabs trimming, and there was no commanded movement aside from roll boost.

The roll looked normal, like any other sim except less roll inputs.

The co-pilot typically called out unlocking the feather. He believed the pilot would call out when to raise the feather.

He thought they would say Mach 1.4 unlocking the feather. He was not sure if he heard the Mach 1.4 call. Co-pilots in general made the 1.4 Mach call.

In the sims they always saw the unlocking at 1.4 Mach, and in other flights they never made it to 1.4 Mach.

The small delta between the left stab string pots was the greatest at full nose down. At 9°-14° nose up they were almost right on top of each other.

Scott Glaser was his supervisor.

For qualification, they did a number of sims with your instructor with you. The instructor signed you off for a Rec [recommendation] ride and the Chief Engineer and Check Engineer (TC) signed you off.
He is only qualified in the control room on the stabs position.
When asked if he had any suggestions for improving how he could do his job, he said extra screens, training, and more simulation.
For qualification, he had a couple of EP stab-oriented sims, but they also had a small grilling session asking him about his systems and reactions to the failures.
He personally did not feel any pressure, but yes, there was always pressure to drive a schedule.
When asked if there were any conversations from co-workers regarding pressure to meet deadlines, he said not related to the flight.
Interview concluded at 1650.

12.0 Interview: Dave Mackay, Virgin Galactic Chief Pilot
Date: November 4, 2014
Location: Scaled Composites
Time: 0910 PDT
Present:[2] David Lawrence, Katherine Wilson - National Transportation Safety Board (NTSB); David Gerlach, Christy Helgeson - Federal Aviation Administration (FAA); Mike Masucci - Virgin Galactic; Mark Stucky, Clint Nichols – Scaled Composites.

Representative: Dane Jacques

During the interview, Mr. Mackay stated the following:

His name was David William Donald Mackay, and he was 57 years old. He was the Chief Pilot at Virgin Galactic (VG) since his date of hire in August 2011, and Steve Johnson held that position previously. He had been working full time for VG 2 years prior, part time 2 years prior to that, and had been the Virgin Group since 1995. He flew for Virgin Atlantic (VA) prior to that, and retired in August 2011.

He had a degree in Aeronautical Engineering from Glaskow University. He learned to fly there. After graduation he joined the RAF, in 1979 began flying Harriers, attended TPS at EPNER, was part of the Sea Harrier / Harrier & other programs in the UK, and left in 1995 for VA where he flew B-747's and A-340s.

As VG Chief Pilot his roles and responsibilities included ensuring the correct numbers of adequately experienced and trained pilots to fly the WhiteKnightTwo (WK2) and SpaceShipTwo (SS2) to support commercial operations, and that the pilots had the correct materials to support their training and onward.

[2] The Operations Group and Human Performance Group participated in this interview.

Pilot selection at VG was based on recommendations from Mark Stucky; who might be interested and suitable, and also those pilots who approached him. They ran a recruiting program around 2010 and had hundreds of applicants, probably 50 exceptional applicants, and they also did some head hunting. They found out what they were like to operate with from people who had flown with them, a smaller list for phone interviews, an even smaller list for personal interviews, and then conducted multiple interviews and simulator sessions in WK2 and SS2.

They typically invited 4 or 5 finalists, and were looking to pick 2. It ended up being small nuances; people they thought would fit into the team, people that can fly large aircraft, small aircraft, challenging aircraft.

The day before the accident they started with the Maintenance and ER brief, and the longer flight brief. He was operating as a Scaled pilot and they used the Scaled briefing guide. He started with "it's been a long time since our last powered flight," cautioned that no one should feel schedule pressure that they had to get this flight off and anyone should speak up if they had any concerns.

He emphasized everyone had a say if this was a good thing to do, looked at main changes from the last month's cold flow glide flight; a new fuel, and a new rocket motor. They were trying for a supersonic feathered reentry. Then they went to the ER status, discussed crew status, and the crew chief talked about WK2 work that had been done. It was the same on SS2, with the same on propulsion (rocket motor), avionics, mission control, and the lead for each one discussed their items. The next section was domestic's like frequencies and call signs. They covered the cards from front to back, made any changes they wanted to make. After that they generally go into things like NOTAMS, weather, things like that but he said they'd cover the details of those in the day of flight Delta brief although he mentioned there was a several-hour weather window where the forecast conditions appeared favorable. Chase, bailout altitudes, fuel states are covered. The day prior brief was a pretty detailed brief that finished up in the afternoon.

The accident crew was there as was the mission control room team, management, maintenance, and a room full of people.

He arrived on the morning of the accident at 0400, and shortly thereafter got a message from Forger that he wanted to push the brief 30 minutes due to the vehicles not being ready. The Delta brief began at 0500, covering any changes (very few). On the previous brief they made some redline changes. One was that they had planned that after release WK2 was going to go look at some Vmc data, and they redlined some of those points. There were no significant changes.

No concerns were discussed. He gave Pete Siebold the chance to run through his card again; it's generally memorized but appropriate to go through the details again.

The concern was DAU-1, which had failed and had been taken to Scaled for bench testing.

Additional concerns were the nitrous had gone in cold, which was colder than expected and it looked like it might be several hours to delay. He thought the Nitrous temperature (b) (4) so it looked like the potential for a very long delay. The rocket motor team did some things to increase the warming.

The delta brief is normally very brief, but since they were delayed for the Nitrous warming, they discussed things like the Nitrous temps and limits in detail. They then went to the FAITH hanger (where WK2 & SS2 were kept), but Pete and Mike stayed at Hanger 78.

He thought it was about 0730 or so when the rocket motor team said they were ready for pre-press. They went to the van and Jason Devinere was going to drive them out. He tried to call Pete and then drove out to 78 to pick them up. He ribbed them about leaving them behind. They both looked relaxed. They discussed the possibility of winds going outside limits and that they would dump the nitrous and come back mated, and the possibility of even taking off if the winds were out of [SS2] limits to facilitate dumping and then landing. Mike was part of that discussion. This was the 3rd SS2 launch that he had done from WK2 and this went the smoothest. There was a PSC that had a problem, but it was only an indication problem and the PSC was good to go.

About 0905 they took off, and it was one of the heaviest they had ever done so it felt slow. The tires may have had flat spots so it was a bit bumpy, but it seemed to be matching predictions so he called normal acceleration because he thought one or two people might be concerned. Shortly after takeoff they went to full power; something they don't normally do at lighter weights to clear the hills there.

They flew fast for safety, and headed up north. There were some small cirrus as they approached the northern point, and there were heavier clouds so he turned a bit early and after that they were above the layer. He gave Clint the controls who then flew the rest until they were at launch altitude.

He took control for the L-10 checks and they aimed to be above 44,000 feet barometric or inertial altitude and desired more speed. He traded a bit of altitude for airspeed for release and at the time of release they were exactly at 0.55 Mach at release and he was very happy with that.

It was a clean release. When SS2 comes off it's a big thump, and the WK2 jumped up and he continued upward to maximize separation before pushing over.

He pushed over, but only saw blue sky and his first thought was it was a really clean burning motor and he wasn't seeing it. He heard a Mach 1 call followed by a "knock it off call" in a tone of voice that made him think something was really wrong.

He heard the knock it off in a very urgent voice and it became clear that something bad had happened. There were a series of calls and he thought the Extra said the vehicle was in a spin. Joshua said there was a loss of radar data. After doing the pull up and not seeing anything, the plan had been to do a 90° left turn and then go down to the R-2515 border and towards the Hyundai track. They were in the process of this when these calls began, and then they heard the calls and that there was a parachute. They dirtied up, gear down, speed brakes out, but they came down fairly slowly because they wanted to stay above the chute and debris. They knew the Extra would be below them and they went down to 15,000 feet for de-confliction. None of them saw anything at all, which was really frustrating, and then they heard parts were impacting the ground and the parachute was on the ground. They then went down to 10,000 feet while CJ was lower and then they circled around eventually seeing what they thought was a tail boom north of Koehn Lake.

They did some radio relaying and CJ did an outstanding job of coordinating the rescue. They did talk to a helo on 123.4Mhz which was a request from Joshua, and then they gave them the mission frequency. They elected to stay until they saw 500 lbs. in any fuel tank. They finally did see a chute on the ground. They RTB'd for a landing and that was about it.

They did not have the capability on WK2 to monitor hot mics from SS2 after separation. They did have a switch that allowed them to listen to SS2 [while mated] and they thought someone on SS2 accidentally hit it; it was easy to do. They listened to them and enjoyed listening to them discuss potential MFD failures and actions, what the weather looked like, etc. At that point they were about to get into a final detailed briefing and he wanted to do that with his crew too, so he asked them if they had the ICS switch on and they said "oops they do." He was not aware of the MFD issue at the time.

They were monitoring the cloud layer but when they turned on the run in line it was quite good. The winds were steady at 9 knots they have a 10 knot limit for launch but the TC reported it was steady and it seemed like a good decision.

L-30 second check was where the SS2 arms and goes full forward on the stick. There was a pylon arm switch and a release switch in both cockpits and either can arm and release but the

way they normally did it was SS2 armed, they see the yellow light in WK2, and WK2 counts down and releases. Clint pressed the release button and the vehicle separated.

After separation, he heard only mission control; they did not hear what was inside SS2.

The 2 main events for the mission was supersonic feathered reentry and the other being the new rocket motor fuel which has been extensively tested on the ground. It had a new (b) (4) system to heat up the head end of the rocket motor.

The first concern on the first powered flight was transonic flight, but he did not feel there was as much concern for supersonic feathered reentry.

The next flight was scheduled in about 3 weeks, but that would be dependent upon the results and the data analysis. There were no hard dates for launches.

For SS2, after release the pilot flying's (PF) first job was ensuring the vehicle was flying properly. You're not going to call fire until that. Based on his own experiences on PF03 they released, Forger armed the rocket motor and as soon as he was happy, he called fire and he lifted the guard and selected it.

Just before fire they had their heads and arms back getting ready for the acceleration. After ignition there is a 0.8 Mach call from the right seat as preparation for the transonic pitch bobble.

After the bobble, he called trimming; it's a critical system and they want the guys on the ground aware that we're about to use it, and it's also a cue for the right seat to be ready to call out the trim values.

You have some motion in pitch and roll and you want to focus quite closely on the PFD for flying a smooth profile and that's why it's critical for the pilot in the right seat to call the trims. The way he briefed it was if he was slightly off, Forger would fine tune it to -14 and then call -14.

His flight was a 20-second burn and so they were fairly early in the gamma turn when the motor burned out. They got to just less than 1.4 Mach. They unlocked the feather at 1.3 Mach.

For this flight, after setting the trim, the next event for the right seat would have been to unlock at 1.4 Mach. If everybody did things efficiently, the trim was set around 1.2 Mach. His experience in the sim was there were usually a couple of seconds between that and 1.4 Mach.

The reason they unlock the feather was to remove the possibility that the locks did not unlock. If they do not unlock until the end of the burn, then they were faced with an unfeathered reentry. They had a procedure for that, but it ends up with very high g's, very high speeds, and they were concerned about flutter and heat loads on the vehicle.

The reason they unlock the feathers at 1.4 Mach was because there was a substantial down force on the tail and in conjunction with the loads in the actuators which were holding the feather down anyway, they did not need the locks engaged.

When asked if there a danger range where you need the locks, he said there was a range, "I'm not sure of the minimum Mach number" but he thought around 0.9 to 1.2 Mach there was an uplift on the tails and the actuators could not hold them down. When asked why they unlocked on 1.3 Mach on PF03, he said it was because it was not anticipated that they would go above 1.4 Mach.

Virgin and Scaled pilots trained together. He had done sims with Forger. It was his understanding that all the pilots knew about the 0.9 to 1.2 Mach risk. After previous flights they had to address the unfeathered reentry concern. Then it was in their procedures. His understanding is they knew about the risk, but it possibly was not written in any pilot manuals. This was a testing program, not an airline, and his understanding was that there was an uplift force in that range. When asked how he become aware of this, he said it was his understanding that years ago they did not do this, and then people became concerned about it and Jim Tighe said that if you did it above Mach 1.4 you don't need the feather locks so that became their documented procedure.

It was his understanding everybody knew about the transonic range where it was critical for the locks.

Asked if that was written anywhere, he said possibly not. It was a test and development program, not like a mature airline, and they were developing their procedures and POH as they conducted the flight test program, so you won't see everything in the current POH. It was his understanding that everyone was aware of the background of unlocking the feather lock.

The simulator was their main training device for systems reviews, flight readiness reviews, and discussions among the pilots. They did not have formal airline type training; it was test and development, writing reports, talking to engineers, and the like.

They did full integrated simulations with the crew, with the sim console operator and the control room. They also often went into the sim with just the two pilots to practice.

The last integrated simulation was on the Wednesday before the accident, and that left Thursday the day before the flight for the crew to go into the sim and practice on their own. It was always good to go in the day prior and practice normal flights without emergencies.

There were emergencies injected into the last integrated simulation, and they typically gave the pilots rocket failures, feather failures, and system failures that they thought were of a concern. Also included were the mechanical system of the feather, pneumatic jam, and system failures like ADC failures.

Their NP's [normal procedures] were essentially their SOPs. They were more detailed than typical airline checklists. The SOP for the powered flight was essentially the test card, what you're going to do after you separated from WK2. It was generally memorized because you did not have time to go through them during the flight.

When asked if the requirement for memorization and the way the callouts were done were the same for all pilots, or if some pilots have their own way, he said for this flight Pete had one change. When Forger and he flew they decided upon themselves that Forger would arm the motor, and when he [Dave] was happy he would call "fire." Pete's call was simply "fire" which indicated to Mike that he would flip the arm switch and then the fire switch. On his flight with Forger, he said he would call arm and he would then call fire when ready. Everything else was identical.

Pete was going to call 0.8 Mach, and Mike was going to call the trim.

There was flexibility in how calls were done, and it was a test and development, and he was not saying what Pete did was wrong, it's just another way.

Typically there was no documentation when the pilots went into the simulator on their own, so if you were to look at their records you would see far fewer simulator sessions than they actually did.

When asked how long before this test flight did the crew have this test card, he said a long time, he could not give an exact time. It was a long process. His guess was they had the card several weeks in advance and after that it would only be very minor changes.

The feather locks were checked on the ground and then during the L-10 checks. He could not confirm if they were done, but mission control would not have given them permission to release if they hadn't been successfully done.

There was a caution that occurred at 1.5 Mach if you did not unlock the feathers, and then you typically just unlock the feather after getting that caution.

The 1.4 Mach callout was when he would say Mach 1.4 and unlocking the feather. There was no cross-check by the PF prior to unlocking the feather.

When asked if there had there ever been any unlocking of the feather transonic simulations, he said he did not believe so.

The preflight the day before was done around 1400.

Risk assessment was done via the FRR, a Delta FRR, and an executive FRR.

He thought the FRR was done about 10 days before, the Delta FRR a few days before and the Executive FRR a couple of days prior. He attended all the FRRs. Scaled would have all the FRR slides, the action lists and the response lists for all to see.

At the FRR there is a group of say 5 people who had the final say so and they agree that all the outstanding issues had been addressed and they were cleared for flight. Obviously the crew chiefs also had to be happy that the vehicles were ready and the flight crew ready to accept the vehicle.

He was not sure if he saw Mike the week before, but he saw Pete and he expressed no concerns. He flew with Mike a few days before the flight for some high g training in the Extra, and he thought it was Monday. It went well, and it was the first time he'd flown with him in the Extra. He was an excellent pilot, had a good set of hands, and he really enjoy flying with him [Mike]. In fact Mike did the majority of the flight, he [Dave] did the takeoff and landing and the first spin and Mike flew all the rest.

VG did have CRM meetings. They had a lot of new pilots, and that was something they were going to do on an annual basis. He worked the presentation, highlighting things like sharing information, SOPs, everyone was involved in the flight, and checklists. There was a lot of pressure around them, if you read the press you might think they all walk on water but he stressed they were all fallible and he was open and honest. He would be happy to show the presentation.

He had no concerns about Mike. He was a gentleman, a joy to fly with, and had no issues at all. He had flown with Pete in WK2, and said Pete was a very professional pilot, knows all the rules, and knows all the vehicles in depth.

There were obvious differences in the displays between WK2 and SS2. The MFD configuration was about the same, but they did not have a rocket motor so there are some differences. WK2 was used to train for glide in the SS2 and the guidance displays were identical.

He had flown with Pete in the sim recently. Pete's CRM was good, and he had never had an issue with Pete. He was another guy that was a joy to fly with.

VG now did the WK2 checklists, and it was Sooch's responsibility, but he had an input on them and they all contributed.

Forger had the responsibility for the checklist before VG took WK2, and they would give suggestions and he would accept or reject them. VG now took that responsibility for WK2, and Forger continued with the SS2 checklist responsibility.

They did not wear flight suits and gloves during simulator training. In the sim, you were not typically strapped in and you could reach levers easier than if you had strapped into the actual vehicle. When asked if there were any visual obstructions wearing a mask, he said no, you come down to an e[mergency] pattern and you forget it's there.

He thought the stab settings for his PF03 flight may have been slightly different than the accident flight, but he would have to check. The change in stab trim settings was the motor had a little shorter nozzle, and the cg had changed slightly.

For this flight, the burn time was done on a timer. At the end of 38-seconds the timer would shut down the motor. Looking ahead they did it based on a predicted altitude. They always set a burn timer, but they may shut it down prior.

He said the POH, NP's and EP's were the source documents on the SS2 for the pilots. There are a lot of other documents. When asked if a pilot could check in the POH to see if the section on the feather lock had a caution for operating prior to 1.4 Mach, he was not sure if the POH contained that information.

Debrief that included flight techniques essentially occurred during the debrief. They would go through all of that in detail and then there was a follow up data review. For instance, if Pete came into the debrief and said the gamma turn was too tight or slack, then the engineers would look into it.

The pilots would get together and talk about systems on the vehicle and systems, but there were no regular meetings since the SS2 flew so infrequently.

When asked if there were any outside organization that provided outside input about how things were going, he said yes, Scaled would bring in outside folks. Scaled would bring in engineers from outside programs that would ask hard questions and throw little "hand grenades" and the like.

He did not know if Scaled received any help from Northrup Grumman. He thought the FAA attended their "redline" meetings.

When they are in attendance can they give inputs into safety concerns? Yes, anyone can.
He said all of the program pilots were available to attend the briefs and debriefs. All of the pilots tended to come along and watch the simulations.

As backup copilot to PF04, he did some simulator sessions with Pete about ten days ago. He also did one or two with Forger who was the backup pilot for PF04. Those were just regular integrated sim sessions. He thought he did 3 with Pete, and the same number with Forger, and they were full up sims. They operated the feather locks during those sims.

He thought Pete's cadence was satisfactory. Generally they were getting the trim set about 1.2 Mach and there was a sufficient gap to get the trim set prior to 1.4 Mach.

When asked if he ever got the feather lock caution, he said he had. Whether he got that in the runs or not, he was not sure. He was not overly concerned about that caution, he would just open the locks.

If the feathers did not unlock, he would abort. When you move the lever, the light should go out, but his primary concern was the lock display on the center MFD, and it took about a second for the locks to open.

He was not aware of any time delay from when an action occurred in the vehicle to when it was seen in the control room.

The burn time for this flight was determined to achieve the 1.2 Mach for [feathered] reentry, and that was determined by engineering.

The memorized procedures were for both pilots, and it was not laborious since it was a cadence for events that came in a timeline.

A failure, or a caution and warning could interrupt the cadence, or a failure of a screen, and this was practiced in the simulator. Normally the failure led you down a different path, and you would not go back to where you were before.

When asked if there was any point he would pull out a written procedure, he said yes, and the TC would normally tell them the procedure.

The memorized process happened when the vehicle was in a very dynamic environment, and the procedures were verbal. There were other times when the procedures were run by challenge and response. An example was when the PM would ask for feather down and the PF would command it. It was the same with the gear.

The pilot monitoring was looking at the PFD for the Mach number and waiting for 1.4 Mach. He would expect them to say 1.4 as he put his hand on the handle, and then moved the handle. It's highly unlikely mission control would say anything at that time. That's what the CAS warning was for.

When he flew the SS2, he was operating as a Scaled pilot, and Scaled had his training records. Test cards were organized in phases. As the flights got longer, they may become a little more complex. He did not know if the crew memorized the cards but they are in a format where you can look down and pick up the steps.

It was fair to say the flight cards served as a good review just prior to the L-4 checks.

There may be some failures where you can continue with certain failures and others where you abort the test card and recover the vehicle.

During the boost, the forces were high, the acceleration was high, and the shock waves may cause the vehicle to roll slightly, but you did have the capability to look at other displays. If a caution were to come up, he could easily look at the center MFD and see what the issue was.

His scan to the MFD depended on the phase of flight. He did not normally look at the MFD, but there was some rocket information there. During the boost, the primary scan was to the PFD. The story about the new trim display on the PFD was that before this flight, the trim information was on the center MFD and that scanning from the PFD to the MFD increased the workload slightly. Because the trim was being moved quite rapidly, it was decided to add the trim information to the PFD on the left side just above the timer.

The airspeed and Mach number were absolutely part of the pilot's scan. They also looked at the back-up indicator.

He said he was not sure if he would notice a feather unlock on the backup display.

Each pilot's MFD was fed by a separate ADC. If the other pilot had an ADC failure, you would you know it. The same was true for an INS failure.

Interview concluded at 1110.

13.0 Interview: Todd Ericson, Virgin Galactic Pilot
Date: November 4, 2014
Location: Scaled Composites
Time: 1130 PDT
Present:[3] David Lawrence, Katherine Wilson - National Transportation Safety Board (NTSB); David Gerlach, Christy Helgeson - Federal Aviation Administration (FAA); David Mackay, Mike Masucci - Virgin Galactic; Mark Stucky, Clint Nichols – Scaled Composites.
Representative: Mark Dumbroff

His name was Todd Christopher Ericson and he was 45 years old. His title was Pilot for Virgin Galactic (VG), and he had been in that position since July of this year. Prior to VG, he spent 23 years in the Air Force flying fighters, and the last 14 years were in flight test. He estimated his total flying time at 8,800 hours, with 7,500 hours as PIC. His test flight experience was in the F-16 experimental and classified aircraft. He came to VG because of commercial space flight, and getting in on a leading edge of the industry.

He was qualified on the WhiteKnightTwo (WK2), with an experimental authorization, and maintained proficiency in the Extra300 and gliders. He had begun his SpaceShipTwo (SS2) training, and was in the academic portion. He was qualified as a test conductor (TC). For SS2, their training program was ground school, and some simulator sessions. They practiced normal and emergency procedures, and his next step would be the right seat on a glide flight with SS2. Ground school was not an official ground school, and it began when you start with the company. Not unlike most prototypes and experimental programs, and included one on one with the systems experts. We were instructed and talked to about the feathering system with the pilots and responsible engineers. On the Scaled side, it was Jim Tighe. Mr. Ericson had been learning the feather system ever since he got with the company. They were constantly revisiting systems as they change, it's an evolving process.

The preflight briefing followed the standard format; they got updates on everything that pertained to the next day's flight , so there were lots of action items to cover. They got inventory for all the work done since the last flight and looked at open discrepancies and ensured that the FRR action items had been closed out. They followed the Scaled process to make sure there were no "hanging chads," and telemetry would be available. They had an in depth review of the test they were about to go to, including weather, and review of the time line. The lead was done

[3] The Operations Group and Human Performance Group participated in this interview.

by the commander of WK2. Participation was from everyone. He was the TC for the functional check flight after its annual, and this was his first TC on powered flight. There was a litany of sims and practice sessions they did. The control room were staffed with Scaled and half with VG/TSC personnel. Numerous powered flight sim sessions were conducted and included normal and non-normal situations. Scaled holds the authorization on who's acceptable as TC, and they obviously signed him off as TC.

On the day of the accident, he had a 0300 wake up, and had gone to sleep at 0700-0730 the night before. He drove into work. They also had a delta briefing that he sat in on. It was concluded they were good to go, and moved down the timeline. There were two issues from the delta brief; one was the pressure of the MOT tank, and the nitrous temperature were too cold to launch. They had stringent requirements for the burn of the rocket, and those were from ground testing. They knew we were going to be delayed. They also were concerned about the crosswinds. Starting at about 11am the crosswinds were forecast to not be acceptable. The were also concerned about the crosswinds and the forecasted window of acceptable conditions with an approaching cold front. There had been a DAU that had been replaced. They continued moving forward.

They manned up the control center, they started the methodical process leading up to flight, and the only limitation was the Nitrous temperatures. There was a discussion to determine how to warm up the Nitrous quickly to stay within the launch window. They elected to go pressurize the tank on the runway, checked that the winds were good, and they elected to takeoff. All indications were that things would be nominal for release. Everything was nominal in climb, though they did have a center MFD that went out and booted back up. Also there was a temp sensor that showed an anomaly, but it was a sensor issue. They met criteria for good to go, and they gave the green for release.

Release was nominal, no issues there, ignition and burn appeared nominal. He remembered the 0.8 Mach call, and trimming call, and he remembered Mach one on energy call watching the big display and he saw the vehicle enter a feather mode several times faster than normal, followed by a loss of telemetry. He started communications with the chase aircraft.

He was monitoring mission and the TC loop, also hot mike from the crew. Prior to launch he remembered Pete reviewing the launch sequence. He remembered Pete briefed Mike he was cleared to arm, and Pete made the fire command. He remembered some grunting with acceleration and some happy "whoo whoo" comment. The 0.8 Mach call he believed came from Mike, and trimming call came from Pete. The trimming call was triggered by .8 Mach. He did not hear the unlocking feather call. He then transmitted the "Mach one, on energy" call on the mission frequency.

He confirmed the test of the feather lock system was completed during the L-10 checklist. He did not remember what they said, it was a normal procedure. It was a challenge response checklist that the control room monitored and everything was nominal.

The callouts by the crew were a cadence. SpaceShipTwo was designed to be flown without a control room, you would expect an arm and a fire call from the PIC which would be executed by the PM. He expected a 0.8 Mach call from the PM, followed by a trimming call from the PF, which would have been -14 degrees nose up. Then he expected the PM to monitor trim positions and call out the changes in trim. At 1.4 Mach would be the unlocking the feather call, typically from the PM.

When asked why they had a call at 1.4 Mach, he said the feather locks were part of the system and add structural integrity to the system as the vehicle transitioned through transonic speeds. The aero forces caused a large upload on the tail to drive to the feather position and the locks provide additional structural integrity. He believed it was at 1.2 Mach that there would be enough downforce that the locks were no longer required. The other concern was the failure mode, and they tried to avoid a feathered down reentry. If you could not feather at that point, there were flutter concerns, etc. The assessment at the time would include the need to make the abort decision. When asked how long that risk area of transonic lasted, he did not know. They selected 1.4 Mach as the reasonable time. He said you would have to ask the engineers how long that transition lasted.

Asked why you would not want to unlock the feathers before 1.4 Mach, he said his understanding was that it was a transonic risk. Unlocking the feather at 1.4 Mach was decided through the safety process, and they came up with 1.4 to unlock the feathers. If done before 1.2, the aircraft could prematurely feather. When asked if the pilots knew about the effects on the tail and why to hold off unlocking the feathers, he said yes. Those were things they discussed. He would have to look in POH or other engineering documentation to see if that was documented. Upload data could be answered by engineers. He could not say what the vulnerability was, and 1.4 Mach was a reasonable time where they had sufficient margin from that regime.

After the breakup they tried to ascertain the status of the vehicle. They could not establish comms with the vehicle, and his TA started the (b) (4) notification procedure. That was Scaled's emergency action plan.

The most current simulation was a couple of days prior to the event, and he did not remember what was covered. Nonnormals were covered. They concentrated on off-nominal. They did off-nominals during that sim session. Earlier in the week, they basically went through a variety of emergencies through the systems. Many [in mission control] had not been through a powered flight before. They went back to focus on normal procedures and normal flows.

Thursday at 1030 was the ER briefing, the comm checks were at noon, and a rerun of PFO3 at 1300. The idea was to view at their stations real data consistent with what they were going to see the next morning.

He thought it was a 20-second burn for PF03, and this flight was scheduled for a 38 second burn.

The flight crew was not involved in the PF03 rerun, just the control room. There would be a log of that through Scaled, who was required to keep records for the launch permit.

There were no concerns at the ER briefing, just the weather. The pilots were at the maintenance, ER briefings and comm check.

When asked if there was any documentation that said what you need to cover for training, he said they had a training folder that documented things.

The pilots were participants in the risk assessment done for the flight. It identified hazards, and those were mitigated to the extent possible. A flight readiness review was also done. They developed action items, and those must be closed before proceeding with the flight. You would have to talk to the Scaled guys for details.

He had known Mike and Pete since the mid 2000's. He never flew with them, and never heard any concerns about them. He never heard from them about concerns about the test program. At VG, they have regular pilot meetings, which was easy when there were only four of them. They covered decisions on operations, and takeoff and landing data discussions.

After the MOT had been loaded and the temperatures were low, they let the sun rise and put thermal blankets or something to warm it, and also pre-pressured them. He had no idea if Scaled had ever done that before. When asked if there were any hazards considered with the techniques to warm up the tank, he said there were no hazards identified. On the L-10 checks, he could not recall if there was a challenge and response on the checklist. Asked if that was the normal response for that checklist, he said yes, and it was done by the checklist, not rote memory.

Asked if anyone critiqued the pilot's performance, he said yes, everyone. He said they were not more critical of other pilots compared to their own. There were no differences between the VG and Scaled pilots, they were all extremely professional. He considered the flight crew member as a part of the control center team. and they are all one team.

He began part-time work for VG in January this year, working on the general operations manual and learning about WK2 and SS2, and the systems and aircraft in general. He also did some

simulator work. He spent two years as the Chief of Safety for a developmental flight test organization. Prior to that he spent a year as Chief of Safety for Edwards and Eglin AFB. His most recent job prior to VG was as operations group commander.

For calls following release, he remembered hearing fire call, could not remember the arm call, and the 0.8 Mach call was made by Mike, but he was not sure. Pete made the trimming call, and he remembered making the Mach 1.0 energy call.

When asked, he said he had first-hand knowledge that Mike had recent formal CRM training.

They did a tremendous amount of simulations. They debriefed everyone's performance. They simulated events that the crew would not pick up, like in the boost phase with an impending flutter situation or flight control issues, and the control room crew could go straight through to the crew. Others were funneled through him that were less time critical.

Not all simulations ended in a landing, and some would require a bailout procedure or an off nominal landing divert. Some sessions had the crew induce issues to train the control room crew. The TSC VG crew did a VG simulation on Thursday day afternoon. He said they simulated well in excess of the AST sim requirements. Scaled documented the training. Much of his past experience involved the control room.

He made a Mach one energy call on VHF. That was in the script, and they had practiced it in the sim. There was a boom cam video displayed in the control room, the crew cockpit cam, and he looked at that video stream during the event, then went to the engine to ensure it was burning nominally. He looked at the displays, the vehicle feathered, and then there was a loss of telemetry. The last images were frozen on both displays.

They had a TC and control room checklists set up in the command center. They had normal procedures on charts, and all emergency procedures on similar type documentation for easy access during flight. There were 3 different situations; abort, abort to shut the motor down, knock it off for safety of flight, and terminate to stop an event. That would be followed by a discussion of what went wrong.

The expectation of crew with an abort call was to shutdown the motor. Knock it off would be to get back to a control flight situation. In that case, for the knock it off call was to stop what you were doing.

For the knock off call, he wanted them to stop the feather. Abort and knock it off had about the same urgency. He monitored the crew on the normal checklist. Asked if at any point he had the authority to intervene, he said absolutely.

All the determination of the transonic numbers and procedures were determined prior to his arriving at VG.

If the vehicle departed, he would expect them to shut-down the engine. He was not sure what the time delay was from what occurred on the vehicle and what was received in control room. A couple tenths of a second would be significant.

When asked what would be the best course of action if you saw a feather unlock at 1.1 Mach, he said calling an abort, but in this case he saw the actual movement of the feather system.

There were a lot of calls intra-control room. He would have to check the script if there were any additional calls made.

Pilots were to move to unlock at 1.4 Mach, or they would get a CAS message. He would transmit a feather unlock call to crew if they did not unlock or a failure to unlock, and then he would assess whether they are doing that and transmit a check feather locks call.

The control center did not control anything on the vehicle. You could think of it as a second cockpit at zero airspeed and 1 g that could help the pilots. The rocket motor controller could shut down the engine; it monitored a lot of parameters, and could shut down for anomalies.

Interview concluded at 1258.

14.0 Interview: Pete Siebold, Scaled Composites (SC) Test Pilot
Date: November 7, 2014
Location: Bear Valley; Tehachapi, CA
Time: 1000PST
Present: David Lawrence, Katherine Wilson - National Transportation Safety Board (NTSB); David Mackay – Virgin Galactic (VG); Mark Stucky – Scaled Composites (SC);

Mr. Siebold was represented by Mr. Gary Halbert, Attorney, Holland and Knight.

Mr. Siebold stated the following:

He expressed his gratitude for meeting, and wanted to get his memory out before it got clouded. The test pilot in him wanted to report on what he observed. He might decline to comment on questions that he felt he could answer adequately a week from now.

Wednesday, with regards to the SpaceShip flight, they had the executive FRR which was a summary FRR given primarily for the FAA's AST benefit. They don't normally include them in what he called the "sausage making reviews," but boil it up to a higher level that showed all the concerns and how they were addressed.

They met with the FAA safety inspectors who did the background records checks. AST did things a little differently than part 91 -- they wanted to make sure that Scaled did not get itself in trouble so they did an inspection to make sure all the licenses and medicals were in order for all of the SS2 and WK2 crews.

Thursday was quite a bit busier. He had scheduled a nominal sim, an opportunity for Mike and him to get in the sim without all the hoopla, set up the scenarios they wanted that might not have been covered, perhaps likely emergencies that were not written down, things like the airplane did not fly like it was supposed to, "what if" scenarios.

They also honed in on the weather, and updated the weather with the flight day's predicted winds and loaded that into the simulator. Most practices used standard day winds and this gave them the chance to see how the instruments would be displaying on the flight day.

They discussed the .8 Mach switchover from the ADC to the inertial and there may be an offset, and how the INS may show faster or slower depending upon that day's winds.

They flew many, many profiles focusing mainly on the boost profile. Their sim logs the sim sessions, making a historical log and that data existed. They flew a couple where they purposefully over sped in anticipation of the predicted headwinds. They discussed how the limits would change and they were planning on 345 KEAS as the inertially-derived airspeed. They thought 325 KEAS would be the more nominal and anything above that was either atmospherics not being the same or perhaps the rocket motor might have more thrust than expected. They had thrust predictions based on ground test data but there were different nozzles and altitudes, so they were just predictions.

They flew an over speed profile, worked on how they would make decisions, and how they would work the CRM. They flew other profiles that were more dynamic, maybe more realistic. When you consider real time adrenalin, the simulations tend to be more optimistic. They looked at early shutdown, off nominal, to get what they were expecting. They wanted to establish a new nominal.

He purposefully rolled 180 degrees and did other off-nominal things to force reactions that might occur due to reality not matching the predictions.

They flew some profiles to landing, and he had Mike fly a couple to landing since he was Pete's backup and that was an emergency possibility.

He was unsure how much Mike had practiced on his own but knew he often did. He had done so also, and they would take that opportunity when able.

After that was the preflight briefing, the maintenance and ER briefing where they brief the status of the vehicles and went through the flight cards in more detail, rather than getting caught up "in the weeds" on the day of the flight. On the day of flight they still wanted people to bring up issues as required but they hoped to get through most of them on the day prior.

They then went into the comm checks, where they get in the vehicle and aside from checking out the communication they also took a look at the data in the control room. They were still having trouble with some of the avionics at that point, and his recollection was DAU1 was being temperamental. They had swapped it out several times, and he could not remember where they were in the troubleshooting tree at that point.

When they were done he had asked for the playback of past flight data in the mission control room. The simulation was perfect and some of the models were not perfect, some are generalized so that some of the displays may indicate trends and characteristics that may be subtlety different on the day of flight. By playing back the previous flight data everyone could see actual parameters, see the actual response of the instrumentation, any noise in the signals and so forth. They now had the ability to drive the actual MFD displays and the pilots could see firsthand what the flight would look like.

They finished up the day prior, and he thought they all could feel it, they had worked hard to get ready for that flight but at the end of the day they all realized that we were ready and there was nothing left to do. Everything that he had personally wanted to do had been completed, all the questions he had had been answered. He personally went home, relaxed and was ready to try to get to bed early.

On Wednesday evening, he had purposefully gone to bed early and got up early Thursday morning so that meant he would be more tired than normal Thursday night and not toss and turn. He felt the worst thing was when you go to bed at 7 but were not really tired. He went to bed on Thursday around 7 and was probably asleep by 8.

He got up at 2am, got ready and went to work for the 0430 briefing. He got an email from Forger that they were not quite ready and delayed the briefing till 0500. He took the time and drove over to FAITH and looked at the vehicles, and tried not to distract anybody. He went back to building 78 and went to his desk and looked at the weather. They were concerned about the winds and cloud cover primarily impacting their ability to get the flight off.

He went to the delta briefing, and nothing popped out as significant. They had a bit more discussion that morning about weather, and there was a real possibility that because of the delay with the nitrous loading that they would bump up against the forecasted winds bumping against our crosswind limits. They discussed things like; what if we were out of limits prior to takeoff, after takeoff but prior to release, and after release. They had a good plan for all of those scenarios. The winds ended up being near the limits but not up against them.

Because of the delays they got the briefing out of the way and then had several opportunities to discuss the trajectory of the nitrous warmup and when it might intersect the trajectory of the forecasted winds. He and Mike stayed in building 78, separately. They were picked up by David Mackay around 0730 and then driven to the hammerhead where the vehicles were loaded.

The previous day they had discussed whether they would use the Scaled parachutes or the VG parachutes and had decided to use the VG parachutes since they would be ending up at the

FAITH hangar. He preflighted his parachute the day prior and on the day of, proceeded with his normal preflight checks.

The WK PIC conducts the briefing on the morning of the flight. The SpaceShip pilots participated and in a small segment briefed the details of the SpaceShip flight but the majority of the briefing was covered by the WK PIC. The SpaceShip pilot normally picked up the brief at the release and walked through the card. They spent more time on the post landing steps since this was the first time with the (b) (4) system and there were extra safety procedures in place. They spent more time addressing concerns about if the valves leaked there may be a hazard and they went through the procedure that would be used to safe the vehicle post landing.

Back to the day of flight, the only anomaly that he remembered that was out of the ordinary was they had a parameter that was fed back from the nitrous pressurization controller, and the enabled flag that was sent to the avionics was flickering. They noted that on the preflight checks and they had a discussion with the control room. The control room made the decision that they had extra data confirming the status of the PSC and they were good to go. He was comfortable with their extra data and they proceeded. He did not remember any issues after they took off.

He remembered the MFD rebooting during flight, it was the first time that had ever happened to him in flight. He did not remember what he was doing, perhaps turning a page or something and it rebooted. They had not had any more issues with it. They went into the L-10 checks with everything acceptable. They had a thin layer of clouds in the northern area, and they discussed it with the WK2 crew since they had a better view of it. The overcast was a concern. If they did the boost he wanted to have a good geographical references although they always trained to have the ability to safely navigate without visual reference. Going into the release point he had adequate visual reference of the mountains and valleys and had good references for where he would be.

He did not remember exactly what Mike and he talked about but there was a time gap, and he thought it was between the L-10 and L-4 checks where Mike and he briefed one last time about the specifics of what they were going to do, and then they were approaching the release point.

The release was nominal, with standard little pitch oscillations. Somebody on the ground probably wouldn't notice them but as a pilot you notice them. Things happened in seconds but he described them as minutes.

Mike was cleared to arm the rocket motor immediately upon release without any input from him [Pete]. There were multiple safeties in place to protect the WK2 crew. He got comfortable with the aircraft that it was a good flying airplane, called for fire and Mike commanded fire. They had a good light; the thrust came on in what he would describe as a two-step ramp up. It was smooth. His experience base was SpaceShip1. Although no pilot had flown this motor before, he could not comment on it as compared to the earlier motor. There was significant Nx acceleration, something that the simulator could not adequately prepare you for.

Taking a step back, he had all the personal equipment on. He was snugged up in the seat, put his head back on the headrest and felt his oxygen mask obscured about the lower half of the

instrument panel. He had a good view of the upper PFD and was comfortable with what he could see for the flight. He adjusted his head but informed Mike that he did not have all the visibility that he wanted, but proceeded. It was an observation that he thought, "ha, that was interesting" and they should discuss it after the flight. Maybe they could come up with a better head cushion design or something.

Back to the flight, he tried to limit his roll inputs to avoid being high gain. The next flight regime was the transonic pitch up that occurred when portions of the airplane were supersonic and the nose tried to rise, and then all of the airplane was supersonic and it pitched back down.

His first inclination that something was not normal was that pitch up. It might be as simple as the sim did not prepare him for that g transient, but his first inclination was a pilot, something wasn't quite normal. The pitch attitude seemed higher than normal. His inner voice, or he annunciated over hot mike, he did not recall, he announced it as a big pitch up. He felt it was more than he thought it should be, it might not be significant but he wanted the control room to hear it. Perhaps it might make them or Mike with a decision if they felt it was off nominal.

The next thing he observed was the aircraft just started pitching up wildly, the g levels went through the roof. They had been routinely training for 5 or 6 g profiles. This g was so sudden that his feeling was it was well above what they had anticipated. His estimate, although well off his experience base, was 10 g's. He remembered either himself or Mike grunting, the sudden g onset rate pushed them down in the seat and he almost couldn't breathe. He did not know if it was him, Mike, or the both of them. At that point, he knew something was wrong. Up until then he thought this was just not quite right. He knew that the recent changes in the CG, the nozzle scarf angle, the new trim settings, he knew there was going to be some variability. They were opening up the envelope.

There was very little he could do in that G. It felt as though the vehicle pitched over on its back. The next thing he recalled was a loud structural failure of some kind. A single bang followed by all the indications of a rapid cabin depressurization, and the feeling of all the air leaving the lungs. Everything that he'd described up till then he had a very clear recollection of the order, the sequence they occurred.

After the separation he was aware of a wind noise, a very high pitched whistle, his helmet was not straight on his head, his oxygen mask had shifted, and it was obvious he was in a very high slipstream of some kind. He had to work really hard to open his eyes. What he saw was just the desert. He estimated his body sitting in the seat [indicated face down horizontally, slightly head high]. It was extremely cold, and very difficult to open his eyes. He instinctively reached for his seatbelt, he thought he reached out with both arms.

Stepping back to the L-10 checks, he went through the mental steps of a bailout; it's not something you could refer to a checklist. He felt the buckles, reminding himself how the buckles opened and in which directions, and where the emergency oxygen was.

He successfully unbuckled his seat, he knew he had to as that was the only way the parachute would work. He recalled using two hands to unbuckle the seat but did not have certainty that he

did use both hands. He pushed out of the seat. He never saw anything else around him, no crew cabin, maybe his legs.

He was above or falling through the cirrus layer that was present at the time. The seat became disconnected and he went to a new aerodynamic configuration. It was obvious that he was free from the seat and went to the freefall position, spreading his arms and legs.

The next thing he recalled was the parachute deployment. It surprised him. He did not know whether he was conscious at the time. If he was unconscious it brought him back with that jolt. If he was conscious he would have been thinking about manually deploying the chute. He was unsure if that memory should be trusted. The chute did automatically deploy.

The chute was configurable, somewhere around 13-15,000 feet for automatic deployment.

His next action was to see if he could see Mike and there was no other chute visible. It's a relatively small parachute and he hoped Mike was above him. Somewhere in there the Extra, flown by CJ, circled him and he motioned to him. He believed he waved to him.

He reached for the oxygen system many times. He did not know if it was in the seat, after the freefall, or when on the parachute. He had at no time the sensation of the oxygen being activated. With a well-fitting mask he should have felt a positive pressure flow and without activation he should have had difficulty breathing without oxygen flow. He remembered the mask had not been square on his face and possibly that was why he was not suffocating. Perhaps the emergency oxygen was flowing out of that opening. In any case, he tried multiple times to activate the emergency oxygen system and never could.

He tried activating it under parachute and became aware that his right shoulder was hurt. He thought the oxygen system had a small range of motion and perhaps he could not tell it was activated.

He knew his arm was hurt and he had had a previous injury to it and knew he was going to have to make a parachute landing fall but he could not raise his arm. He thought it was dislocated and tried to put it back. He thought it was worth the investment in pain to steer the chute. He was not successful and was not able to steer the chute. He had a foot injury several years ago, and he was preparing himself for the landing He was in a small corkscrew. He was worried about winds but the inversion was still in place and the winds were calm when he landed.

His eyes were very painful to open during the fall. He thought maybe it was the ice crystals. His eyes were very sore and watery. He thought he had maybe gotten a branch in his right eye, and he could not open it.

He waved at the Extra to let them know he was conscious. He could not move, though, and he did not move from his landing position. He came to the conclusion his right arm was badly injured. He had blood on his chest. If he tried to move it he heard clunking noises. He decided to just wait. He heard WK2 overhead, the Extra, and then a helicopter landed.

The first responders were great. He did not lose consciousness. They did all the first responder stuff. He took his helmet off, and they put him in a neck brace, backboard, and removed his shoes. They were in silver first responder stuff. A National Test Pilot School pilot got out. He did not know who it was, but he recognized the face. They transferred him to the medical helicopter and flew him to the Antelope Valley.

Asked about the headrest and looking over the oxygen mask, and if there was any loss of peripheral vision, he said one was actual, one was perceptual. His head would have gone back and his mask would have obscured anything below the center of the MFD. In that environment you also get a tunnel vision where you are focused on your task. His task was to fly the vehicle while waiting for the Mach number to begin trimming the vehicle. There was some level of tunnel vision not because of g but because of workload.

When asked if he practiced that in the sim with donned equipment, he said no, and he was a bit frustrated by that he had not really thought about that beforehand. He said he kind of kicked himself, and thought it was a significant observation and he was going to bring it up in the debrief. Maybe they would change the headrest or maybe every pilot would have their own.

When asked if he saw Mike reach for anything, he said no. He had not been following the news. His wife called and told him the NTSB had briefed her Sunday night that there was evidence that Mike had unlocked the feather. He was a very analytical person and that was not an option that occurred to him. He did not see it.

When asked about CRM, they practiced a "One Mississippi" unlock before actually unlocking, he said no, they briefed multiple times that he was to unlock the feather at Mach 1.4. He knew of the hazards associated with unlocking the feather prior, and it never crossed his mind that there was a scenario where the pilot could feel the need or have misleading information or whatever that might cause him to unlock.

When asked if there was anything on the PFD that could give him confusing information, he said he was going to stretch here and he was surprised by his reaction. Several weeks before that, he had put together a primary video of his flight in SpaceShip1, and he wanted to prepare the team for possible off-nominal indications.

SpaceShip1 was set up similarly but different, with a lot of parameters around the airspeed indicator. SpaceShip2 was slightly different. He played that video prior to sim session, and when he got into the sim they had some new parameters displayed in that general area of the display. During one of the sims, if not the very first one, he did not remember which parameter he was looking at, and he looked at the new information on the MFD under the airspeed indicator and he looked at it instead of the Mach number information and he reacted on it instead of the Mach number information and he did not know it until afterwards. He saw a number that did not seem right. He did not remember specifically, but he mentioned it to Mike from a human factors standpoint. He attributed it to the SpaceShip1 display that he had seen a few minutes ago. He figured he had created a connection to something way back in the recesses of his brain.

Asked about any new display information on the PFD for this flight, he said the parameter was a new indication for pitch and roll trim information. They had identified it as desirable; there was no urgency to incorporate it. It was included about two weeks before, and he could get the exact time later.

Mike also had a lot of experience in WhiteKnight1, and it was it the same display as SpaceShip1. Mike had a lot of experience both in the SpaceShip1 control room and WhiteKnight1, and it was an identical display.

When asked if there were any changes on the flight cards for this flight, he said nothing that stood out. He remembered wishing they were not talking about some things. They were up against weather and wind limits. You do not cancel a flight for it; you push on and watch it. Everyone had a chance to speak up, and there was nothing out of the ordinary.

When asked if he had moved his headrest from where it was installed, he replied no.

Interview concluded at 1130.

15.0 Interview: Jason Kelley, Vice President of Operations, Scaled Composites
Date: December 9, 2014
Location: Scaled Composites, Mojave, CA
Time: 0935 PDT
Present: David Lawrence, Katherine Wilson – National Transportation Safety Board (NTSB); Christy Helgeson, Brett Vance – Federal Aviation Administration (FAA); Clint Nichols – Scaled Composites; David Mackay - Virgin Galactic.
Representative: Gary Halbert, Attorney, Holland & Knight

His name was Jason Michael Kelley and he was 44 years old. His title was Vice President of Operations at Scaled Composites LLC and had been in that position since 2005. His roles and responsibilities as vice president of operations included several functions within operations. Three quarters of the company's personnel reported to him or his direct reports. Personnel included composite fabricators, composite technicians, A&P mechanics, systems mechanics, all personnel that supported manufacturing roles, a small group that supported flight test activities, environmental health and safety, facilities, and back shops, which included machine shops and weld shops. He described the group that supports the flight test activities as A&P mechanics that started in the manufacturing room and progressed to flight support activities such as ground crews. Also, within the facilities department were personnel that serviced ground support equipment to help maintain the flight test activities.

Test pilots were not a part of his responsibility within the operations department; he did not know why. His guess was that most of the test pilots were engineers and served roles in both engineering as well as flight test activities so it was the most obvious choice for them to report to Ben Diachun in engineering or Pete Siebold as the flight test director. He could not answer if test

pilots' responsibilities were more as engineers or pilots since that was not his expertise. He did not interface with Ben Diachun regarding test pilots' roles and responsibilities.

Prior to joining Scaled Composites he was in the US Air Force stationed at Edwards Air Force Base as a structural mechanic doing composites and painting. After leaving the Air Force, he worked for a couple of companies before getting hired by Scaled Composites in 1996 as a composite fabricator and then had an opportunity to become the lead of one of the programs in the shop. Shortly after that he was involved with environmental health and safety ((EH&S) training, then became a program business analyst, and then in 2000 he became the plant manager.

Asked what his roles or duties were on the day of the accident, he said the programs themselves maintain the crews and maintain the agenda for the day. His role was to show up at his normal arrival time of 0700 and he had no real assigned duties for the day; however, he went to the room below mission control to view the data presented on the displays. He was there in that room with some people from the FAA and others. After arriving in the room, he could see the two large displays on the wall. As the two vehicles were climbing to altitude, he could see certain displays such as nitrous pressure, pitch and roll and he could "for the most part" hear what was being said in the control room and some of what the pilots were saying. The boom camera stuck out to him the most. As they approached the point of release, he was looking at the left boom camera which gave him a good view of the rocket nozzle, fuselage, and inside of the right boom. The release was clean, a "beautiful level release," 3-4 seconds of freefall and then ignition seemed beautiful, everything seemed good. It was maybe 6 seconds of horizontal flight before he started to see the gamma turn to achieve vertical flight. Then it looked to him like the spaceship went into the feathering mode. When he saw this and that the rocket motor was still ignited, he knew they had a problem. He did not know they had an incident yet but he ran out of the room and to his office to get the (b) (4) protocol book and radios, and dispatched himself to Kevin Mickey's office. It was around 1010 when the (b) (4) process was started.

For any vehicle flight, even though he was not assigned any duties, he found himself staying in Hanger 78. He would view the flights in the room below mission control so he could see exactly what was going on.

He was not part of the flight review prior to PF04 nor was he part of the delta review the morning of the accident flight. He was not aware of any concerns from his people leading up to PF04. Steve Losey, a SpaceShipTwo crew chief, would send an itinerary that itemized the agenda for the day and he would have updated Mr. Kelley if there had been any concerns or issues prior to a flight.

He was not involved in applying for or maintaining the FAA permit or waiver; however, he tried to help the company observe the regulations that were required because of the permit. Part of the launch license was crew rest and identifying safety personnel so he worked with Steve Losey and others to ensure those were being met. He was not 100% sure who at Scaled Composites was responsible for the permit and waiver. He said that Bob Withrow worked with them a lot on the FAA launch license compliance.

He briefly read through the operational components of the waiver. Most relevant to him were safety parameters and working with the airport and airport security to make sure those safety parameters were maintained, such as the entry points when they were "fully charged and ready to fly"; that included the runway parameters. His role was more on the ground side of operations. He would help support the waiver from the ground operations side.

He could not recall if he provided input to the waiver, but it would have been with the storage of nitrous oxide and quantities. He was not 100% sure who was responsible for the operational side of the waiver mitigations, to include use of multiple chase planes and simulator training, but said there were multiple people that could provide that information, such as Ben Diachun, Pete Siebold, and Bob Withrow. He had no interaction with the FAA regarding compliance. He had a lot of interaction with the FAA since October 21, but he usually only saw the FAA in the room below mission control during a launch. He did not know if FAA was present for other activities besides the launch activities. Bob Withrow worked with the FAA to identify what was in the launch license and would say if help was needed in an area; Mr. Kelley helped to support that. Regarding PF04, Mr. Withrow did not come to Mr. Kelley regarding any discussions or concerns about the waiver or what needed to be done in order to be compliant with the waiver.

There had not been any internal review or ongoing look at the organizational structure or operation specific to the spaceship that was within his responsibility since the accident flight. What came to mind was the (b) (4) and the interaction with the (b) (4) regarding recovery and working with multiple agencies after the incident. There had been discussions with other people about getting the outside agencies together to share lessons learned. That would be his responsibility. They had not done a review of the (b) (4) because of the work being done with the NTSB. Several things went extremely well but he was a believer that they needed to do a review and identify lessons learned.

He personally had minimal interaction with Virgin Galactic. If he had a couple of questions, he would call Enrico at Virgin but he usually went through Kevin Mickey or Matt Stinemetze. To his knowledge, his people were talking to Virgin Galactic on a regular basis.

Regarding his role in ensuring crew rest was met, he said Steve Losey would give him an itinerary of the 2 weeks leading up to a vehicle flight that provided times when certain activities

were going to happen. It was an opportunity to keep him updated. If Steve Locy had any concerns about crew rest he would let Mr. Kelley know. Mr. Kelley would be updated on crew rest for the ground crew and mechanics working on the vehicle. For ground crews, Bob Withrow put together a presentation that outlined the guidance. If he recalled correctly, it was no more than 12 hours per day, a minimum of 8 hours of consecutive rest, and no more than 60 hours per week. These times had not been exceeded to his knowledge.

He did not participate in the fault tree or hazard analysis for the system safety assessment.

He was proud of the safety culture at Scaled, because they were "way different" than other companies. Part of the flight test motto was "to question and not defend"; he was a big proponent of that. The environmental health and safety manager was a resource to people but safety was everyone's responsibility. To some degree, they did not want anyone to think safety was not their job or that it was someone else's job because they held that title. Injury rates were down. Northrup Grumman did an audit of Scaled every 3 years and before the accident they were getting ready for an audit. Their belief in safety was spelled out in several company manuals. Environmental health and safety was led by Charlie Clark.

Northrop would provide a report from the audit and he would see that report. The latest review was conducted 3 years ago. Things they did well were having retractable extension cords and the intranet so all employees could access relevant documents. There were some housekeeping items like a respirator was left out of the bag after use or confusion on what PPE (personal protective equipment) employees should wear; Scaled explained to Northrop that there was minimum PPE required and some employees went above and beyond that wearing more. Scaled responded to all issues in the report. The audit scheduled around the time of the accident had been rescheduled for around April 2015.

In addition to the audits, there were several documents that discussed the safety culture at Scaled and what they believed in. Education was a big tool of that. Scaled had several training programs that covered safety given to an employee when starting at the company; there was a 2 week introduction. They would be shown the intranet, the handbook was distributed; documents within the handbook described the safety culture. Northrop Grumman had the "open line" managed by their ethics and business conduct department in which Scaled employees could call if they felt there was no person to talk to at Scaled. These issues would then be brought to Scaled for an internal review and Northrop would be briefed on the results. Scaled also had anonymous suggestion boxes managed by the human resources department that senior management would review. He was very proud of the Scaled open door policy and stated employees had no issues going to him, Scaled's president, human resources or anyone else they felt comfortable with to discuss any issues; but employees were encouraged to work issues first with their manager. Employees also knew they could report any issues without fear of retaliation.. This was all

described in the employee handbook. He was not 100% sure if the engineering handbook discussed the safety culture because that was not his area. The engineering handbook did include ground testing procedures which had safety language in that. There was an internal publication "Carbon Copy" that discussed safety concerns and "things to watch out for" and were "toolbox talks" scheduled based on a programs needs and hot topics, such as EH&S. There were board meetings comprised of Scaled senior management and a few members from Northrop Grumman to discuss things going on at the company. Included in the board meeting was a safety presentation that discussed, for example, incident rates and any trends. Company meetings would be held as soon as practical after the board meetings to let the entire company know what was discussed during the board meeting. The leads would also pull up the intranet to go through safety practices on how to handle, for example, resins and tools.

Asked if any training on how to maintain the safety culture was provided to employees, he said they had several resources from Northrop that would bring individuals in to train their EH&S personnel or would send the EH&S personnel out for training. Scott Freziers was their EH&S liaison at Northrop Grumman and he would come in to help educate the staff. But they did do a lot of internal training because the training was program specific and it was difficult to stop everyone and put them through training, so they would develop training based on the needs of the program; they educated their staff to be able to do that.

The integration of team members between Scaled, Virgin Galactic and The Spaceship Company (TSC) personnel to work on the spaceship went "extremely well." There were a lot of upfront meetings to prepare for that and lots of discussions on the shop floor daily shop. The only complaint he heard was the Scaled project team members did not have a lot to do other than to help the Virgin and TSC team members. It was a good transition and good team work from his perspective. There were no complaints he heard from Steve Locy.

Asked if he received reports or monitored pilots' use of simulator, flight currency or Extra 300 flights, he said no.

On the day of the accident, because what he saw on the monitor did not look normal to him, he ran to his office to grab the (b) (4) book. He was looking around to see if there was any indication that they had an incident. The process would be to get a text message that the (b) (4) was initiated and it was when he was in Kevin Mickey's office that he got that text message. The rest of the management team would then come to Mr. Mickey's office and each person had their own responsibilities and would go through their checklist, such as making sure the customer, Northrop Grumman and outside agencies were notified.

A lot of his responsibilities during the (b) (4) was to dispatch ground crews to help support it. Once there was a known incident and had the information, Kevin Mickey and the rest of them

decided to dispatch the ground crews out to the GPS coordinates sent from mission control. That helped to support local agencies with materials safety data sheets of what was on the vehicle and material lists which would help outside agencies to know and understand what they were dealing with. In addition, he was, and still was, involved with the recovery, which included transporting crews to and from the accident site, getting cranes, and getting components transported to and secured at Hanger 75.

He had never self-dispatched before where he went to get his (b) (4) book. He clarified that he would be in the room below mission control for flights although he had no assigned duties, and for those previous flights he had not seen anything to make him self-dispatch. But this situation was different because he had real-time data that he would not have had for an ARES or "Old School" flight.

Back in the SpaceShip1 days they had a hard landing and the landing gear collapsed. It was a time for them to remember that they were human. People were out enjoying the flight test. On that day, he was on the other side of the airport and after the hard landing he found himself trying to get back to Scaled. So he had since let management know that he would be in the room below mission control during a test flight to reduce reaction time between an incident occurring and when someone could step in to help. So his decision to self-dispatch in the future was based on personal experience.

The (b) (4) notification included a number of people on the list and Mr. Kelley was on that list which was why he received the text and email about the (b) (4) being initiated. IT put together the list and the text can be sent by Sam Brown, the front desk receptionist, or IT personnel.

Asked who was responsible for the operations from a ground crew perspective, he said it was a shared responsibility between Steve Locy and John Krueger. Steve Locy was recognized as the crew chief for SpaceShip2 and John Krueger was recognized as the assistant crew chief for SpaceShip2. As a part of Steve Locy's responsibilities, he was going through the checklist on preparing the vehicle and John Krueger was assisting him with that. The nitrous fill occurred early during the preflight and several people helped support that process, he thought Luke Colby and Keith Fritzinger. As crew chiefs on SpaceShipTwo, Steve Locy and John Krueger would report to Matt Stinemetze. If they were not assigned to a program, they would report to their homeroom supervisor, Chris Tolson; Mr. Tolson reported to Mr. Kelley. Asked how Steve Locey and John Krueger were assigned their crew chief duties, he said Mr. Tolson was the one that made the assignments happen, but it required trust of the crew chief and the crew chief demonstrating expertise, and involvement from the flight test director and the program manager.

Regarding the lessons learned from the fatal ground explosion in 2007, he did not recall Northrop doing an audit of the accident, but he knew there several outside companies that were supporting it. For that accident, he had more of a support role than a technical role. What he saw happen was an improved cleaning system for all the components, ground test procedures changed to some degree, and more training emphasizing using and handling nitrous oxide.

Matt Stinemetze did not work for Mr. Kelley, but he thought his homeroom supervisor for the SS2 program was Ben Diachun. Mr. Stinemetze also reported to Mr. Mickey on a business program. They had support functions and direct reports. It was not too often that someone within operations that would bounce from one project for 2 weeks to another project. But there were people in support roles that bounced around, for example systems liaisons and training individuals. There were people from time to time who bounced from project to project but it was rare at the current time.

He could not give a percentage of Scaled employees that worked on the SpaceShipTwo program but it was a small percentage compared to other programs at Scaled. Referring only to personnel within the Operations department, within the crew that they had put together to support the SpaceShipTwo program, all of those individuals were dedicated 100% to that program. Steve Losey, as a system liaison, started to take on some more responsibility. He clarified that from time to time someone may have to support another program for a week or two and then return to the original program. It was rare to find a program where everyone was dedicated to that program alone 100% of the time. This was in line with the business model of the company that supported multiple functions within the company. He thought this helped to prevent layoffs.

The safety culture at Scaled was different than bigger companies in that it put a lot of power in people's hands. If anyone had a problem at any time, they could stop what was going on. He previously described the routes people could take to prevent retaliation. Scaled had 16 operating principles which include a safety and quality statement. The intent of the safety and quality statement was to broadcast that programs had ownership of the entire program, whether it was getting support from purchasing or safety or quality. People could stop a process pretty quickly if they had any problem. They gave people resources so they knew and understood what was going on and what should happen. It was not just a process. They wanted to make sure they educated their employees so that they took ownership of their program; it was an attitude, it was not a process or a book or something pulled off the shelf every once in a while. It had to be embedded in everyone's day-to-day activities. It was covered in Kevin Mickey's letter in the handbook to the operating procedures and "on and on".

The interview ended at 1040.

16.0 Interview: Pete Siebold, Scaled Composites Test Pilot
Date: December 9, 2014
Location: Scaled Composites
Time: 1300 PDT
Present: David Lawrence, Katherine Wilson – National Transportation Safety Board (NTSB); Christy Helgeson, Brett Vance – Federal Aviation Administration (FAA); David Mackay – Virgin Galactic (VG); Clint Nichols – Scaled Composites (SC).
Representative: Mr. Gary Halbert, Attorney; Holland and Knight.

During the interview, Mr. Siebold stated the following:

His current title was Director of Flight Operations for Scaled Composites. He had overall responsibility for flight test and normal flight operations, managing flight crews and selecting flight crews, scheduling flight crews, providing training and currency opportunities for flight crews. He had contact with FAA for airworthiness, pilot certification and licensing to include initial and recurrent, and AST permitting process. In addition, he had a role in the safety organizational structure to participate and observe each of the individual programs, review and approve flight cards within the flight readiness review process. If outside his comfort level, he would reach out to Cory Bird and discuss whether we let a program proceed, hold or review it. He answered to Ben Diachun, VP Engineering.

The Scaled pilots fall under engineering. Within his organization he had two direct reports for five pilots; some report to another part of the organization and were "matrixed" to me in a pilot capacity. Some report through another management chain. All the pilots report up through the VP of Engineering and not necessarily directly to him. When asked why the pilots fell under engineering and not operations, he could not answer the question of why the management set up the organizational structure the way it was. His position reported through VP Engineering.

For SpaceShipTwo (SS2) training, a big part of the training was participation in the program from an early stage in the project; a lot of the in-depth knowledge design decisions, how we operate the aircraft. The pilots were involved in the design stage and reviews, flight readiness reviews, and were soft ways of learning about the vehicle and the various concepts of operations. The PIC path had more formal regulatory training requirements when the vehicle was flown as a licensed experimental glider, requiring pilots to hold an experimental authorization. The FAA set forth the training requirements for that path. For co-pilots, they did not specifically call-out that SS2 was a true two-crew aircraft like they did with WK2. There were early concepts that they might fly SS2 as a single crew aircraft. Early on they did not say that the second pilot had the formal requirements of the PIC.

On the PIC side there was the LOA and more formal training; on the co-pilot's side basic training involved participation in individual simulator sessions and group sessions; 2 hour sessions involving pilot, co-pilots and mission control. They did those starting with the very first glide flight.

There was a distinction between an AVS and an AST regulated flight. AST had firm requirements; under AVS they could decide internally what was sufficient for training. On one they had to "dot the i's and cross the t's." On the other they had more flexibility and no regulatory requirement to do so.

For AST regulated flights they set an internal requirement for a minimum of three combined group simulator sessions for each powered flight, presuming that the crew had participated in previous flights. He was not sure if that was in their permit. For the Extra, there was a minimum of three sorties in preparation for the flight, including maintaining and gaining g tolerance and upset recovery training. They had no formal requirement for WK2 flights. They looked on that on a case-by-case basis. He paid more attention to that for the PICs for landing currencies. WK2 was able to simulate the approach and landing phase, and was not effective in other flight phases. He did not recall if there were a minimum number of approaches to be conducted in WK2 prior to boost flight.

One of his functions was to monitor the pilots' currency, and prior to approving a specific flight it was something he'd have a pulse on whether they had flown recently and was ready. He would work with the VG counterparts to get currency or use one of their other aircraft to prepare. There were no documented minimums. It was a small test organization, and with the limited amount of flying they did each year, it was not something as an organization that they did unless there was a specific requirement. They do not accept unreasonable minimums.

For SS2, the training simulations were a great opportunity for him to gauge the pilots' proficiency. He would observe in a simulator session the pilot and team's performance. If he was not involved, he would observe the performance. Most of their simulations were very structured and very emergency-procedures intensive. A lot of what they were doing was refining their procedures, seeing whether the procedure was written well was all part of the process. The vehicles were still under development, and this was not an operational system, and they were still developing the procedures for the vehicle.

For the 0.8 Mach callout, there are a couple of things that happen in that region, and it was a busy time. The aircraft was going transonic, the aircraft would pitch up without any pilot input and once it went supersonic the neutral point shifted, so it went through this region. In addition, there was an air data source switch that occurred in that region. Below 0.8 it was measured by the ADC, and above that speed it was measured by the inertial, which had errors in it, primarily

due to winds and temp. It was not a lag, but a jump in speed. For example, with a 50kt headwind, the inertial did not know that, corrected for density it might be 30kts lower. Similarly for temp offset, there would be a jump.

The sim had the capability to input forecast weather which would incorporate those features. There were a number of issues involved with that system in the simulator prior to the first boost flight, and they defaulted to flying a standard atmosphere with zero winds which did not have an appreciable jump in those parameters. In his recollection for the last simulations, they had real wind profiles.

From his standpoint, as PF and PNF having the situational awareness of what was going on in the cockpit was important. The PF had his hands on the stick and had immediate feedback. For the PNF, any motion that was unexpected or different was not immediately known. So, as part of the preparation, it was something that allowed Mike and he to communicate where he [Pete] would call the transonic pitch up which occurred at around 0.8 Mach, and Mike would call 0.8 if the transonic pitch up had not occurred yet or maybe to remind him to call the pitch up. It was a way to communicate since that time was very busy. He was focused on his task, but those call-outs were useful for keeping the information flowing between the pilots. He did not recall other information from previous flight influencing this that led to the 0.8 Mach call.

Regarding the trim setting included on the display which had not been included in previous flights, he said the transonic regime was very busy. After the transonic pitch up was complete, the PF action was to trim the stabs to optimize the pitch up. Before that point the trim setting was set for release. After the transonic pitch up, the PF had a task to actively set the trim position. The primary trim indication was on the center MFD, and they had set up that instead of having the pilot look there during a busy time, the PNF would call out the trim setting. The idea came from SpaceShipOne (SS1), which had the trim setting on the display, and it might be nice to have that on the SS2 display but not required. His recollection was that was something that was being worked by the Virgin team as a commercial improvement, and they flew an early concept of that display for this flight. He guessed they started flying with the new trim display about 3 or 4 weeks prior to the accident. He was not aware of any risk or hazard analysis done for the new display. He was aware of the new display, and as PIC he accepted it, but was not involved in a review of various concepts for the new display. It was a change so close to the flight that he had no plans of using that feature in the flight, and they had not trained to use that feature. They had no plans to use it because it was so close to flight. The minus 9 trim was set well prior to release. Until the transonic pitch up and pitch down occurred, they did not re-trim.

When asked if pilots had other duties besides flying, he said they all had other duties. When asked what percentage was the pilot's responsibility to the SS2 project and others that Scaled needed their time for, he said it was a complex question and it differed from person to person

depending on pilot responsibilities and other responsibilities. For Mike, he would say about 90% of Mike's time was taken by other responsibilities not related to SS2. His [Pete's] was more like 80% other responsibilities not related to SS2. For other pilots, most pilots were roughly in the same boat. Prior to that, their other duties were working on the project as a design engineer, so 100% would be devoted to that project.[4]

A lot of his job responsibility was to ensure that the pilots were prepared and had the currency and proficiency to participate in those programs. He had frequent discussions with the pilots and would encourage them to stay current and proficient. Some of their responsibilities were outside his authority, and for some pilots he would have to coordinate with other managers to get their participation in this program.

When asked if Scaled pilots were engineers first and then pilots, he said they all had various backgrounds. It depended a lot on the phase of the project, the individual and their background. As a test pilot within the company, one of the important aspects was that they participated as a team member early in the program so they could gain that insight to participate as a test pilot later in the program. That's how they ensured that the pilots and FTEs were ready to participate later in the program. It did not always happen like that, but that was what they strived for.

He knew of the waiver but not the details. It was done in a hurry due to statutory requirements, and there was a sense of urgency to get that approved. He was not directly involved in the permitting process; Bob Withrow dealt with that. He did not recall being asked any specific questions about what was not being complied with.

When asked if the accident flight had two chase airplanes as outlined in the Scaled waiver, he said WK2 could serve as a chase plan for the high altitude phase and the Extra could serve for the low altitude chase.

He could not remember the last time the simulator was run at 1.4 times speed, but thought it had been a while since they did that. He did not think they ran the simulator at 1.4 times speed for PF04 preparation.

He had done centrifuge training previously, but to his knowledge Mike had not. Forger would likely have done centrifuge training, and Clint had not to his knowledge. It was not part of

[4] In an April 16, 2015 email from Matt Stinemetze to the NTSB, Mr. Siebold offered the following: "The statement referencing the percentage of time that Mike and I spent on SS2 efforts can be misleading, and I offer the following clarification. The averages estimated were in the context of the previous year where we were not consistently flight testing SS2 and where most WK2 operations had been handed over to Virgin Galactic. During active times in a flight test program, the time spent with that particular test program would be substantially higher, and in the SS2 program specifically, increased substantially with flight test activity."

Scaled training, and they used the Extra as a centrifuge surrogate for high g and upset training to satisfy the objectives one would get out of centrifuge training.[5]

It was his recollection that Scaled had done two CRM-type courses, and the latest one was done by the National Test Pilot School (NTPS). It focused on mission control room training. They had a lot of new engineers that did not have the experience that you might get on other projects prior to SS2. The NTPS training was not pilot-centric, but more test team-centric.

For the 0.8 Mach call-out and the PFD trim display changes, he said he was not aware if those had been coordinated with AST. The regulatory requirements were for material changes to the vehicle, and that the FAA would be notified of those changes.

Regarding CRM training, the second one was a number of years ago, and one of the pilots on staff that had some airline experience put together a CRM course. He did not recall when that was.

Regarding the 1.4 times accelerated simulator speed, he could not recall if it was for the entire duration of the sim period or portions of the sim period since "we used that feature so infrequently."

He had been the Director of Flight Operations since the 2008 time frame. He did not recall the exact date. There were a lot of management changes during that time. Burt retired, and Doug stepped up to president. Doug was the previous Director of Flight Operations, and as an existing VP he reported to the President. At that timeframe, the organization changed and they got a new VP of Engineering. He was not reporting to a new person, but in a new role reporting to the same person.

The development of the procedures for the unlocking of the feather was during that time when Forger had taken the reins to prepare for the first powered flight, and he [Pete] was not on active flight status so his involvement was "limited." He was aware of the procedures, but did not recall being involved in developing them.

While he could not speak for the other pilots, but he had not observed a sim session where a pilot unlocked the feather early, but had observed a late unlock. It did not cross his mind that unlocking the feather early was a hazard. He knew it should not be unlocked early, but he did not think it was a significant risk that it could occur.

[5] In an April 16, 2015 email from Matt Stinemetze to the NTSB, Mr. Siebold offered the following: "In 2011, I had the opportunity to participate in a centrifuge training at NASTAR to evaluate SS2 boost and reentry profiles. These profiles simulated a higher performance motor with acceleration characteristics that exceeded the eventual SS2 hybrid rocket motor profile. This centrifuge training was not repeated in preparation for PF04."

When asked how he knew the feathers should not be unlocked prior to 1.4 Mach, he could not remember if it was in a design review or "water cooler discussion," and said he believed it was common knowledge that the feather locks were required in the transonic region, and it came up many times.

Regarding egress training, he said there were several sim sessions where they simulated failures that resulted in a required bail-out. It was written as a procedure; they briefed it, and performed it up to a certain point in the simulation. In some flights they emphasized it more than others when the risk increased during envelope expansion.

They had a parachute rigger come in and give all the flight crews a brief with an expired pack demonstration. More recently, they had an opportunity to use the emergency O2 on some of their new parachutes due to shipping restrictions to get them to off-sight locations, and they learned that there were design deficiencies in the parachute.

He was consulted on a number of the fault trees and was aware of it going on, but he was not aware of every fault tree. He was consulted on fault trees that involved pilot actions and misleading indications, where they might be able to put a mitigation in place, but he did not participate in all of them. He did not recall the discussion of unlocking the feather in the transonic region being hazardous or catastrophic. They knew it could be hazardous and catastrophic, but did not remember them discussing it in analysis. Typically, Niki [Dugue] was responsible for the bulk of the analysis, and Bob Withrow would discuss it and talk through it. There were many hazards associated with the feather system which he participated in like feathers failing to unlock. He did not recall there being a hazard identified of unlocking the feather early.

Regarding the Scaled safety culture, he said they put a tremendous amount of responsibility on each individual for the safety of their products, but it was expected that they all be mindful of safety in the design and operation of their aircraft. He considered safety as an important part of their culture.

The October 31st date for PF04 was a re-scheduled date. He recalled that the original date was extremely aggressive and they felt that the delay was appropriate. He commented that they went into PF04 feeling really good, and that they were ready to execute, more so than previous flights. That was his opinion.

When asked about a CRM crew brief prior to the flight, he said they had several discussions on how they would communicate in the cockpit, starting as early as the sim sessions. He recalled prior to release having a final briefing; how it was going to go. He could not recall when and where, but they had multiple discussions.

Prior to the release, he had an observation that he was aware of a view limitation in his seating configuration prior to release. They talked through it and determined he could see everything he needed. It was something on his list of things to bring up in the post-flight debrief; to make sure other pilots were aware of having an unobstructed field of view. It was part of their typical interaction between pilots as a combined team.

When asked about the field of view issue he had, he said pilot interface into the vehicle had been a long topic, but he did not recall hearing about that issue before. He had not strapped himself in as tightly as he had for that flight, and he wondered if it was something specific to him and did not know if the other pilots had a similar issue. There were no other issues with the suit and the glove since they wore those in other test aircraft, or anything else leading up to the flight.

He did not recall if 100% O2 was used before cabin altitude checks, and was not part of the normal procedure, but did after the cabin altitude checks.

When asked if he recalled if the seat felt as if it was in one piece or not after the accident, he said he reached for the seat belt, so he must have known he was in the seat, but unaware of whether it was intact or not. He did recall seeing nothing else around him, and recognizing that he was not in SS2 anymore.

When asked if he had any theories as to why Mike may have unlocked the feather early, he said he was not aware that the feather was unlocked and could not climb inside Mike's head.

When asked if they ever swapped pilot assignments, he said within the test pilot program they did not. There were early concepts that considered things like crew rotations. The realities set in that with so few flights there was not enough training opportunities. It was important with the pilots they had to use their experience to minimize the risks for future flights.

At the time of the accident, there were four designated Scaled test pilots participating in the SS2 test program.

For weeks before the accident they practiced the call-outs in the simulator. It was primarily to satisfy his situational awareness of what Mike seeing and that he was doing and incorporate them into his tasks. The 0.8 call was designed to give him information that the pitch up should occur. It was a very dynamic environment, and the pilot workload was extremely high. If things were not going well, you focused in on those items. He said that on the accident flight, his impression was it pitched up more than normal, and he thought he called a big pitch up to get across that it was larger than expected, either for Mike's awareness or the control room's awareness. He did

not recall whether that was his reaction to the big pitch up or whether it was to the expected normal pitch bobble.

He said the FAA minimums were not sufficient for the type of operation that they conducted here in terms of overall proficiency. He would like to see his pilots flying 60 sorties a year as a target. He would regularly look and see how close they were to 60 hours over a variety of aircraft. It was not an absolute number. They had access to some unique aircraft that they flew regularly. All were qualified on the Proteus; that airplane was unique and not the easiest aircraft to fly. They had access to a twin, so he would assign pilots to fly it and others to maintain currency and proficiency.

In October 2012, the regulations changed for Part 61.58, which included PICs who flew experimental turbine aircraft to fly a yearly pilot proficiency flight with an FAA examiner. That led to a dramatic change in the flying requirements. The overall number of sorties had increased and the focus on the flying had changed. As Director of Operations he could just observe a pilot flying for proficiency, but now it was more regimented and had to comply with the rule. An experimental authorization check-ride would be counted as a proficiency check-ride. Prior to the check ride, the pilot would have to demonstrate proficiency to ATP standards.

For recurrency training on an infrequent basis, on some of their flights they would fly relatively inexperienced crew members on an "uncomplex" flight. Each member would be briefed by the PIC on use of the parachutes and how to egress the aircraft. On a less formal basis, all pilots would discuss emergency procedures. Scaled used John Penney exclusively as an examiner, and were authorized to use Dave Morss as an examiner.

He did not recall any call from Mike. He remembered saying something during the flight about the big pitch up and his voice was strained. He recalled thinking he heard something similar from Mike. He did not recall what Mike said, but that their voices were strained. It might have been the vibration, but he could not recall.

He had flown one previous powered flight on SS1, and this was his first powered flight on SS2.

Regarding pilot interface with systems, he said they had a wide selection of pilots to try to incorporate into the design from a size perspective. There were non-boosted flight controls, and they came up with designs that enabled use of non-boosted flight controls such that the stick and rudder throws became larger than typical airplanes and forces were high requiring two hands. The designs incorporated large pilots and short pilots, and pilots fitting in the cockpit and being able to reach switches. SS2 was one program where they spent more time than they ever spent on the cockpit design since they knew it was going to go into production. They wanted it to be redundant from a pilot operations standpoint, and capable of a single pilot operations. Ultimately

it was still a research and development project, and they made the best choices they could up until the point the project had to be frozen. They made minor changes and "tweaks" as they had the time. They certainly thought about it, and pilots had opportunities to provide feedback in the design of the vehicle. He did not use any design requirements or ACs or MIL specs.

In the glide phase, the second crew member was not required to be a licensed pilot. In WK2, a second pilot was required in the POH, so the second in command was required to meet Part 61.55 requirements for second in command. Part 61.55 did not apply to SS2.

For boost flight, he would have to refer back to the permit. He knew who the crews were, and he was confident the pilots met the requirements of the permit; commercial instrument rated pilots.

The simulator did some things very well and others not at all. In terms of procedures and pilot interaction with the vehicle, it was pretty high fidelity. SS2 had the highest fidelity of any simulator they created at Scaled. The visuals and the displays and avionics were very close or identical to that actual vehicle. The avionics and flight displays were essentially identical. The environment that was very hard to model was the high g phase, the vibration and the adrenaline pilots had during flight. That was something they compensated for in workload and flights in the Extra.

For flight preparation, he would visualize the flight and go fly the simulator by himself or with a co-pilot in a non-stress environment, and look at nominal flights or things that the simulator instructors had not thrown at them during the simulations; being mentally prepared.

He believed he and Mike did have simulator sessions on their own prior to the flight; once the day before or the day before that, but he was not sure.

When asked why they used to run the sim at 1.4 times speed, he said on the SS1 and later on the SS2, they had access to Bob Hoey, a research engineer consultant on the X-15 and other research programs at Dryden. They felt that running at 1.4 speed felt more realistic to the pilot of what a real flight would feel like. They did that on SS1 and felt that was more realistic for the pilot since it compressed the time. His opinion was that it more closely replicated the lack of bandwidth during the flight and pace of the flight. For how it was implemented, he said that maybe some of the avionics would not quite run right. They used it in SS1, but not in SS2.

When asked about his experience, he said he started Scaled as a new employee fresh out of school as a commercial multi-engine pilot in college. He held an instructor certificate for both single and multi-engine and instrument. He started with about 800 hours, and participated early on as a flight test engineer (FTE) on a project proof of concept single engine turbojet. He had a lot of test background; planning, analyzing and testing aircraft under Part 23. It was a great

learning opportunity for him. He was trained in flight test techniques at Scaled, as an FTE and then as a pilot. His first PIC roles were as a safety chase pilot, then PIC on Proteus on a number of campaigns. He flew many of the initial envelope expansion trials. He said their test programs were research tests where things did not always go according to plan and aircraft did not fly as predicated. He had a lot of firsthand experience flying these unique and challenging aircraft.

He also flew a twin engine push-pull aircraft, and did the majority of envelope expansion flights. While he was flying Proteus, he was selected to be one of the test pilots on the SS1 project. His predecessor used early flights as an evaluation to determine pilot selection. He flew a number of the early envelope expansion flights of WK1 and SS1 on 2 glide flights and a powered flight. He had a total of roughly 3,000 hours of flying, and about 2,200 hours as a test pilot at Scaled.

His previous experience flying SS1 brought a unique perspective to the SS2 program and to a group of pilots who had not had that experience before. It was very beneficial to the program.

Regarding other tasks, he had the management task of the flight ops department, making sure the paperwork was in order, the pilots did not have expired medicals, and observing test programs. For other pilots, some were project engineers, or project management responsibilities and looking after programs that may or may not have flying involved. Most of these were technical responsibilities, and some pilots were more business focused, but that was not the case now.

When asked about lessons learned from SS1, he said SS1 was a very fast-paced research program. There was a time deadline to meet, and they made a number of compromises. When SS2 came along they had an opportunity for a clean slate to incorporate a number of design changes they wished they had the time for in SS1. SS1 had a "horrendous layout" in the cockpit. Switches were all over the place, and it was very challenging to fly. At the time, Virgin was advertising that line pilots would fly SS2 after about 6 months of training, so that was in the Scaled pilots' minds, though the test pilots thought that was not a good idea. They made a number of improvements since.

When asked about possible design changes going forward following PF04, he said he knew limited facts of what happened in the accident. He knew Mike unlocked the feather and he had no idea why. In terms of the safety equipment that they had and its performance, he had strong recommendations for changes that he believed should be incorporated, even as much as they should not be flown until there are design changes made.

The communication between the two pilots in boost was all verbal.

When asked if the procedures were written in such a way that there was time to respond to a verbal call, he said in his opinion and perception, there were certain phases of flight where it was

just not practical to have a command-response type CRM setup. There was not enough time. He approached this flight that they were two highly trained individuals working together, and they would execute their responsibilities at the appropriate time and place. Other times it would be different at times when the workload was reduced. He briefed Mike that once they were clear of the hooks, he would arm the motor and Mike did not need his approval to do it, but not to throw the fire switch until he [Pete] commanded it, giving him a last chance to decide not to fire the rocket motor. It never crossed his mind that Mike would unlock the feather early. Mike did not need his concurrence to unlock the feather.

The feather unlock handle in the vehicle felt different than the simulator; it was harder to operate in the vehicle compared to the simulator. He was surprised by the force required on the vehicle. He did not recall any problems during the unlock checks. Mike did the ground feather unlock checks and the in-flight check prior to release per normal procedure.

The feather lock checks depended of the phase of flight. During boost phase, the procedure to unlock the feather was memorized. Some emergency procedures were also memorized. The boost portion of the flight regime was primarily done completely from memory since it was hard to expect a pilot to look down to read a check list.

His "10,000 foot view" was that the rocket was essentially identical to SS1. The rocket motor was smooth, with no vibration. The start-up was essentially two phase, a low level that was followed then by a boost that hit them with full thrust. SS1 was a harder airplane to fly and single pilot, but they operated it in a much simpler manner. Overall, this rocket boost reminded him of SS1.

When asked if he recalled any aerodynamics lessons learned on PF01, he said the pitch up was not predicted to be as large as seen on PF01, and the simulator was not modeled for that. The simulator was then modeled to replicate that pitch up. He did not recall if they made the 0.8 Mach call on PF02 or PF03.

When asked if during previous boost flights they always unlock the feather during boost, he said he did not recall what the procedure was in the early days of the simulator. Unlocking the feather was mitigation to a hazard identified. He would assume they did not unlock early on during simulator flights and was incorporated later on. Unlocking the feather was discussed as mitigation against a feather lock jam where the feather fails to unlock. It certainly was discussed, but he did not know if all the pilots knew about it.

The interview concluded at 1530.

17.0 Interview: Dan Armstrong, Scaled Composites
Date: December 10, 2014
Location: Scaled Composites
Time: 0800 PT

Present: David Lawrence, Katherine Wilson, Lorenda Ward - National Transportation Safety Board (NTSB); Christy Helgeson, Brett Vance – Federal Aviation Administration (FAA); David Mackay – Virgin Galactic (VG); Clint Nichols – Scaled Composites (SC)

Mr. Armstrong was represented by Mr. Gary Halbert, Attorney, Holland and Knight.

Mr. Armstrong stated the following:

His name was Daniel James Armstrong, and he was 59 years old. His current title was engineering manager; a position he had held for about a year and a half. Prior to Scaled, he had been an aerospace engineer and had worked in industry since late 70s. He came to Scaled 4 years ago. The initial program he worked on was proprietary; he worked as an engineer, then became a project engineer on another proprietary program, and after a year and a half of that project became engineering manager.

He was primarily responsible for staffing across all programs, recruiting and administration - such as amounts for raises and bonuses. He was responsible for engineering budgeting, engineering supplies for training, and was deputy to Ben Diachun, VP Engineering.

On the day of the accident he was a spectator. Immediately afterwards he was a back-up (b) (4) team member. (b) (4) was a process or procedure for aircraft in-flight emergencies or ground accidents if people are hurt or killed. He was a back-up to Ben Diachun. The procedure was to make contact with Ben and be available. He sent Ben an email and waited. Ben began giving him administration tasks not related to the accident. He did not recall what they were.

He knew Mike (Alsbury) outside of work. He had met him at 2002 through soaring at the glider port. After talking to him he invited Mike and some friends over to his house and got to know him better. Mike called him about 4 and half years ago and told him about work at Scaled, he came to Scaled because of Mike. Pete [Siebold] was a peer, sits in the next office, and they talk all the time. They had done paragliding and hang gliding together. He did not know him before that.

He said he was Mike's supervisor. Mike was one of the Project Engineers. He had dual responsibilities. His primary assignment was project engineer on a proprietary program. He also flew a lot and in that capacity and reported to Pete Siebold.

Mike had significant responsibilities, a lot. He estimated roughly two thirds to three quarters of Mike's time was spent on other projects. Because SS2 was late in development, Mike was also doing some flying on Ares and Proteus.

When asked if Mike's SS2 flying was under the direction of Pete Siebold, how was his time balance coordinated, he said Pete Siebold sat next to him and they discussed every one of Mike's responsibilities. Mike or Pete could bring it up, and Pete and he would discuss it so they coordinated to cover both areas. They would do this a few times a month. Clint Nichol's time was also discussed. The balance varied with every assignment, and varied over time.

Leading up to PF04, the proprietary program that Mike was working on had had its ups and downs. About a year to year and half ago it had peaked and Mike was working very hard. Then there was a period when he caught up on time. The schedules and times changed, and there was no way to know for sure beforehand. Mike was still working on that project in the month before the accident, and Mike went away to support that other program earlier in the week prior to the accident.

Mike came to him frequently about the people on the project working hard. Some of the people on that project were being pushed very hard. Mike was a very hard-working person and was very productive. There was a role change coming up in the project, and Mike suggested a role change in the team. That person was now the project engineer on that project.

He said Mike compartmentalized the work. His expectation was Mike would do his stuff while he was gone since there was no mechanism for Mike to do it at Scaled. As an employee, Mike was exemplary, one of their best. He always let him know when he was going to be gone. Mike would put notices on the calendar, send emails out when he left, and delegated work to his people. Mike was a good time manager. He was a hard working guy, but his family was very important to him. He made sure there was time to do stuff with them.

He wrote Mike's performance evaluation. It was outstanding, one of the highest reviews. The scaling was 0 to 5, and he recalled Mike was rated at 4.5, which was very high. The 360 reviews meant all-around review; peers, people who work for you and managers. They were anonymous, in that there was no name provided. There were comments from Mike's peer review that there were some challenges balancing his work and engineering. The project engineer had a very demanding job and the flight test had a very demanding job, and they were difficult to de-conflict.

He and Mike discussed every comment on his evaluation. Weeks before the accident they discussed replacing him on the proprietary program and they had planned to do that. Mike

brought it up and suggested it; he had been working too much, more than most. Mike probably worked more than most everyone. The people who worked on Mike's proprietary program worked the most number of hours. He was Mike's "Home Room" manager. Everyone working on that proprietary project had said they had too much work and there was too much travel. They were trying to finish the program. There were schedule changes on Tier1B and on the proprietary program. They had been planned to de-conflict, but schedule changes were hard to overcome.

Pete Siebold had two test pilots whose primary responsibility was test piloting – Mark Stucky and Eric Hansen. He had two other test pilots who flew as pilot in command (PIC) – Mike Alsbury and Clint Nichols. Then there were others who could be co-pilot and Flight Test Engineers (FTE), who might fly in the right hand seat. For Clint and Mike, at times their responsibilities as a test pilot were primary, especially when they were in the flight test mode. Things would frequently change.

Over the previous year and a half to two years, Mike took over as project engineer and was largely working on that program. He did not recall Mike telling him that he needed to fly more. Mike's motivation was to fly and to finish the projects. Mike liked flying. He could not recall Mike expressing any concerns regarding the SS2 project, though Mike was concerned about getting bumped off the schedule for the vehicle about 6-8 months ago. He was concerned he might not get to do one of the flights because of the Virgin pilot crew being folded into the program. It was not his [Dan's] concern – that was Pete Siebold's. Pete did not work for him, he was a peer.

He and Pete discussed scheduling, and made sure people were available, like for example making sure Clint was available to fly Ares with his scheduling and planning. They would coordinate when he would need those people, when someone would become a project pilot, etc.

They did not hire for project engineers. They hired "direct contributors" and then saw if they had the ability and skills to become a project engineers. He hired engineers and they developed from within on virtually everything they did. He promoted multiple people to project engineers. They had to work up within the system. It took a while to learn the culture.

The direct contributor was primarily responsible for the technical issues, for some physical hardware component, and getting it built and tested. As a project engineer, the additional role was schedule and budget responsibilities and management of the folks accomplishing the task. Any engineer would be looked at more closely if they had a flying background. Almost three quarters or so had a flying background. That helped with risk management.

When asked to describe the culture at Scaled, he said it started with the training they gave them on the very first day. Most everything they did was proprietary. They showed them the projects.

They read chapter 1 of the Handbook, which described the Scaled culture in good detail, as well as chapter 7. They were going to train them, and provide them more responsibility at an early point in their career. They taught them to be more innovative, and to try different things. They were told that early on, failures were expected. He said if there were no failures, "you probably were not trying hard enough." Culture was also defined in the subsequent training. The first two weeks included composite fabrication training and learn to fabricate composite structures using the processes. This also allowed familiarization with the manufacturing side of the company. Next, they were given 4 or 5 days of CATIA training, which was a 3D computer-aided design program. Fabrication training was immediately after their introduction. CATIA and the engineering series of lectures was in the first 6 months including conceptual design, structural design, composite design, flight test, ground test and design of test. All of those different lectures, included lessons learned from previous programs, and were given by internal experts and people who worked at Scaled and had been involved for a long time.

The introduction of the engineering handbook had a discussion about the culture, and "the culture at Scaled is definitely different than most places." Chapter 7 had testing and test safety, and new employees were asked to understand the safety processes. There was a desktop procedure that described system safety. The safety officer was the President or his delegate, and that was Cory Bird.

There were quarterly engineering meetings run by Ben Diachun, and all the engineering staff attended if available. He said he [Dan] was responsible for project engineer meetings. Presentations from those meetings were held on the server, and included a test class that Mike put on.

They hired pilots since those were people who had risk management experience. Mostly, risk management training was done internally. The class that Howard Au gave and the desktop procedure gave people that training for the responsibility for programs that could result in injury or death.

Mike was working on multiple programs, and he flew other aircraft. He was a test pilot at times and he was asked to do those missions. He was not aware that Mike had gone on a trip earlier in the week and after they had gone, they were asked to return early.

Mike had not brought up any concerns specific to PF04. He did not know Mike's wife. He was not involved in the FRRs for PF04.

Regarding the culture at Scaled, they did hard things; dangerous, hard things and they wanted not to have accidents. He was not familiar with any of the audits that Northrop Grumman did, although there was some feedback from his bosses from board actions.

He had previously said that when training new engineers, they told them not to be afraid of failing. They designed things rapidly and tested rapidly, and that was related to failures that did not result in damage to property or people. They had a culture that said "design it fast, then test it, if it's ok then you proceed; if it's not, you fix it rapidly." If they did not take that risk, it would take much longer and cost much more. But if there was a risk to people or property, there was much far more oversight in the flight reviews and test reviews, and peers had the opportunity to come in and review.

The project Mike was working on was not ending, but coming up to an important milestone, and Mike was in a leading role on that project. Mike was motivated to fly in Tier1B. He expressed concern for his people but not for himself. He expressed that to him [Dan] directly.

Mike had to do simulator sessions, training, and other responsibilities with Tier1B. They were not continuous or on-going. There was a period when he did not fly for a very long time.

He did not know what the risk level was for PF04.

He said he wanted his project engineers to work on the things that were the most important. If you were engaged on a flight test, that was the most important for that period. That was true for anyone working on that flight test.

To assess performance, he basically looked at schedule adherence, capability and time off. For those who were not maintaining a workload balance, he would typically see them not make a schedule, or they would perform a task poorly, and then he would say "you're falling down, what's going on?" Mike always made his schedules, and would set up and make his vacation times.

Between him and Pete Siebold, he did not know all the programs Mike was involved in. He was not read onto all the proprietary programs. Pete and Mike had been colleagues for longer than he had worked at Scaled. There might be a "tiny little" program that he would not even know about; maybe a flight on something he did not even know about, or something that might take one morning.

Mike worked about and average 55 hours a week on the high end, and maintained that throughout the year. A normal work week was 40 hours.

He said Pete Siebold never came to him to say he needed to back off some of the projects, specific to Mike. When the Tier1B aircraft were down for modifications they were not flying for a while, and that involved a time when they were putting new brakes on WK2.

There were no concerns expressed about Mike, his workload, or management style. Pete Siebold said Mike was working an awful lot, but Pete also mentioned that about Clint Nichols, Mark Stucky and Eric Hansen too.

Crew rest was monitored by Pete Siebold, but the initial responsibility was on the guy himself. He would not necessarily hear about it if someone exceed those requirements, but Pete Siebold might mention it. Pete was concerned about it from a planning standpoint, not that there had been any exceedances. Mike never mentioned to him a need to back off any of the other projects as they approached PF04.

He wanted to hit one point and emphasize it. He wanted to differentiate between programmatic risk, where Scaled asked people to push hard and see failures. That was not acceptable at the flight test level. They asked people to do innovative things that are difficult and do them rapidly, in small groups and work fast, and be able to have failures at the level of design and build. But in flight test it was very important not to have failures. Scaled's history had been good; they'd had two major failures that have resulted in death and that was not acceptable, but they had 30 prototypes in 30 years that had been flown.

He came in and worked on several programs and worked on the one that Mike was on, but he never worked on Tier1B. At one time he did participate in the FRR bending moments on the T-top wing.

The interview concluded at 0930.

18.0 Interview: Ben Diachun, Vice President of Engineering, Scaled Composites
Date: December 10, 2014
Location: Scaled Composites, Mojave, CA
Time: 1230 PDT
Present: David Lawrence, Katherine Wilson – National Transportation Safety Board (NTSB); Christy Helgeson, Brett Vance – Federal Aviation Administration (FAA); Clint Nichols – Scaled Composites; David Mackay - Virgin Galactic.
Representative: Gary Halbert, Attorney, Holland & Knight

During the interview, Mr. Diachun stated the following:

His full name was Benjamin Lee Diachun and he was 39 years old. His title was vice president of engineering for Scaled Composites and he had been in that position since 2008. Before his current position, he held the titles director of engineering, project engineer, design engineer and bids and proposals manager. He was hired by Scaled in 2003 after graduating with a master's degree from Stanford University.

His roles and responsibilities included oversight of the engineering homeroom department, flight operations homeroom department, quality assurance homeroom, and bids and proposals. He was also a part of the senior management team at the company.

Asked to describe the "homeroom" concept, he said they were a project-centric company and had their own resources, staff, and equipment that were "matrixed" out to projects. Homerooms exist over time while projects start and stop.

On the day of the accident, he was an observer in the control room. When the accident occurred, as a senior manager, he initiated the emergency response and was involved in the emergency response after that. His responsibilities were to stand up the investigation team. The president would be in charge but because Mr. Diachun was the highest ranking person in the control room, he facilitated the flow of information between the control room and the command center which was located in Kevin Mickey's office.

In an emergency response situation, his engineering manager, Dan Armstrong, was his back up. His office assistant also helped him coordinate with the crew families. In the control room, he received information from a number of people that he then passed out to the response team.

In his position as vice president of engineering, he had technical oversight of all programs. On the day of the event, he had no specific role that day related to the Tier 1B program, which was typical. He had previously been the technical advisor in the control room during a Tier 1B powered flight, but on the day of the accident, Mark Stucky was in that role. He had also been a "photo-chase" for Tier 1B glide flights.

He knew the accident crew. Pete (Siebold) was a "direct report" to him.

He thought the organizational structure placed the pilots within engineering rather than operations because of historical precedence and also because their test crew was sourced out and developed out of engineering. In the engineering department, test pilots were sometimes design engineers, flight test engineers, and project engineers; their workload varied widely based on the project, person and role. How their time was split between projects was done on a case by case basis to meeting the project requirements. The percentage of time a test pilot's time was split between projects was based on what was appropriate to meet the project requirements, being safe, and balance all of the priorities. It varied on a case by case basis.

At the time of the accident there were four test pilots that reported to Pete Siebold. Two pilots spent more time in a test pilot role and the other two he was not sure about. There were times when a test pilot would be more in a test pilot role and other times in an engineering role. It was based on the project requirements, safety and their development at that time.

At the time of the accident, Mike Alsbury was a project engineer as well as a test pilot. He thought his time was split 50-50 between the two roles but he would have to validate that.

Test pilots were considered both test pilots and engineers. They sometimes referred to them as engineering test pilot. Mike Alsbury had an engineering degree, engineering background and test pilot background; he was an engineer first and then developed into a test pilot.

No test pilots, including Mike Alsbury, ever voiced any concerns to Mr. Diachun about their workload during the last year and leading up to the accident. The only conversations he recalled were related to scheduling conflicts.

Schedules were monitored on timesheets and through outlook calendar meetings. He would defer to Dan Armstrong on Mike Alsbury's time because Mr. Armstrong managed and approved his time on a day-to-day basis. They monitored a pilot's time by reviewing and approving timesheets. The hours a pilot worked varied from week to week. Pilots were paid a salary but the hours they worked were tracked by project. Mr. Diachun was responsible for pay of the engineers, but the program managers were responsible for the budget for the program and the number of hours an engineer worked on a program.

The average overtime worked by employees was about 5%. He thought Mike Alsbury and Pete Siebold worked more overtime than the average, but he was not sure how much overtime they worked. Employees worked "nine-eighties;" 5 days one week and 4 days the next week, with Friday off. A person would work more hours one week but it averaged out to 40 hours a week.

Pete Siebold was an excellent performer and was highly skilled. He would have to look at the January 2014 review to discuss any positive or negative comments from Mr. Siebold's review. Asked what he recalled from the review, he said technically was where Mr. Siebold shined but they were working towards making him a better manager. As a part of the 360 degree review, people had expressed that they wanted Mr. Siebold to communicate his management decisions more, to provide more information about what went into his decisions.

Pete Siebold never expressed concerns about his workload or his role on the Tier 1B project. Outside of his SS2 test pilot duties, Mr. Siebold was also the director of flight operations. There were no specific concerns discussed by senior management about workload and time management, for example about Mr. Siebold being director of flight operations and his SS2 role. But it was very typical to have management discussions to make sure they were balancing project requirements with their resources. There were no specific concerns about Pete and his role around PF04.

Mr. Diachun's workload was high but it was pretty consistent with hours of the department, about 5% overtime throughout the year. He worked an average of 45-50 hours per week. He was working more since the accident occurred.

He monitored his flight operations director role by having meetings with him on the status of things and he also got a feedback from Mr. Siebold's team; the status was good.

Before Pete Siebold was the director of flight operations, the position was held by Doug Shane. Mr. Diachun worked for Mr. Shane and with him on several projects. Mr. Shane left Scaled Composites for a position at The Spaceship Company.

For issues related to the experimental launch permit and waiver, Bob Withrow could best answer any questions, but Mr. Diachun was familiar with them. He knew Scaled had applied for a waiver at one point, but did not know if they applied for a waiver in May 2014. He knew that the waiver was filed because they were not compliant with some of the CFRs. At a high level he was familiar with the training and simulator requirements but would have to look at the document for specifics. On the day of the accident, they were using two chase planes – the Extra and WhiteKnightTwo. He did not know if they were still running the simulator at 1.4 times normal speed. He observed simulator sessions often. If he had the responsibility as the technical advisor, he would be in the control room as well. He observed the full integrated simulator session but he could not remember if it was the one right before the accident flight or the one before that, but he knew it was one of the two sessions prior to the accident flight.

He liaisoned with the vice president of operations, Mr. Kelley. They were both part of the senior management team and have status meetings together with the president and coordinate any interfaces. Mr. Kelley had a functional management role, providing resources to the programs.

Scaled Composites was very program-centered– the program manager reported to the president and the vice presidents helped manage the business and also "own" the resources that get "matrixed" out to the programs that are managed by the program managers.

Some staff, including test pilots, worked on multiple projects. Regarding Mr. Alsbury, at the time of the accident, he was a project engineer on one project and a test pilot on the Tier 1B program. He was also a part of the senior leadership at Scaled and would informally mentor people and was a subject matter expert for other projects, so he was sure that other people came to talk to him but it was not an official assignment.

Mr. Alsbury was paid a set salary and did not get paid overtime pay for hours worked beyond 80 hours a pay period. Although not paid for overtime hours worked, all employees documented all hours worked on their timesheet. Test pilots worked a 5-4-9 schedule, working 9 hour days and having every other Friday off.

Crew rest requirements were monitored at the program level; he did not monitor that. He was aware of the requirements on a third hand basis; there was a rigorous schedule that allowed for proper crew rest. It was the responsibility of the individual and the program manager to ensure the requirements were met.

He was aware that Mr. Alsbury was called back early from his trip the week of the accident flight but he was not involved in the decision. He was not sure who made that decision but thought it could be the president, his other project leadership, or Mr. Alsbury himself.

Asked if any employees at Scaled had a human factors background, he said Howard Au had formal training, and previously worked at Boeing and had training there as well as in school, but was not working on the Tier 1B program. Mr. Diachun had a human factors engineering class in graduate school but had no formal human factors training at Scaled.

Scaled did a lot of human factors design and human factors on the job training, but it was not formal human factors training. Asked what guidance was being followed to ensure adequate human factors on the job training, he said informally, engineers and pilots would meet so that pilots could give feedback to engineers, for example on the usability of a system and from that the engineer learned about usability and could incorporate that into the system.

There were multiple parts to the flight readiness review (FRR); he attended some of those parts but not all of them. He had no concerns about PF04 by the last FRR. There were issues that had remained open which was why they had multiple FRRs, and everyone had a voice to bring up any issues. He always had a concern if there was an open issue but all issues were closed before the accident flight.

There was pressure to have PF04 completed on October 31, but not undue or unreasonable pressure. There was also pressure to perform the flight safely and pressure to meet the program requirements, so they were constantly balancing all of those pressures. If there was a reason to not meet a schedule, everyone had a voice to speak up, and they all had spoken up at some time, and if that was the case they would adjust the schedule. That was why they did not publically publish their launch dates, so they would not feel undue pressure.

He did not know when Mike Alsbury was originally scheduled to return from his trip prior to the accident flight but he would find out.

He did not manage routine reports on what pilots did to stay current; they were mostly managed at Pete Siebold's level.

To determine, in general and not specific to Tier 1B, if a pilot was safe and ready for a flight, they held FRRs that involved the pilots; the test card would be reviewed and test points that needed "proficiency to perform" would be provided. Depending on the vehicle, a pilot might need additional ratings or currency which would be reviewed. They would also ask the pilot and do a "fit for flight check with them." A pilot could say he was ready to fly but they could watch a pilot's behavior to determine if anything was out of the ordinary; it was much more subjective.

The risk for PF04 was assessed as high. The hazard assessments were part of the FRR. The assessments were made prior to the FRR and then brought into the meeting. Asked if a pilot's program and scheduling responsibilities would change based on a high risk assessment, he said yes, they made more accommodations the higher the risk, such as making sure they had gone through all of the preparatory tasks previously discussed, more simulations, more g training, or glider currency. There was a list of currency and proficiency requirements to make sure it was all completed.

Regarding who would provide the informal human factors "training," the project test pilot for the program would do the training. At the time of the accident there were four test pilots. He did not know if the pilots had formal human factors training. He clarified that he would call it usability training that was being given, such as usable was a panel or switch.

The safety process or culture at Scaled was woven into everything they did. It went back to how the company was set up. Burt Rutan was an engineer, fabricator, technician, test pilot and flight test engineer. He set the company up such that employees could produce better results for the company if the person understood and could do all of those steps in the process, or at least have familiarity with them. As the company grew, Mr. Rutan maintained control over each project in order to understand the whole lifecycle; the argument was that you could produce faster better results, more safely by having that multidiscipline person. Being multi-disciplined related to safety; the designer was also the flight test engineer or the pilot and that built in safety because that person was intimately involved in the whole process. It began with the mission statement, then operating principles, system desktop procedures and system safety process, and involved everyone in the company. Everyone was responsible for safety and had the ability to affect safety.

Part of their process was to push ownership and responsibilities down so that the people doing the work could make decisions and he believed that made them safer. The company's motto was "question don't defend"; always ask what if, what could fail, what could go wrong. They were encouraged to always ask questions; they were never done questioning. They also had an open door policy. If someone was not happy with what their supervisor told them, they could go to another supervisor's office. Employees were encouraged to escalate an issue if they did not get a resolution that was acceptable to them. If they did not get an acceptable answer from the company, there were also external ways to voice a concern such as the hotline with Northrop Grumman. When people did that and they got resolution, the company would ask the person to share their lessons learned so that junior people would know it was okay to talk about this.

Scaled's president was the safety official or liaison for the organization and then someone on a program would be assigned as the safety official for the program. It was usually the project engineer, program manager or the lead. That safety official would balance cost, schedule, technical and safety for the program. For the Tier 1B programs, it was Matt Stinemetze. Per their TRR/FRR process, if there was a test coming up, the program safety official would ask if it was a major test that required a readiness review. Senior management would be aware too and could call for a readiness review. At this point, the company safety official would come back into the process, and then they would have the review.

The president delegated the company safety official role to Cory Bird, the general manager.

Attendees at the test readiness review and flight readiness review included the project team/test team, the review board which was overseen by the president or Cory Bird, and independent subject matter experts such as flight operations, structures, systems, the crew chief, and any unique technology or discipline would be brought in.

They had a protocol for the meetings. They would lay out what tests they were preparing to do during the test, then would step back and think "are we ready to go?" The independent reviewers in the room could concur that they were ready to do the test or not. A list of open actions would come out of those reviews, they would work towards closing them and when the open issues were all closed, they would be ready for the flight.

He clarified that the review board was made up of people who were not working on the project and that was who he was referring to as independent reviewers/subject matter experts; they may work for Scaled or an outside agency, but they were not working on the program.

Cory Bird was not on the Tier 1B project recently; he was independent from the project. He reported directly to the president.

Asked how the company guarded against test pilots getting spread too thin across multiple projects, he said they monitored hours and performance, and they talked to the individual and their project team members. If any of those showed an anomaly or issue, it would be addressed, for example spreading the work across people or defer the work.

The company recognized that Mike Alsbury was going to have a lot of responsibility for PF04 so he had other people helping him on his non-Tier 1B project even though he still held the project engineer title. He was not removed from his other project but offloaded a lot of the work to others on the team. This had been done months or even a year before the accident. This was done as a part of normal resource planning. The company saw his upcoming responsibilities and started offloading some workload; it was not because of something Mr. Alsbury said. A replacement had been found for Mike Alsbury as project engineer on his non-Tier 1B project who was scheduled to take over at the end of 2014.

Scaled Composites did not have a formal fit for flight form that test pilots completed.

Mr. Diachun had access to training records but regarding a formal syllabus for training, he had to defer to Pete Siebold. Mr. Diachun clarified that could look at pilot records and he thought some of the training records were included in that. He had seen pilot records that included pilot certificates. There were separate training records but he was not sure how they were organized; he would have to check on that.

He did not liaison with anyone from the FAA on a regular basis. He was not involved in the hazard analysis done for SpaceShip2 but was aware of the work.

He saw the accident crew the morning of the accident flight but he did not see anything unusual. He knew Mike Alsbury and his wife outside of work. Mr. Alsbury's wife never mentioned to him that she had any concerns about her husband's projects or work.

The interview ended at 1340.

19.0 Interview: Terry Hardy, Great Circle Analytics
Date: January 22, 2015
Location: via telephone
Time: 0900 EST
Present: David Lawrence, Katherine Wilson, Mike Hauf, Mike Bauer - National Transportation Safety Board (NTSB).

Mr. Hardy declined representation.

During the interview, Mr. Hardy stated the following:

His name was Terry Hardy, and he was the Director of Safety and Risk Management for Great Circle Analytics. His background included over 30 years engineering experience in government commercial organizations, including 15 years at NASA, and 4 years at the FAA. Some of his experience included space propulsion and cryogenic fuels, software development, launch vehicle safety, human spaceflight and satellite safety and assurance. He started at the NASA research center, left after about 12 years and worked for some startup companies in software and risk management. He came back and worked with the FAA, then left and had been doing consulting work with Great Circle Analytics since 2010. In that role he provided system safety and software safety work for the government and commercial organizations.

In the FAA, he was an aerospace engineer developing hazard analysis regulations, and wrote a number of guidance documents including advisory circulars on system safety and reliability, and software safety. In 2011, he started providing consulting services to the FAA on an as-needed basis through a subcontract with ACTA, Incorporated. When he was in FAA, he was in AST 300, the group currently headed by Stewart Jackson.

With Great Circle, for commercial space he only contracted with the FAA. His other contracts were with NASA, developing hazard analysis and system safety work. His role consulting with the FAA was a maximum of about 40 hours per month, giving advice and reviewing documents, in large part trying to help the group process. He stopped consulting with the FAA on his own choice right after the SpaceShipTwo accident. When asked why he stopped after the accident, he said after 3.5 years he did not feel his recommendations or the work he did was improving the safety process. He felt that after offering recommendations to the FAA he was "spinning my wheels" until the FAA made significant changes to the way they approached system safety and their evaluations. He let the FAA AST managers know this.

In 2011, he was asked to start evaluating Scaled and SpaceShipTwo, in part because of his background and experience in developing hazard analysis regulations, and his work on the SpaceShipOne evaluation. He saw that Scaled was not meeting the hazard analysis regulations, in his opinion, specifically the 437.55 regulation. After nearly a year of follow up from 2011 to 2012, he viewed there were few answers to his questions, and the FAA issued Scaled the permit without meeting the regulations, which was frustrating to him. There were follow up conversations and a few calls he was allowed to sit in on with the applicant. In 2013, when Scaled was up for renewal of their permit, there were many discussions with the FAA on whether or not Scaled met the regulations. The FAA eventually concurred with his conclusions that Scaled had not met the regulations from 2012, and the vehicle had flown since then without

meeting the regulations. He proposed a "get well" plan for Scaled. Instead of the FAA ensuring that Scaled met the regulations, they issued Scaled a waiver. That showed that the FAA was not making sure Scaled met the regulations, and instead they just waived the requirements.

He said from 2003-2007 while he was at the FAA, there were a number of commercial space permits that came through his office, and he worked on most of them. He was tasked under the current contract to review 3 other applications and parts of those applications. His caveat was that as a contractor, he did not have access to all the safety decisions and documents, and his recommendations were solely based on the information the FAA provided him. There could be other documentation and information the FAA had that could have answered some of the questions on the permit that he had. When he was given the contract to analyze Scaled's application for an experimental permit, he was not allowed to speak directly with Scaled or any other applicants. He did have a few conversations with the applicant, but they were always facilitated by the FAA. AST 300 was the division that would facilitate the meetings.

Going back to late 2010 and early 2011, he worked primarily with Jay Naphas at the FAA, who was the system safety lead at that time, and it was Stewart Jackson who originally requested the analysis on the permit. When asked if it was typical for the FAA to contract 3rd parties to conduct permit analysis instead of doing it in house, he said for SpaceShipOne, the FAA contracted with Aerospace Corporation to do an independent analysis, so the FAA had done it before. In this case, the FAA had a limited number of system safety people, and they had a large number of applicants, and it was difficult for them to get through them all with the limited number of people and the limited experience of those people. The person leading system safety did not have much experience. Since that time, Tom Martin became the system safety lead, and he wanted his help from a workload standpoint. He said these systems were very complicated, and having only one or two people looking at them was tough. It helped having other people take a look at it. He was sure some of the management had lots of experience in the field and some did not. Some people like Jay Naphas were younger people with limited experience, compared to Tom Martin.

The process he started with when reviewing the Scaled permit was comparing it to the regulations; did they meet the regulations. He then looked at the advisory circulars. He also had his own checklist, and also used his experience having looked at hundreds of NASA reports and performing dozens of analysis. He looked for things in particular that applicants typically missed. He also reviewed other guidance material. He found after reviewing the Scaled permit that there was insufficient evidence that the regulations had been complied with, specifically 437.55 with regards to hazard analysis and hazard identification. He found a number of hazards that had not been addressed like software and human error, design inadequacies, and these were explicitly mentioned in the hazard analysis regulations. Risk assessment also had a requirement to show risks before and risks following mitigation. The point of the process was to show that the applicant identified the risks and put in the appropriate risk mitigations, and show that risks were

actually reduced. He also found that their risk mitigation measures had not been shown. Part of this was the approach that Scaled used, which was a quantitative analysis, and they did not put any risk mitigation measures in their functional analysis. The result was that the FAA did not have insight into Scaled's risk mitigation measures that had been implemented. He also found the verification to the regulation had not occurred, and the applicant had not shown they had been testing their analysis or inspections to show that the risk mitigations had been effective. Then he dug deeper, and had questions related to elements of the vehicle, and could not find information to validate that Scaled had considered various aspects of risk, particularly in software, which was his expertise from working at NASA. He had questions related to the vehicle that he asked the FAA to give to the applicant. He was very concerned with the process, that the FAA had accepted an application at the end of development. The vehicle had been built, and everything done, and then the paperwork was approved. The FAA did not have insight to what was being done during development. This was a general concern that Tom Martin and he tried to improve the process on; getting the FAA involved earlier in the process. Without that, it essentially became a paperwork exercise where you did not see the process and how the vehicle was developed. There was also pressure on the FAA to get a permit out in 120 days.

In general, he was concerned with Scaled's use of quantitative analysis for an experimental permit, which Scaled relied heavily on. Scaled's process was that they would have a top level hazard concern, then they would do a fault tree analysis to analyze that concern and come up with a quantitative number. If that quantitative number met those criteria, they were done. They did not have to document all the mitigation measures that they used. Those mitigation measures used to reduce risk were not shown by Scaled, because they felt they had done a quantitative analysis and that was enough. The idea of using quantitative analysis on an early vehicle that had never flown could be used as a tool, but should never be used alone. His concern was the data that had gone into that quantitative analysis, especially when a component and system had not been flown. They had data that could have been in environments or configurations that this vehicle would not be flown in. If you read 437, the FAA expressed specific concern about using quantitative analysis.

When the regulations were first made, Congress said to make the regulations for a license easy. It was a chance for the industry to experiment and do things that would get them to a license regime to fly passengers. They used a three-prong approach to safety: system safety, quantitative analysis in the form of casualty analysis, and operational restrictions to keep them in an operating area. The FAA decided in the effort to make it easier for a permit since the data had not been developed, they said to not include quantitative analysis. That was stated in the preamble to 437 dated March 31, 2006, yet Scaled was an example of an applicant using quantitative analysis to justify not doing a system safety analysis.

He was not making any statement about the vehicle being high risk or low risk, since he really did not know. His biggest concern was the missing information and not having that information made it difficult in making a credible risk assessment. There was just a lack of information, and because of that he did not feel that he or the FAA could make a proper assessment from a process standpoint. The FAA used later in the justification of the waiver that Scaled was relying on the pilot's control of the vehicle, yet the FAA did not have the procedures in hand, and they had not considered human error and human factors, and it did not make sense to him that if you were relying so much on the humans than why did you not do that analysis. He said he did not see the procedures, and assumed the FAA had it, but the fact that the FAA was not even asking for it from the applicant seemed disturbing. He was sure the applicant had done a number of things to reduce these risks, and knew the pilots had procedures, but he had not seen them.

He said the FAA did go back to Scaled following his analysis, but it was limited. There were conversations in May 2013 before the Scaled renewal where they were asking questions about their application, and it was concluded that Scaled had not met the regulations. That was when they decided to do the waiver. They did not ask Scaled to update their renewal application; the FAA just went along and issued the waiver. There were some updates to the application in terms of questions and answers provided by Scaled that he thought became part of the application.

Regarding the waiver, there were 4 or 5 mitigations identified. From his previous knowledge, they were doing training and definitely had simulators. The two major ones were the operating area restrictions and the controllability of the vehicle. The FAA stated that the risks associated with an inadequate hazard analysis could be mitigated by operating the vehicle such that it remained contained within an operating area. But as he mentioned to the FAA, part 437 explicitly stated that you had to do both a system safety analysis and remain within the operating area. What the FAA was saying that if you complied with one regulation you did not have to comply with another, which he found inconsistent, and not correct. They were saying that Scaled pilots could control the vehicle so that it stayed away from populated areas. But that may not be a sufficient risk mitigation measure if a potential hazard causes and risk mitigation were not understood for events that could lead to loss of control. Just being able to control the vehicle did not mean you could mitigate the risk, for example if the pilots were receiving false information from their displays that caused them to fly over a populated area. There were a number of hazard conditions that he felt Scaled had not adequately addressed. Scaled may have had that information, but the FAA did not have it or did not provide it to him for his analysis. He said the FAA likely did not ask for the information since they issued a waiver based on risk mitigation measures that had not been met.

During his analysis of the permit for SpaceShipTwo, he never went to Mojave. He had been there before for his work on SpaceShipOne, and was there for one of the flights as a safety inspector within AST 300. In 2004, the process changed and AST 400 did inspection duties.

All questions that came from the technical team went through a management review and were reduced in number and scope before they were received by the applicant. He did not know of any cases where AST 300 talked directly with an applicant without going through FAA management. Any questions that reached the applicant had been reviewed by FAA management. When asked why, he said "that's a really good question." In November 2004, after they had a "lessons learned" following SpaceShipOne, the team came up with a number of issues including communications that were overly strained. The FAA safety engineers were not allowed to talk directly to the applicants, and this was based on political pressures to reduce the burden on applicants. That was what they felt in 2004. What he felt now was that culture of not wanting to over-burden the applicant still remained. As a result, there was a screening of questions and a limitation on direct communication with the applicant.

He worked with various companies where there was a free flow of information, and through that there were a lot of problems headed off with the gathering of information. He felt the FAA was missing an opportunity to do that with a free flow of information. He said it was FAA management that was primarily behind the effort to reduce the regulatory burden on applicants, based on their review in 2004. He felt that it still continued.

He did not have any role in writing the waiver. There was a memo in May 21, 2013 that characterized the issues, and was an internal memo that summarized what he had in his analysis previously. He saw the waiver the first time when it was published, and he was really surprised what was written in the waiver. One question he asked was that if no human error analysis was required to be performed, how a determination could be made that the mitigations identified in the waiver would be effective. He did not know about Scaled's use of the simulator run at 1.4 times the speed. He knew of others on the technical team at FAA that had problems with the waiver, certainly the system safety folks. Another concern was the waiver had been written by FAA management and not the applicant. It seemed a little odd that the FAA was writing a waiver, and to his memory he did not think Scaled even wanted the waiver, instead wanting to show that they complied with the regulations. The waiver came from the FAA, and he had never seen the FAA write a waiver for a public applicant.

Scaled relied a lot on redundancy and failure tolerance. There may have been single point failure considerations but he was not familiar with those, other than the pilots making a mistake. He said Scaled was concerned about the feather locking system, going back to the SpaceShipOne days, but from a mechanical knowledge he was not familiar with it.

The concerns he had with the application were voiced to Jay Naphas, then to Stewart Jackson and Randy Repcheck, then to Ken Wong, who signed the permit. Management knew of his concerns prior to the issuing of the waiver.

The wavier was renewed again in October 2014 prior to the accident. To his knowledge the waiver was extended without looking at the risks of extending the waiver regarding error accumulated over time. It was extended without additional risk analysis. There was also a memo that extended the waiver to all hazards, not just software or human error, and was issued to Scaled.

He also expressed his concerns to Tom Martin, who started in 2012. Tom was part of the waiver but not the original permit.

He participated in the writing to the regulations for the experimental permit and the advisory circular. He was the lead on writing the hazard analysis regulations. He wrote the initial draft of the hazard analysis advisory circular before he left the FAA.

Scaled used a combination of functional hazard analysis and fault trees. Scaled would come up with a catastrophic hazard and then develop a fault tree, and from that fault tree develop a quantitative analysis. If the quantitative analysis showed that for the particular hazard they met their own internal quantitative analysis criteria, then no further work was needed to access the hazard and therefore they did not need to identify mitigation measures. He did not feel that Scaled's approach was acceptable based on the regulations, and told that to the FAA.

Doing a functional analysis combined with a fault tree was totally appropriate. Those tools were fine, it was how Scaled used them and the information they provided that was the issue. When asked if Scaled should done a failure modes and effects analysis (FMEA), he said not necessarily, and with the tools they had they certainly could have done what was intended in the hazard analysis regulations.

To him, it would not have been that big of a step for Scaled to have taken the functional hazard analysis and fill in the blanks, as he suggested in the get-well plan that he wrote, and they could have described what they had done, like procedures used, design standards, safety procedures, and then took each of those and analyzed them to show how each of those were effective.

In the review of Scaled's analysis, he looked at the assumptions that were made. For example, some of the training for the pilots should have come out of the hazard analysis, and it should not have been an assumption that it had already been done before the procedures are filled in. Also, Scaled's assumption that structure was not an aircraft system invoked a whole lot of deduction. That was a pretty rare situation, and not having structure as part of the hazard analysis was odd. Scaled apparently had done a structural analysis that had satisfied the FAA, but he was not a structures expert and did not analyze that. He knew that one concern was that the structural

analysis had not been updated prior to the last flight. Scaled had identified the top level hazards, but more could have been done to describe the scenarios for those hazards.

For documentation of human error and hazard analysis, he would expect the FAA to accept fault trees and/or a separate analysis, but had not seen where the FAA AST had pushed for that. About 2 years ago he was asked to help determine what the FAA should look for since there were broad areas to be covered. He was not a human factors expert, but the FAA had a lot of information regarding human factors that he would hope the FAA would reference.

When he voiced his concerns to Jay Naphas, he did not receive a lot of feedback from him, and assumed Jay took those to his management. He was not sure what management did beyond that. He and Jay and Tom had talked about Scaled's fault trees, and generally agreed that the fault trees were incomplete. Scaled and the FAA had thought that all the mitigations had been included in the fault trees, and he found that not to be true.

For human factors analysis classifications, there were several inputs to consider from a top level. Then it came down to answering a series of questions like; if the personnel had experience, were they properly trained, was the cockpit automated, were the systems demands on the operator compatible with what they could do, system/human interface, what did the pilots need to know and what actions did they need to take. Those were also the concerns back in SpaceShipOne. Some of these items were learned through history, like at NASA where there were certain systems where one operator at a time could control a safety critical function with confirmation for a possible hazardous action.

Through his AST work, he had not seen other applicants use the same methods and assumptions that Scaled used. Many of the mitigations Scaled listed relied on the pilot making the right decision, and he questioned Scaled's reliance on the pilot alone as risk mitigation. In his experience, he had never seen an applicant make the assumption that a pilot would not make a mistake when considering hazard analysis or fault tree construction.

He did have a part in creating the 460 regulation relative to informed consent. He did a white paper on how that worked in other industries to help create that language. He did not have a role in the pilot experience requirements language of part 460.

He was asked to review the updates to the hazard analysis of the second Scaled renewal relative to software under the new fault tree. He sent a memo to FAA in August 2014 with questions for the FAA to ask Scaled, and followed up with his concerns regarding software. This memo went to his point of contact, Tom Martin. To his knowledge his software questions had not been addressed.

In March 2013, he and Tom Martin and Jay Naphas put together a set of recommendations on where the AST office should be going and what they should be doing. One of the recommendations was for the FAA to be involved earlier in the development process and have more hands on discussions with the applicant. While the FAA did have AST 500 folks on site, during the pre-application consultation process, the FAA would get the "biggest bang of for their buck" getting more involved in the development process with the applicant, otherwise it simply became a "paper exercise."

He said there was frustration with the FAA offices to define what was AST's role in evaluating these applications. Some people in AST felt the FAA's role was simply administrative and making sure the paperwork was done, while most believed AST should be more involved in the engineering evaluation to evaluate the risks to the public. That had never been made clear to those in the AST office. He also believed there should be a real evaluation on the culture at FAA to determine what safety means to them. Before he left the FAA, he wrote a safety management system document that mirrored what the safety system management system was at the FAA and recommendations for AST, but he believed that was never implemented.

He also said there were clear lines defined between AST 300 and 400 and 500, and in his opinion the communication lines between those departments seemed to have broken down.

The interview concluded at 1020.

20.0 Interview: Bob Withrow, Scaled Composites
Date: January 28, 2015
Location: Mojave Airport conference room
Time: 1000 PST
Present: David Lawrence, Katherine Wilson, Mike Hauf, Lorenda Ward – National Transportation Safety Board (NTSB); Brett Vance, Christy Helgeson (via phone) – FAA; Niki Dugue – Scaled Composites; Michael Masucci – Virgin Galactic.
Representative: Gary Halbert

During the interview, Mr. Withrow stated the following:

His name was Robert Warren Withrow, and he was 61 years old. His title was Project Engineer at Scaled Composites. He worked on several things at Scaled, and currently was the project engineer responsible for the aircraft called "old school" and was responsible for transitioning all the Tier1B assets to the customer, and was helping out with engine control on yet another project. He was also supporting the NTSB investigation into the SpaceShipTwo (SS2) mishap. He held a BSEE (Bachelors of Science Electrical Engineering). His background included working a number of years in the IT industry, eventually working for the chief technology officer

at Nortel as a "technologist." He then came to Scaled about 5 years ago. He had a commercial pilot's license, single engine land, and was building a composite aircraft (Cozy MarkIV).

His roles and responsibilities as a Scaled Project Engineer varied depending on what project he was working on. On the "old school" project, he was responsible for all the engineering and flight test activities, and directed the engineering talent that worked on the project, along with the shop personnel and with the Crew Chief. He also interfaced with the customer and managed the budget. Other programs had different requirements.

Specific to the Tier1b program, over the course of the program he worked on various items. He started by working on transferring technical information to the customer. He then was responsible for the rocket motor control (RMC) on the SS2, and then became responsible for the Scaled experimental permit. He was later assigned the role of transitioning all the assets to the customer. He then became the Flight Test Project Engineer (FTPE) for the remaining flight tests on SS2.

On the day of the accident, he was an observer in the control room, and to take notes for things that could be addressed in the future. He remembered that the mission was nominal with a few nuisance items like the DAU that came up. There was a delay related to the nitrous temperature, but on the whole it was a nominal evolution leading up to the launch. The L-10, -4 and -30 checks were all nominal, and nothing stood out. There was a clean release and he remembered a nominal ignition. He remembered a call of "unlock" that came at an unexpected time. At that time he was looking at the video display on the "big board," and saw the feather system move. He then saw the decomposition of the vehicle.

When asked what his role was in the waiver process, he said "I had no role in the waiver" and that "Scaled had not applied for a waiver." Scaled did not believe they needed a waiver in that area. His primary interactions with AST were through Michelle Murray, and a few days before the waiver was to be issued she called him to tell him the wavier would be issued. He did not know who wrote the waiver. No one at Scaled helped write the waiver, and it was his understanding the waiver originated within the FAA. He thought he got to see a draft of the waiver a few days before it was issued. He did not have any concerns about the language in the waiver since "it did not affect anything we were doing."

The language in the waiver relieved Scaled from conducting hazard analysis in two areas required by 437.55; human and software error. Scaled believed the hazard analysis they performed already covered those areas. Scaled spent a lot of time focusing on human error and software error in the program. When asked about the mitigation of using WhiteKnightTwo (WK2) discussed in the waiver and whether WK2 was actually used as an additional chase airplane on the accident flight, he said they had used it as a chase airplane. He went back and

looked at their original permit application to see if there was language that discussed the use of chase airplanes, and he could not find any representation about chase airplanes. In the context of the waiver, the FAA never came to Scaled to ask them if they were using two chase airplanes. Regarding the simulator being run at 1.4 times speed, he said that they did "sometimes" run it at 1.4 times. The application stated that they would sometimes run it at 1.4. Asked when the last time he knew the simulator to be run at 1.4 times speed, he could not specifically recall. He did not believe they did that leading up to PF04, at least not when he was the flight test project engineer.

He was only involved in the development of the pilot procedures to ensure they were updated frequently. He was not involved in the content of the procedures. During simulator sessions, the Director of Flight Operations, pilots and flight test engineers could decide to update procedures. There were updated procedures between PF03 and PF04, but he would have to go back and verify what they were.

There were procedural changes for PF04 related to the new rocket motor, and they had to do with the new (b) (4) system. There was a rocket motor model for the simulator that was updated based on the most current data. He did not know when that was last updated. The rocket motor modeled in the simulator did model the rocket motor flown on the accident flight, he just did not know when that was last updated. He did not know the details or specifics of the updates. Scaled pilots did not ask him about the differences in the new rocket motor for either training or the actual boost flight. He was not involved in the 0.8Mach callout, or the feather unlock procedure.

He knew that the feather locks were scheduled to be unlocked around 1.4Mach, and there was some margin built around that number as far as the forces on the feather system, and there was a 1.5Mach caution if the feathers were not unlocked. The history of the forces involved on the feather system went back to SpaceShipOne (SS1). There were documents submitted to the NTSB that showed briefings regarding the aerodynamic forces trying to open the feather system were greater than the forces trying to close them. That information was used in the design of the feather system and used in the requirements for the locks. It was well known and briefed in the FRRs. Test pilots were included in those discussions, and at least one pilot was a board member on the flight readiness review. They were required to attend and to sign off on the FRR. He did not recall who the pilot was for the FRR leading up to PF04.

He did not know if Scaled participated in data entry in the FAA/NASA Flight Test Safety Database. He did not know what that database was.

When asked if Scaled factored in pilot error in its hazard analysis, he said yes, in two ways; in their fault trees and in the methodology section of the hazard analysis, they discussed the means

of reducing human error through training and procedures, and the simulator, training and procedures.

When asked for an example of a fault tree that included pilot error, he could not recall a specific function number or specific fault tree. In general, there would be a case where a pilot would be involved in responding to an action, and the probability of that pilot's action being correct would be estimated based on the workload. Different numbers were used for different workloads. None of the fault trees began with the pilot error leading to subsequent errors. The analytical tools they used started with a functional hazard assessment (FHA), and they started with the functions of the airplane and thought of all the ways that "function could fail to provide the function." For hazards considered catastrophic, a fault tree analysis was done with all the hazards that could lead to that particular hazard to assert itself. That included human error, software error, human components and so forth. They were all treated the same way.

Scaled did not make a formal response to the waiver. They certainly did not change anything they were doing. They recognized that there was a waiver and continued about their business. Scaled did not view any of the things identified in the supplemental portion of the waiver as "requirements" on their own. Scaled viewed them as things the FAA was extracting from the application materials. On the day of the accident, they had two chase airplanes; one was the Extra and the other was WK2. Scaled did not use three chase airplanes, and the FAA inspectors were the ones who ensured regulatory compliance. Scaled did not see the waiver as regulatory in any way, but rather as a way to relieve responsibilities; they did not apply additional responsibilities. Scaled did not believe there was a requirement to use up to three chase aircraft, and it was difficult to find chase aircraft that could do so up to 50,000 feet.

There was a letter from the FAA in May 2014 from Ken Wong concerning the waiver, but it did not purport to actually be a waiver. There was no additional waiver issued that he was aware of.

The pre-application consultation was a mechanism for an applicant and the FAA can resolve issues that could impede the application process, and allowed the FAA to become familiar with the applicant, and allowed the applicant to become familiar with the FAA application process. It was a way to get a lot of those things out of the way before the formal application process began. This began in 2010 for Scaled. He and Niki Dugue worked on the process for Scaled, and on the FAA side they worked with Glenn Rizner, Michelle Murray, Ray Jenkins and other people in AST. It was a 2 year process, so there were a lot of people involved. The hazard analysis was discussed with the FAA. The assumptions in the fault trees were also discussed. He did not recall any disagreements from the FAA during those conversations. The FAA had questions about their methodologies and how they arrived at hazard probabilities, and how their hazard analysis protected the public safety. There were questions on how their analysis reported the likelihood of hazards before mitigations and how systems were being analyzed.

The tools they used were described in the advisory circular (AC) as an acceptable means of compliance. They did a preliminary hazard analysis, and the AC had a 4-step process to follow, and all their steps could be mapped into those steps. The AC stated that the functional hazard assessment tool they used was an acceptable means of compliance. It also cited other aviation references they used, like AC 23.1309 for system safety analysis.

When he referred to "the customer" he was referring to TSC, The Spaceship Company. They started with a functional hazard assessment, and looked at how those functions could fail to be achieved. For certain ones of those that were sufficiently severe, they used fault tree analysis, and those included human error and software error. They used the fault tree analysis to determine the severity of all the causative ways that function could fail as described in the hazard analysis. He was familiar with AC 437.55-1 and had read it several times. They addressed the human errors identified in the AC through the analysis in the fault trees, and also through the hazard analysis where they used more general mitigations like training, simulation and procedures. He could not remember any specific human errors identified in the fault trees. Regarding the hazard analysis capturing a pilot action at the wrong time, he did not know there would be a statement that mirrored the example in the AC. He was not aware if Scaled had used any outside source references for human error modeling.

The hazard analysis included a pilot failure of a task through the fault tree. His belief was that the tools Scaled used met the requirements in the regulation, and was covered in the hazard analysis and their mitigations.

He was involved in the AST inspections prior to the PF04. The inspectors attended simulator sessions and briefings. They inspected pilot and vehicle maintenance records. That started about a week before launch. He never saw the FAA's inspection checklist, and only facilitated the FAA in completing their checklist items. He did not know if the waiver items were included in their checklist, and there was nothing in Scaled's checklists related specifically to the waiver. In his role as FTPE, he just made sure that the Director of Flight Operations said the crew was ready. He could not recall if there were any details regarding 460 in the pre-application process.

He did not know the chase airplane they used for PF01. For the permit part of the application, there was a series of 460 requirements that needed to be ensured were complete. His role was to verify that those things had been done. For PF04, the timeline was based on completion of those requirements. He did not recall the specifics of the delay due to the nitrous temperature or DAU issue.

For the simulator sessions, they would have a briefing prior to the simulation covering checklists, simulator status, and general areas. They would then debrief after the simulator sessions. For use of the 1.4 simulator speed, he could not recall what phase that would occur in.

He was the project engineer on another airplane. He was appointed in 2012 and had conducted 166 test flights and 400 hours on that airplane. An experimental permit was to conduct testing on a new craft, conducting new crew training, and to show compliance to obtain a launch license.

AST never "tolled" their application, and Scaled never asked for one. Early in the process, they delivered to AST a draft of their application. There were questions and answers covering a variety of issues including containment area, and part 460. He did not recall the FAA telling Scaled there were unresolved issues during that process.

In their terms and conditions, Order A covered basic conditions Scaled was allowed to exercise their permit like safety zones, pilot flying etc. Order B was a financial aspect that required them to carry insurance. The terms and conditions did not mention the waiver. The terms and conditions changed after the 1st application and the 1st renewal, and then they basically stayed the same. Scaled had renewed their permit twice, and there were three modifications, two of which were concurrent with the renewals. There were a lot of questions from the FAA for the 1st renewal, as with the 2nd renewal. There was no expressions from AST of deficiencies.

Scaled did not have any input into the AST waiver process at all.

The goal of the hazard analysis as required by the regulation was to protect public health, safety and property. The hazard analysis process focused on the safety of the vehicle and the safety of the crew, based on their background as an aviation company.

When a fault tree was initially created, Scaled would use a conservative number, 1/1000, for the components in the system. That number was picked because it represented the worse that could be imagined. By using the conservative number, if the system met that criteria it would be considered "robust" and it did not rely on the failure probabilities of the things you were analyzing. If the system met the requirements, you were done. Otherwise you would look further at the system and redo the analysis. Scaled used a database of components, and matched as closely to the component on the SS2 and used that probability number.

The Scaled fault tree analysis had software error in it, and the body of the hazard analysis described how the software was developed and the mitigations used. The rocket motor controller was a safety critical item on the vehicle. The fault tree analysis showed the rocket motor controller software as a point of failure.

Scaled considered structure as safety critical. They had a separate means to analyze a structure different than a system. In the AC 23.1309, it described the techniques to identify what was structure and what was a system. That AC was also mentioned as guidance in AC 437.55-1.

Scaled cooperated with AST. There was never a timeline given to him to answer AST questions by AST, though during the application process they had a week goal to answer AST questions. Most of the questions from AST came either as formal written questions or during technical interchange sessions, which were essentially free-form information exchanges. Those meetings were on a weekly or bi-weekly basis. Technical meetings were topic specific and scheduled with AST. Scaled provided formal written answers to the formal written questions. He was not aware of any issues not resolved or heard of questions posed to Scaled from AST that were filtered.

In his opinion, all piloted vehicles had human error as a single point failure. The tools they used for a specific scenario with a human action applied probabilities to the action. Challenge-response protocol was not a risk elimination means.

He never worked as a flight test engineer prior to Scaled. He came to Scaled in November of 2009.

During the initial application process they received 25 question packages from AST. He did not know the exact number for the renewals, but it was not as many.

He thought the pre-application process worked well, and had no recommendations for improvements.

His role differed depending on the project. On Tier1B, he was new to the role. As a flight test project engineer for Tier1B, he focused on "all the stuff that had to get done, got done." He conducted flight test planning meetings to discuss contents for the flight test card. He recalled that they held a flight test planning meeting for PF04, and did not recall a discussion of why the feathers would be unlocked.

When asked about his physical reaction, in the control room for the accident, he heard the unlock call being made, then saw the feather begin to move, and knew the outcome would not be good.

He did not recall the details of the fault tree for the uncommanded feathering. He recalled a note gate that said "feathers are unlocked" and the intent was that the feathers had been unlocked on schedule during the boost phase. It did not mention specifically during the transonic region, and that was based on the assumption that the feathers were already locked, and did not consider an unintentional unlocking of the feathers. It was always known that you did not unlock the feathers during transonic.

He said the best thing to say about the fault tree was that it was incomplete, and there were other fault trees that were similar. Part of the fault tree should consider flight phase after 1.4Mach, and another that should consider transonic. When asked if he had any mitigation recommendations for the early unlocking of the feathers, he said it was an interesting discussion since, early in the glide flight program, they had a situation that required the pilot to unlock early to recover the vehicle. It was something that should be looked at, but he was worried about the consequences of any mitigations.

He was part of most of the simulator sessions for PF04. The transonic unlocking of the feather system in the simulator was not modeled, and it never happened in any simulator sessions he attended.

He thought they had a cordial working relationship with the FAA.

The unlocking of the feather system was derived from the SS1 program. The issue of the transonic region was discussed in meetings, and was covered in the POH (pilot operating handbook), Emergency Procedures (Eps), Normal Procedures (NPs), and Cards. There was also the normal expectation that pilots would be very familiar with the vehicle, and would discuss these things with other pilots.
He did not remember who came in to do safety inspections prior to PF04. It used to be Dave Gerlach.

A single point failure would be a failure that alone would cause an outcome. When asked if there was time to recover from an action, would that action be considered a single point failure, he said he would have to think about that.

He thought the POH said something in the EP section about feathering above 200KEAS could be catastrophic.

His percentage of time he worked on Tier1B would vary based on the various projects he had. If they were between powered flights, the majority of his time would be on other projects not related to Tier1B. Over the course of the past year, his workload varied a lot.

He did not recall any discussion about changing the waiver. The letter from Ken Wong in May 2014 he received from the FAA simply said there was a waiver, but the letter did not purport to be a waiver, so they did not make any interpretation of the letter at all. There was an October 2014 letter addressing the modification.

The interview concluded at 1135.

21.0 Interview: Michelle Murray, AST 500 Deputy Division Manager, (FAA)

Date: January 28, 2015
Location: Mojave Airport offices
Time: 1510 PST
Present: David Lawrence, Katherine Wilson, Michael Hauf, Lorenda Ward – National Transportation Safety Board (NTSB); Brett Vance, Christy Helgeson (via phone) – Federal Aviation Administration (FAA); Michael Masucci – Virgin Galactic (VG); Nicolette Dugue – Scaled Composites (SC)

Ms. Murray was represented by Mr. Brad Preamble, FAA General Counsel.

During the interview, Ms. Murray stated the following:

Her full name was Michelle Suzanne Murray. She was a supervisory aerospace engineer at the FAA and also the deputy division manager of AST 500, Operations Integrations Division. Prior to the FAA, she worked for Lockheed Martin at NASA's Goddard Space Flight Center in flight operations and then flight dynamics. She was first a subsystem engineer and then a flight dynamics engineer. In 2001, the FAA did a massive hiring to expand AST from 30 to 60 people which was when she was hired. She had worked in every division or with every division and held most job titles in AST. She was working in AST 100 when AST 500 was created. In 2009, she came to California to establish a field office in Mojave.

The reason the Mojave field office was started was because Dr. Nield, the AST Associate Administrator, wanted to have "eyes and ears" on the ground, wanted to build better relationships with the companies in the area, and wanted someone who could learn about the operations and translate back to headquarters; to be the interface between the companies and the engineers back in Washington, DC. At the time she was working as a technical advisor to Dr. Nield.

Her roles and responsibilities as deputy division manager included managerial responsibilities such as budget and timecards, and before she became the deputy manager she was the liaison to many companies. When she became the division manager, she offloaded all of her cases except Scaled and Space-X. In her current role with Scaled, she was interfacing with the company, building a relationship, and facilitating communication, from the time when a company starts with an idea of what they want to do, to the pre-application consultation, to the evaluation and operations; throughout the lifecycle of a project they have one point of contact.

Asked who she was a liaison to at the FAA, she said she interfaced with all of AST; it depended on the phase. She put out a weekly activity report from her division so that headquarters knew what was going on with the companies in her area. Her supervisor was Glenn Rizner.

On the day of the accident, she was in the auxiliary control room, also referred to as the VIP control room, directly downstairs from the main control room. Her role was to support the safety inspectors if they had questions and to provide real time inside information to Headquarters. She

has an open phone line with Headquarters and provided real time updates to Glenn Rizner. Safety inspectors had a separate means of communication to Headquarters and would contact the duty officer.

In the auxiliary room, they had access to cameras, telemetry, mission frequencies, and hot mics. She was watching the boom camera and arrived around takeoff. She did work on her laptop until about 10 minutes before release and then started observing. It was a clean release, the rocket motor started, and it was a good ignition. About 8 seconds after release, she saw the feather start feathering and then they lost telemetry. She reported back to Headquarters that they had an uncommanded feather. She went outside and saw the large cloud of nitrous. She told Headquarters that she did not think it was an explosion but thought they lost the vehicle. She had been to all boost flights and all glide flights except for two of the glide flights.

During glide flights she would watch from the base of the tower, the main control room, or the auxiliary control room.

Inspectors were monitoring compliance with experimental permit laws and regulations. She was also a credentialed safety inspector but was not working in that capacity. Asked what a safety inspector would do if a noncompliance was observed, she said the goal of the inspector was to recognize a noncompliance before it occurred and alert the operator before they were noncompliant. Asked if Scaled had been noncompliant and was notified prior to being noncompliant, she did not recall but said the most typical noncompliance happened when the public encroached into an area they should not be in when there were hazardous operations on the ground.

She was not aware of any noncompliance issues with PF04. She did not recall the number of chase planes used by Scaled on the day of the accident. The experimental permit application and experimental permit did not specify chase planes. She believed Scaled used the Extra 300 as a chase plane on the day of the accident. Use of chase planes was mentioned in the waiver but she did not know why because it was not mentioned anywhere else in the application. She was not involved in writing the waiver so she did not know why it was there.

She did not recall the dates she observed the simulator sessions and did not recall if the simulator was run at 1.4 times the speed during her observations. Her recollection was that it was run in real time. To her knowledge, Scaled pilots were not trained in the centrifuge. The simulations blended together for her but she believed she observed some for PF02 and PF03. She did not recall if they used the 0.8 mach call out during the simulator sessions she observed for PF02 and PF03.

When AST observed dress rehearsals and simulations, they made sure the operator was complying with the permit such as introducing anomalies. She would be in the control room when observing the simulator sessions, at the back table that did not have a console. She would observe when the inspectors could not be at the simulator sessions to observe.

She clarified that every inspection performed by AST was optional, including the day of the launch. AST personnel could perform an inspection but they did not have to. Inspections were

not mandatory. For the safety inspection plans, an inspector would be assigned to the evaluation team, for Scaled it was David Gerlach, and the inspector was required to develop the inspection plan through the course of the evaluation. It was AST's policy to inspect every launch but not required per the regulations. She could not speculate how AST 400 would know whether a company was meeting compliance if there were no required inspections, and further stated that regulatory requirements was on the company and not the FAA. The only requirement was that the operator must give facility and data access to the FAA.

Right now they observed every launch and it was imagined that a day would come when there would be so many launches that they would go to a regime where they were not inspecting every launch. There was no plan yet for how compliance would be determined if they could not observe a launch.

She had not seen the safety inspection report that occurred after PF04. The safety inspection plan had not been shared with her either.

She thought she was with one of the inspectors who did the inspection for an earlier powered flight, PF01 or PF02. She recalled that they sat in a conference room with Pete Siebold and projected online databases of their flight records and other records onto a screen.

AST 300, the rulemaking and analysis division was responsible for rulemaking and developing advisory materials and technical analysis in flight safety analysis, system safety analysis, and maximum probable loss analysis. AST 400 was purely safety inspection and all members of that group were safety inspectors who focused on mishap, enforcement and range partnerships. AST 500 was operations integration, and was responsible for government partnerships, pre-application consultation and project integration.

Regarding the Scaled project, she mostly communicated with the team lead who was in AST 200. Most interaction was through the team lead and if someone on his team, which included AST 300 personnel, needed to have a technical interchange meeting with Scaled, she would set that up and AST 300 would be on the telecon. She did not have direct interaction with AST 300. Information was filtered to the AST 200 team lead. Asked about what information was filtered to the team lead, she clarified that all information she received was sent to the team lead.

The team lead held weekly meetings to gather requests for information from the team. This was done because Scaled asked that all questions and requests for information were put in writing. The team lead would gather the questions, management would review the document, and then she or Ray Jenkins would send it directly to the company.

Asked why technical staff could not contact a company directly, she said AST received feedback from the industry that it was a drain on their resources and created a burden to have large number of engineers calling the company directly.

Frequently, after AST sends questions to Scaled, they would have a technical interchange meeting involving FAA and Scaled engineers to provide clarification and discussions.

Regarding why management reviewed the questions going to Scaled, she said the AST 300 manager and licensing manager needed to review the request from their staff, and depending on the phase, whether it was the initial permit or modification, some upper level management were involved as well.

Asked if questions from AST 300 technical staff were every changed or altered before being sent to Scaled, she had seen redlined versions of the request go back and forth between different managers trying to make sure the questions were clear and relevant to public safety. If a question was not relevant to public safety, it would be redlined. A redlined item meant that the item was deleted; that happened frequently.

Occasionally she would sit in on the team lead's weekly meetings and there would be complaints from the AST 300 technical staff doing the evaluations. She could not recall the specific complaints but it was generally about not having enough information or the right information. To address those concerns, the licensing manager was also typically in those meetings and would talk to the team. Asked how else concerns were addressed, she said Ken Wong would be in the licensing team meetings. Also management from AST 200 and 300 were on the distribution list for documents that were redlined and it was their responsibility to discuss that with their staff.

She kept up with what happened at Headquarters and learned that during the Scaled renewal process, different analysts reviewed the renewal and found some items were not meeting the requirements. AST 300 was going to recommend to AST 200 that they needed a waiver or the application needed to be updated to address those items. She facilitated a teleconference between Scaled, AST 300, the team lead and Michael Kelly (the chief engineer). They discussed the different areas that were deficient or not and Scaled gave an explanation for each one. At the end of the call, Headquarters staff said they would think about the information provided. Her role was to facilitate that call. This call was with the first renewal of the application and focused on the hazard analysis. Scaled believed it met the intent of the requirements except one, whether or not they assessed the risk prior to mitigation. They said they had but it was not in the application.

Michael Kelly and Sabrina wrote the waiver. She said the FAA always wrote waivers. The applicant would apply for the waiver but did not write them. Scaled did not apply for the waiver explicitly. The FAA had issued waivers in the past. If the application did not meet the requirements, AGC had said in the past that that was an implicit application for a waiver. Everything was done case by case. She did not agree with AGC issuing a waiver without the applicant applying it because it was cleaner when the applicant applied for the waiver because they would clearly lay out what they want waived and the justification. She had told this to "many people" in AST after the Scaled waiver was issued but could not recall to who specifically. She said having applicants apply for a waiver was "our standard course of business."

She thought she remembered a letter from Ken Wong stating that the waiver was still in effect with the renewal. She was not familiar with a letter that waived Scaled from all of 437.55 hazard analysis.

Bob Withrow and Nicolette Dugue from Scaled were on the call previously discussed about the waiver.

Asked if safety inspection plans were required, she said procedure #8 required a safety inspection plan for an inspection.

The office policy was that inspectors would inspect every launch, but if there was a circumstance where the inspector could not make a launch the launch would go on; they did not have to wait for the safety inspector to show up. The reason the FAA had inspectors was to monitor operations, dress rehearsals, readiness reviews, and post flight reviews. For other projects they would do inspections of ordinance installation. She reiterated that no inspections were required.

Scaled was required to abide by the permit, the representations in their application and the law, but she was not sure if Scaled was required to comply with the waiver.

Asked if she was a part of the discussion of what information would be requested from Scaled, she said she mostly facilitated it but the management team would often ask for her opinion, mostly to make sure that the terminology used made sense. The purpose of the management review was to make sure the questions were clear, concise and relevant to public safety.

AST 500 was created 2-3 years ago.

She began interacting with Scaled when she moved to the area in September 2009. At that time she interfaced with Nicolette Dugue who walked her through the operations of the spaceship and its systems. Ms. Murray discussed the regulations with Ms. Dugue. The goal of the pre-application consultation was to educate and teach an applicant about the regulations. Ms. Murray said the most effective time that they could affect safety was during the design. After some time, Bob Withrow became the Scaled liaison.

Her office received the Scaled draft application material that she sent to Headquarters. It was the same team under Ray Jenkins that did the pre-application consultation work. They would review the application and get comments back to her and then she would get the comments to Scaled so they could implement changes for the next draft.

She did not recall directly interacting with the AST 300 engineer evaluating the application.

She was not aware of any human factors experts working on the application or pre-application.

She was aware of the contract with Terry Hardy to review the hazard analysis but did not recall what it said. She did not know if the findings of the whitepaper created by Mr. Hardy were shared with Scaled.

During the renewal process, AST did not ask Scaled to modify their hazard analysis to address the issues.

Without going back to her email, she could not think of any specific examples of what was redlined in the information requests sent to Scaled. Asked how they determined what items were not relevant to public safety, she said things that could only manifest themselves when the vehicle was over an unpopulated area would not be a public safety concern.

Asked if she remembered anything from the pre-application that could affect safety, she thought maybe from the mission planning side and where they were going to operate. What she meant was with hazard analysis, once that was completed and the design was finished, if a hazard was found that was unacceptable and a safety could not be designed in, there would only be less effective mitigation measures likes procedures, training, and things that were less effective than designing safety in from the beginning.

She did not recall any issues identified related to human error.

She gave an example of not opening the microwave when it was running. It was more effective to put a lockout mechanism on the microwave so it could not be open rather than a sign on it that said do not open while running or training people because people make mistakes.

Her recollection was as they went through the hazard analysis all of the hazards that involved a pilot action had human error embedded in the fault trees. The hazard analysis performed was a functional hazard analysis rather than a subsystem hazard analysis. Hazards were broken down by function so there was no hazard for a human making an error. If a function was performed with a human action, in the fault tree when determining how that fault could happen, there was a reliability number put in that tree for that human error for that action. She believed it was done for all human actions but did not recall the feather system specifically.

Asked if she thought the waiver was needed, she said the FAA issued the waiver to Scaled because it was needed. The FAA issued a waiver when regulations were not being met.

She clarified that she did not think that training was less effective as a mitigation to human error, but said she was speaking generally for any hazard. There was a hierarchy of effectiveness that was standard for hazard analysis, and training and procedures were at the bottom for any type of hazard.

She did not think the Scaled waiver was needed because she thought Scaled adequately showed that the public would be safe. She thought the waiver summarized that, and with mitigations like training and others that the public would be safe.

AST 500 was not involved in the evaluation.

The weekly meetings held by the team lead were standard but the lead did not have to wait for these meetings to gather or send out questions or requests for information to management for review before being sent to the company. If the request was sent to her, she would ask if it had been vetted through management before sending. Consolidating the questions for the applicant did slow down the process a bit but it did facilitate more effective communication.

It was known that Scaled did not think they needed a waiver and probably would not apply for it, but she believed the AGC decided a waiver was needed and wrote it.

The week of the SS2 launch, AST 500 continually kept in touch with the launch operator to understand schedule updates or delays, reasons for that, and relay that information to inspectors. They also attended any readiness briefings, Spaceport and Scaled briefings for emergency response coordination, and any dress rehearsals before inspectors arrived. On the day of the launch, AST 500 would observe the activities. One member of the staff would attend the morning briefing and the post flight briefing. For the first three powered flights and many of the glide flights, she would attend the morning briefing. PF04 was the first powered flight where she did not attend the morning briefing.

She had not seen the safety inspection plan to know what was included.

Ms. Murray was asked what the procedure was if an inspector saw something amiss on the day of a launch. Launch operators were always asked to sit next to the safety official. If there was no safety official required per the permit, they wanted to know who to talk to in case there was a problem and they would relay it to that person. An example of a problem would be public encroaching upon a cordoned off area. They saw those things frequently. They would give the operator a heads up but they were usually aware and taking actions to move people out of the area. They tried to identify something early so it did not become a compliance issue. On launch day, the inspectors were primarily observing for compliance issues.

During the simulator sessions she observed, she never felt that Scaled was doing something she was not comfortable with or being rushed to complete something.

Regarding whether companies did a total hazard analysis versus a subset analysis for public safety, she said in many operators' cases, AST wanted to make sure hazard analysis was something the operators were using and living by. The operator would do a mission assurance analysis and public safety analysis together because they only wanted to do it once. AST would encourage the operator to just give them that joint analysis and then would identify which hazards were public safety related. If the operator only did an analysis for public safety, it would "likely just sit on a shelf." AST wanted to get the whole living document that they were actually using and then identify which hazards within that were public safety related.

AST had worked really closely with Virgin Galactic to iron out all the issues related to their application for the license and as far as she knew all the issues had been addressed.

AST had the authority to suspend or revoke a license or permit. She did not believe the safety inspectors had that authority delegated to them so they would have to go to Headquarters to get a letter to revoke or suspend a permit. Whether they could do that in a timely manner to stop a launch the same day, she did not know because AST had not done that. When timing was going to be an issue, AST could delegate that authority to the inspector.

The analyst at the time of the original application felt that the requirements were being met which was why a waiver was not originally issued.

She did not recall if Scaled knew that the call previously discussed regarding deficiencies in Scaled's renewal application was a direct rebuttal to a waiver coming up.

She had formal training in system safety analysis, specifically courses in system safety and advanced systems safety as well as on the job training with evaluations of other licenses. She did not recall when she took those courses.

Her opinion about the effectiveness of communication between AST and Scaled was that most people she heard complain about communication were people asking a lot of questions not relevant to public safety. AST's goal was to have efficient communication between the applicant and the FAA. The applicant requested that requests be put into writing and AST did that. She thought there was effective communication between Scaled and the FAA but less effective communication within AST.

Her perception of how much interaction the team lead had with Scaled was that they had biweekly telecons with herself, the team lead, and Bob Withrow; so she did not agree that communications with Scaled was not good. Most email traffic would go through her with the team lead being copied.

Ms. Murray was asked if she understood her roles and responsibilities when working in different roles throughout AST; for AST 100 and 300 she said yes. She was never in AST 200 but she was assigned to be a license team lead even though she was not in that division and was essentially working for that manager. She was also currently a credentialed safety inspector but was not in AST 400. When AST 500 was established there were certain roles and responsibilities that were made very clear but there were also some flexibilities allowed because it was the newest division and they wanted to let it evolve. In terms of her roles and responsibilities with Scaled Composites, Dr. Nield made it clear that this was her role based on feedback received from the SpaceShipOne project and since then. That protocol had worked and they put it in place at other companies based on similar feedback and were seeing improvements based on that. An example of an improvement was that one company recently called and complained that they had 5-6 different people from AST calling them. They put one point of contact in place and the company was much happier.

She thought some AST 300 analysts had a very clear idea of their roles and responsibilities when they reviewed applications and did an evaluation. Other analysts were used to work they did elsewhere where they were concerned about mission assurance.

She only saw requests come from the team lead because the permit team had a representative from each AST divisions so when AST 300 analysts had a request they would give it to the team lead and then it would come to her. The process of requests being made by representatives on the team was not well documented but the questions needed to be in writing. The questions would go to the team lead who would give them to her to vet them with management. Either she or Ray Jenkins, copying the other on the email, could send the questions to Scaled once it was cleared through the chief engineer and AST 200 and 300 managers.

Once the questions were sent to Scaled they would typically hold a telecon with Scaled to discuss the questions and the essence of the answers. Once the AST 300 and Scaled engineers were talking to each other, if they understood the answers then Scaled would put the answers in writing. The answers would come to either she or Ray Jenkins and Mr. Jenkins was responsible for distributing that to his team.

Almost every question set sent to Scaled was followed up with a telecon where the engineers talked to each other. That was part of the standard way they were operating with Scaled. Engineers were not allowed to just pick up the phone and call Scaled. They set up a more structured regime where the engineers would submit questions that would be vetted by management, the questions would be sent to Scaled and then a telecon would be set up the day or two after. Scaled wanted the questions ahead of time so they could have the right engineers in the room. After the telecon, Scaled would put the answers in writing and send them to herself and Ray Jenkins. She would listen in on the calls. She did not recall an engineer saying they were not getting an answer to the question that they wanted. She then remembered that at least once where someone said something like that and Bob Withrow said he was happy to answer questions that were not related to public safety verbally but not as a part of the application.

She did not recall a question wanting to be asked that was related to public safety but was onerous in nature and could not be asked of the applicant.

The safety inspector would have to go to Ken Wong who could delegate authority to suspend or revoke a permit.

On the day of the launch, in the VIP control room from the FAA was herself and Sherman Council. The room also had lots of other people; she thought there were some badged guests also but did not recall who they were.

She confirmed that she was on phone with Glenn Rizner in real time. Inspectors did not have an open phone line with Headquarters. They were instant messaging because that created timestamps.

Glenn Rizner was manager of AST 500 and she was his deputy.

There was one official chain of communications during a launch from the safety inspector to the duty officer to the AST 400 manager who then notified AST 1 and 2 when things happened. There were a lot of people located around the field sites who lived and worked in the area and knew the operations very well, and frequently when there were questions, senior management would call the field operations people for information. So they were always trying to stay abreast and aware of the operations because senior management would contact them with questions. To summarize, there was not an official notification requirement, but AST 1 and 2 knew that those in the field were fully informed aware of the status of launches and would come to them for information when they did not hear information from other divisions because the official chain took some time. This had happened in the past but it was not the official chain of communication. They did not want to interrupt a safety inspection in progress so senior management would call or email the field operations person. She thought that process could be

improved and her recommendation was to have one AST 400 and one AST 500 person in the control room so that the local representative who knew the operations the best could provide some consistency and support the inspectors to answer their questions about the operation.

She confirmed that AST 500 was the Operations Integration Division. AST 500 had more intimate knowledge than AST 400 of the applicant because AST 500 was collocated with the operations or located near the operation and were working as points of contacts at the company throughout the entire project. There were some collocated inspectors at other operations such as in Florida and at the federal ranges. She was not aware of discussions to have inspectors collocated in the Palmdale/Lancaster area but did think there was a need for inspectors at more active locations.

Her workload was "extraordinary" which to her meant there were not enough hours in the day; her workload was very, very high. The high workload could be attributed to an increase in activity and lack of additional staff. Also AST 500 was split in half to become AST 400 inspectors.

She clarified that the FAA believed that the waiver was needed but she did not because Scaled provided explanations for the areas where AST thought they were deficient. The structures analysis was separate from the hazard analysis, there was a separate software safety assessment, and human error was not a separate analysis but was built in throughout the entire hazard analysis. She thought they met the intent of the regulations similar to the first assessment of the Scaled permit.

Referring back to her microwave example, she did not recall any discussion about the feather locks that came from the evaluators, but said with every lock that was put in place a new hazard could be introduced.

It would be very rare for something so severe to happen where the FAA would want to revoke a permit on launch day. AST personnel on site for a launch could not stop a launch, but they could say that if the operator continued that they would be in violation. If they had the authority delegated to them they could stop the launch. She had had that authority delegated to her when she was the lead safety inspector for SpaceShipOne. This was not the case for SpaceShipTwo and the assumption would be that there would be enough time to contact Headquarters.

The very high workload she discussed was before the accident.

Ms. Murray was asked if there were any questions sent to Scaled that were not answered. She recalled one recent example when an AST propulsion engineer had some additional questions and she believed Scaled pushed back and said the question was not related to public safety. AST took another look and agreed with Scaled. She did not recall any questions being asked that Scaled said was not public safety and AST disagreed. Scaled always answered questions.

When the management team finalized the questions, it was the management's responsibility to talk to their staff. If staff pushed back on items that were redlined, then the manager should have brought it back up for reconsideration.

Definitions were provided in 401.5 but she was not sure if there was a definition of public safety. She thought it might be apparent that it was a member of the public or public property would be encompassed. She would have to check the regulations. She paraphrased how she thought public safety was defined as causing serious harm, injury or death to a member of the public or damage to public property.

She confirmed that she believed that AST General Counsel believed the Scaled waiver was necessary but also said that she was not directly involved.

She hoped that when the NTSB was deliberating for recommendations, that they were meaningful, actionable recommendations that were clear to public safety. She did not have any recommendations to suggest for the investigation at the time of the interview.

The interview concluded at 1700.

22.0 Interview: Ed Springer, Federal Aviation Administration (FAA)
Date: February 12, 2015
Location: via telephone
Time: 1000 EST
Present: David Lawrence, Lorenda Ward (via phone) - National Transportation Safety Board (NTSB); Brett Vance (via phone) – Federal Aviation Administration (FAA); Matt Steinmetze - Scaled Composites; David Mackay – Virgin Galactic.

Representative: Sabrina Jawed, FAA Counsel

During the interview, Mr. Springer stated the following:

His name was Edward Jason Springer IV, and he was 37 years old. His title was Aerospace Engineer, and he was an FAA Safety Inspector in AST 400. His background included work as an engineer with Porsche motor sports in their racing division doing engine research and development. Prior to that, he was involved in a variety of internships. He attended Embry Riddle at Daytona Beach, FL.

During his first tenure with the FAA in 2002, he was in licensing and safety and conducted evaluations and trajectory analysis. He also evaluated applications for licenses and spaceport activities. They did not have permits when he first came onboard with the FAA. There was some formal training with respect to the history of the office and process of the office, using videos and training modules. AST 200 also did compliance monitoring role, and a senior manager went through the training with them, and he completed that training, which was ongoing for about a year and a half before he received his certificate of completion of training. AST 200 did the inspections back then, and some of the training included monitoring launches and site visits before actually conducting compliance monitoring. The compliance monitors back then came out of the licensing division.

He left the FAA to pursue opportunities at Cape Canaveral to do more operational work with launches. He did that for about 2 and a half years, and then went into the industry for a while on a support contract with Space Florida and with NASA on their Constellation program. He originally left the FAA in 2006, went to the Air Force 2006, left the Air Force in 2008, was in industry until 2010, then he returned to the FAA in 2010.

His immediate supervisor in AST was Mark Wright. When he came back to AST and was a safety inspector, he went through a qualification matrix to become a credentialed inspector. It involved academic and operational training, moving from an assistant duty officer to a lead duty officer. It was not an onsite role, but eventually he moved to an inspector position, and based on his Air Force training and previous training, and that was leveraged for meeting his qualifications.

He said they used the term "certified" to describe compliance monitors early in the program to indicate they received a certificate of completion. As a safety inspector, they were credentialed, and they do have credentials similar to the airlines. It was a more formalized and authoritative role. It involved completing all the items in his qualification matrix. He was not sure what FAA order the credentialing of safety inspectors fell under.

As a safety inspector, he performed compliance monitoring and ensured the operation was conducted in accordance with the CFRs and the representations made in the application were adhered to. There was a CFR that said a licensee or permittee would allow for compliance monitoring activities. There was no regulation that said they had to be there or the operations could not continue. They did not have a go/no-go call; they had a compliance monitoring call. There was no violation of a CFR for the inspector not to be there. They levy on the permittee or licensee to meet the requirements. He said it was comparable to driving a car, where you do not have a police officer sitting in your car all the time to make sure you are following the rules, but you see them occasionally while you are driving. If they saw a non-compliance issue during a launch, he would contact the operator's FAA point of contact that there was an observed violation of the permit to talk about.

On the launch day for the accident flight, he was in the control room. He had a computer that did not have telemetry information but had a live chat up with his duty officer. He had the computer to also reference the permit. He monitored the data from the screen projections in the control room. His primary role was monitoring compliance. If he saw something that needed to be handled real time, he would drop his role communicating with the duty officer and handle the issue. Milestones of the activities were funneled to the duty officer. He did not notice any non-compliance issues with the launch.

He was familiar with the waiver Scaled was operating under. He was aware of some of the mitigations outlined in the waiver. Regarding the waiver mitigation that said Scaled used multiple chase airplanes, he was aware of it, and Scaled had two chase airplanes on the day of the launch: the Extra and the WhiteKnightTwo (WK2). His understanding was it said they would use two chase airplanes, and WK2 was a "tertiary" option.

He did not recall the mitigation that talked about the simulator being run at 1.4 times speed. He did not recall observing the simulator being run at 1.4 times speed, and was not aware of it.

The inspection for PF04 had Jeff Claxton as the lead inspector, and he inspected the simulations. On the day before the accident, he attended the flight readiness review and he participated in the pilot records inspection. They reviewed the informed risk letters and medical records of the pilots. He also helped inspect both vehicles. For the records review, Scaled pulled up an access to their internal files on a display that showed scans of their records. Scaled stated their flight hours, but they did not see the actual logs of those flights.

He was familiar with the pilot qualifications for an AST flight. They had to be an IFR pilot, and must have endorsements on their certificates, along with a medical certificate. There was a certain endorsement they had to have that involved an experimental endorsement. When asked if they were required to have currency under Part 61.58 and 61.55, he said "I'm not familiar with the airline side of the regs." There were currency requirements, but he would have to look that up. The WhiteKnightTwo pilots had similar requirements since they were part of the launch system. The endorsement used to be in the form of a letter, but now was part of their actual license.

The simulations he observed were integrated simulations for PF02. He observed from the control center, and there was video of the cockpit that was display.

He did not recall ever seeing a pilot unlock the feathers during the transonic region. His familiarity of the unlocking of the feathers came from the reports he was made aware of after the accident. He did not recall if he ever heard the pilots make a 0.8M call out during his observations.

He said on the launch side, he had worked over 150 launches. On the permit side, the PF04 was his second launch to inspect.

Based on his experience, he could not think of any recommendations to improve his job. They had the regulations, and that was what they inspected to. For an inspection, prior to each launch activity, they had an inspection plan. It identified all the areas they wanted to inspect. When the inspection was complete, they kept the inspection plan as reference. They had individual reports for the main topics of each inspection. Those reports were sent to their inspection manager for review and then filed in their records. If there were issues with the inspection, they discussed it during their "hot-wash" debrief, and talked about everything that was covered in the inspection plan, including any anomalies that arose from the inspection. For the inspection plan, he could not recall if it included a review of the items identified in a waiver. There was an area in the plan to cover non-compliance issues. He could not recall if that was reviewed on PF04, and did not know why it was not included.

He said he was familiar with the terms and conditions defined by Scaled's permit, and reviewed them prior to the operation. He recalled the wavier identified non-compliance areas, and Scaled said what they were going to do with mitigations to meet the intent of the regulation.

When asked if he knew about the unlocking of the feathers during the simulator sessions, he said he did not inspect any of the simulator sessions for PF04. For PF02, he was there for one and a half sims, and did not remember the details or those sims.

The inspection plan used particulars from the permit requirements to look for compliance items. All the items in the plan were requirement based and all traced to a requirement from the permit. There were some general recurring items on the inspection plan, like the pilot credentials, and that was carried over to all types of permits. Specifics for compliance to the permit may be more unique.

His day of launch role as an inspector was to establish comms with the duty officer, and checking the permittee as they go through their launch procedures. They looked for anything that fell outside the regulations or permit. The checklist they used was a combination of the items in the inspection plan and what was in their application.

The duty officer was further removed from the operation than the inspector, and they also did not have a go/no-go decision authority. He said "any violation or non-compliance issue during a launch did not necessarily facilitate a cease operations." Enforcement actions and regulations governing them would occur after the launch operation.

He had never seen an enforcement action take place on a launch he worked. They had a pre-inspection checklist as an inspector, and an internal pre-inspection meeting where he reviewed all the issues and non-compliance issues to focus on what needed to be inspector. All the inspectors and managers participated, as sometimes persons from other divisions. They did hold table top exercises about twice a year for possible mishaps.

Inspectors were assigned from credentialed inspectors, and based on availability. He was not aware of any plans to assign inspectors to specific permittees. The duty officer position was staffed from the list of inspectors, and he could be a duty officer.

For delayed launches and for duty days, they did monitor their crew rest and how many hours they were on the clock. That was important within their division. If necessary, they would shift inspectors for delayed launches.

Compliance monitoring involved ensuring compliance with the regulations and presentations made in the permit. Those are what they focused on during their compliance monitoring. It also fell on the permittee to be compliant.

The inspectors created the inspection plan for PF04, and the plan evolved from the previous inspection plans.

He said during some inspections, they may notice trends or issues that may not be violations of the regulations or the permit, but they notice those and may include them in their inspection plans. He said the inspector's role was a critical role for space flight activities. From his experience, inspecting some of the operators, they saw things that may not have been detected if

the inspectors were not there. He said sometimes the risks would change, similar to winds for launch, and the inspector needed to be there to assess those risks.

A permittee must make themselves available for an inspection, but the inspections themselves were not required. It was their policy to conduct the inspections. He did not know if that policy was written or institutionalized anywhere.

Interview concluded at 1110.

23.0 Interview: Sherman Council, Federal Aviation Administration (FAA)
Date: February 12, 2015
Location: via telephone
Time: 1300 EST
Present: David Lawrence, Lorenda Ward (via phone) - National Transportation Safety Board (NTSB); Brett Vance (via phone), Matt Stienmetze - Scaled Composites; David Mackay – Virgin Galactic.

Representative: Sabrina Jawed, FAA Counsel

During the interview, Mr. Council stated the following:

His name was Sherman Council and he was 50 years old. His title was aerospace engineer. He worked for the FAA in AST 500, Operations Integration, and his manager was Glenn Rizner and his deputy manager was Michelle Murray. He had been in AST 500 for about 12 and a half years in November, and prior to working for AST he was employed for 2 years by United Space Alliance in Florida where he was an SRB (solid rocket booster) electrical engineer for the Shuttle program. Prior to that he was with a contractor for the Air Force called Computer Sciences Raytheon from 1987 to 1999. His total time with AST had been in the same division.

His roles and responsibilities within AST 500 included being a part of the pre-application consultation process where the companies contact AST to apply for a license or permit. His role was to coordinate with the applicant initially and provide information and regulatory framework. He also accepted information from the applicant to determine the best regulatory fit for their operation. He worked primarily permits. He worked on the very first AST permit, and had worked on permits for four different companies. He estimated he worked on about the same number of licenses.

AST 500's role was to contact the prospective applicant initially and give them information. They saw the project through from the beginning to the end. They then take a look at the application to determine if it was "complete enough" to begin the 120 day permit clock. They would then bring in the analysis group, AST 300 to get involved to see if the proposed operation met the systems and flight safety requirements. They would receive data from the applicant and conduct independent analysis, and provide direction to the operator. His role was to ensure the communications between the applicant and AST.

Typically, the current practice was if the analysis group had a question, AST 500 took the responsibility of setting up a TIM (technical interchange meeting) which was a phone call to address the concerns verbally. If there was a need to formalize questions, AST 300 would then put their questions together, and they would then get "vetted out" through AST management, including AST 200. AST 500 served as the point of contact to the operator and would deliver the questions to the operator. It sounded long, but usually only took a day.

He said the TIM was an opportunity for AST 300 to discuss what the issues were, and AST 500 would sit in on the TIMs and listen. AST 500 would vet the questions sent to the applicant to make sure they were clear and understood at the management level. AST 500 was "the conduit" and would pass information to the applicant after it had gone through AST management, including the chief engineer.

The vetting process involved first documenting the questions then reviewing them to ensure they were asking the appropriate questions based on the regulations. Management would approve or disapprove that vetting, and AST 500 would be the conduit to get information to the applicant. AST 500 did not vet or alter the information. AST's charter was public safety, and they tried to follow regulations. If a question was not within the regulations or their charter, they would ask the analyst to re-write or re-word their question to the applicant.

He said to the extent they had procedures in AST, they followed those. There was an internal document defining the roles that was distributed to the different divisions, and the division managers were responsible for managing those. Regarding initial application, the expectations were clear with what was expected of the different divisions and what roles they had to insure compliance with the regulations.

On the day of the accident, he was in the break-out VIP room downstairs from the control room with other colleagues from the FAA. His role was to support the inspectors who were on console if they needed anything done while they were on console. He could send a message out to other AST to assist. They were in communication with the duty officer back in DC. He said he was a credentialed safety inspector and had a background with the Scaled operations. There were things that could happen on site that would require his support. He was monitoring displays and parameters of what was being shown on the screen.

He was aware that the waiver existed, but did not have anything to do with the documentation of creation of the waiver. He did not recall the origins of the waiver. He was not an evaluator of the permit. He did not get into the details of what came out from the waiver. He was aware that multiple chase airplanes were used, but did not recall how many there were for PF04.

AST was notified when simulations were going on, but they were not required to be there. Being local, they would try and get out to Scaled to observe. His role during those types of observations was as a liaison. If an AST 400 manager wanted an inspector to observe a simulation "in the seat", that would be coordinated with the AST 500 manager, and then you would have to be a credentialed inspector.

The inspection process is not a regulatory requirement. In particular if it was a new application, or deemed by analysis to be higher risk than others, then they would be onsite. It was a case by case basis. It was an opportunity for the inspectors to gain knowledge about an operator by being there in person. If there was no inspector on site, then it was the responsibility of the operator to comply with the regulations and notify AST of any non-compliance. The inspection process had procedures, and they had a safety inspection plan to document compliance. They attended those inspections based on their internal policies. The operator must allow AST access to their operations, and it did not have to be associated just with a launch activity. For launch specific activities, they inspect based on a safety inspection plan. Being local in California, they would visit Scaled and participate in quarterly meetings to take advantage of the opportunities to view the operations. They typically would notify the operator ahead of time to be "the good government." They had a relationship between the operator and AST 500. The primary mission of AST is to protect the public safety. In parallel with that was to work to have an open relationship with the applicant so the applicant could see that they were trying to work with them, and trying to maintain transparency.

In AST 500, they had procedures internally that defined their jobs. It was not tailored from applicant to applicant.

He was familiar with the permit terms and conditions that were normally added to the permit to make it more complete. He was not aware of any terms and conditions in the waiver.

He did not recall hearing a 0.8 Mach callout during the simulations he sat in on. He was not aware the feather was being unlocked during boost as a part of the normal procedure.

In the control room, they acted as a 2nd 3rd set of eyes, and were not acting as a designated individual credentialed for this mission. He saw what the inspector had available to them. They would share information between each other, and if someone missed something, he might say "did you hear this or that," etc.

Inspectors had the opportunity to come out and sit in on the simulator sessions when they could, and also participated in some technical meetings prior to the launch itself where issues like winds might be brought out, and would be something for them to watch for. As AST engineers, they did not go in as control room experts. They were to follow the letter of the law and to make the operator aware of an issue. Inspectors did not have the authority to make a "knock it off" call.

As an observer in the control room, he was not was not looking for anything in particular during PF04. They normally had multiple AST 400 and AST 500 people attending a launch. Typically, the AST 400 manager assigned an inspector and assistant to come out for a launch. AST 500 would be advised to come out and assist as observers. They would coordinate that between the offices. Being at a launch was an opportunity to learn. There was no requirement for an AST 400 person to be there for a launch.

One of the AST 500 guys could sit in for an AST 400 inspector if it was needed during simulator session, and the information they needed to look for would be coordinated with AST 400. They do not have criteria to measure the success of the simulator. They documented lessons learned

and come to their own conclusions. When they hear things, they documented them as they were stated and passed that to the AST 400 manager. AST 400 inspectors could then use that information for when they were on console for a launch.

He was not in the simulator sessions on October 27-30, 2014. His experience prior to coming to AST was monitoring the electrical components of the SRB, including the integration process of the SRBs.

AST 500 had a support role for mishap response coordination, and the inspectors on site would take on the initial responsibility with mishap coordination for AST. AST 500 was in a support role for the entire process, including providing information back to DC.

He classified his workload as "normal." He was located in California. Managing his workload was a process where he would monitor the applicant's work as an observer or inspector and balance that with the other projects that needed to be managed quarterly.

The main role of AST 500 was during the pre-application consultation process. They made sure the applicant was provided the appropriate information on the process, and served as a liaison to offer up meetings with permittee for their questions. They oversaw the entire process, and it was a partnering with the applicant. Once the application had been reviewed to "complete enough," they would oversee that 120 day application process. Once the permit was issued, they would coordinate the process with the other respective AST divisions. They also acted as the point of contact for meetings between other AST divisions and the operator, and were the "eyes and ears on the ground for AST."

He said they had good communications internally between the divisions. There was a review process within AST for "lessons learned." The most recent presidential budget was favorable to AST. They recognized there was a need for hiring more people to support AST.

The pre-application time period was not part of the 120 day permit application process. For a permit, the vehicle needed to be inspected to get to the "complete enough" point to start the 120 permit clock.

Typically when there was an analysis done, there were opportunities to identify the things they thought needed to be addressed related to regulations. AST 300 analysis team documented that, and then it went to the AST 200 licensing manager, who looked at it and shared it with management team as appropriate, including the chief engineer. There was then a meeting that took place to look at how it related to the permit and regulations. It was partly AST 200, including the management team and the chief engineer who made the decision on what went out to the applicant. AST had a TRB (technical review board) where dissenting views were documented, and management documented what was said.

In the control room, he was patched in to the inspectors through electronic messaging (IM messaging), and could say "we saw this or heard this." Inspectors would pass it on to duty officer, and duty officer would then distribute that to the relevant people, which most of the time was to the analysis team. If something was public safety related and was deemed critical, they

would notify the operator of the non-compliance. They typically did not interfere with the operations, and would notify the person in charge on the console. He did not recall if that was ever practiced by AST.

He was not aware of any non-compliance issues found at Scaled. He was not aware of any pushback from Scaled in his interactions with the company. There was no one in particular he interacted with at Scaled, but he would contact Bob Withrow at Scaled as required.

Interview concluded at 1418.

24.0 Interview: Jeff Claxton, Federal Aviation Administration (FAA)

Date: February 19, 2015
Location: via telephone
Time: 1100 EST
Present: David Lawrence, Katherine Wilson, Lorenda Ward (via phone) - National Transportation Safety Board (NTSB); Brett Vance (via phone) – Federal Aviation Administration (FAA); Matt Stinemetze - Scaled Composites; David Mackay – Virgin Galactic.

Representative: Brad Preamble, FAA Counsel

During the interview, Mr. Claxton stated the following:

His name was Jeffrey Scott Claxton, and he was 54 years old. His title was FAA AST safety inspector. His background included graduating from college in 1989 with an aerospace engineering degree. He worked for 10 years as a mission flight control officer at Vandenberg Air Force Base, 5 years as a flight termination design engineer, and another 10 years as a flight safety analyst which involved doing risk analysis. He went to the FAA in 2012 and became a safety inspector within AST 400. His supervisor was Mark Wright.

Regarding inspections, he ensured an operator was compliant within the terms of their permit or license, and within the terms of the CFRs for their particular mission. To certify as a Commercial Space Transportation Safety Inspectors (CSTI) required intensive class work and knowledge of the CFRs for commercial space launch and reusable launch vehicles. After the coursework was completed, the trainee went into the operations phase and he supported several operations as an assistant safety inspector, then they would have an oral board "training exercise" where other inspectors were there and they presented him with scenarios. He then sat as the lead safety inspector for a mission.

The only permitted operation he did inspections on was SpaceShipTwo (SS2). He had minimal knowledge of the 437 and 460 CFRs prior to coming to the AST. When the FAA was developing the regulations, he was on the group that helped develop the regulations, but only on the periphery, and this was with the Air Force. The FAA used a lot of Air Force and NASA support to develop the regulations.

AST currently had about 9 or 10 safety inspectors. Most of them had multiple permits and licenses that they inspected. He worked on several licenses.

He conducted simulator observations leading up to PF04. He was in the control center monitoring communications of the simulation. The purpose was to verify their training steps and get situational awareness of how their operations were conducted prior to flight.

Scaled had simulator training and aerobatic training. He said that was about it. He did an interview with chief pilot to verify their aerobatic training. For the simulator, he was given a tour to check of the fidelity of the simulator. That occurred 2 days before flight, and he was assisted by Ed Springer. For the simulator, he did not recall if there were any changes made to the displays to the pilots.

He said they were in compliance with the terms of their permit and CFRs for that mission. He wrote up one concern on the mission; the go for flight. They used a thumbs up procedure instead of having the critical stations report on the comm network, and he thought that was a poor practice.

He used the safety inspection plan to conduct the inspection. The Stan/Eval officer for AST 400 developed and maintained safety inspection plans (SIP) for each permitted or licensed mission. The SIP could be tailored for that inspection by the lead safety inspector. It was reviewed by assistant safety inspector, and accepted as the plan going in. That plan was used as a guideline to inspect the activities of SS2. They were tailored to the particular permit or license.

He did not recall a specific time he was made aware of the hazards associated with unlocking the feathers early. He was not really familiar with the Pilot Operating Handbook for SS2, and did not know if the those hazards were identified in the manual. He had never seen the feathers unlocked early during his inspections.

He said the principal waiver involved the hazard analysis. The use of two chase airplanes was written in the waiver, but he could not recall if it was written in the permit. They used "technically two" chase airplanes for PF04. They had the Extra chase aircraft, and the backup was WhiteKnightTwo (WK2). He could not recall if Scaled was operating the simulator at 1.4 times speed.

During his inspections plans, he considered the conditions identified in the waiver by discussing the training and simulations for the mission, and verifying an active chase was up and communications were readable from all aircraft. He did not recall if he looked at the multiple chase airplanes and 1.4 times simulator as part of his inspection of Scaled. Non-compliance issues were part of the Safety Inspection Plan. He did not recall specifics of the PF02 or PF03. For PF04, he did not know of any non-compliance issues.

He did not recall if there was a regulation requiring an inspection on a permittee. He said "I just do what I'm told." Even if he and Ed Springer had not done any inspection on Scaled prior to PF04, Scaled still could have launched SS2.

For each mission, they want to monitor as close as we can all permits and licenses. They made sure corners were not being cut and safety issues were not taking a back seat.

After the inspection, the SIPs were kept in a binder as a reference to write his report. The report was the filed in AST, and available for review for future flights, and action items could be used for an action items spreadsheet to see if the items were getting completed. He was not sure of the specifics of what happened to the reports, but he used them to ensure his actions items were completed.

He was a general aviation pilot with a private pilot licenses. He could not remember what the minimum pilot qualifications were for a permitted launch, and thought they may require an ATP license. Pilot ratings were required as part of his inspection, and he looked at their licenses prior to the launch. He did not recall what the PF04 crew had, but said they were compliant.

The go for launch issue was in the SIP that went to Mark Wright. He also documented that in a letter to Scaled Composites. It was not a non-compliant issue, just a concern, and that was the end of it. For that case, because of the accident people had not had time to address it. For PF02 and PF03, he did not recall specifics about any concerns.

As part of the SIP, when he looked at the fidelity of the simulator, he looked to see how much it mirrored the actual vehicle in function and appearance and placement. It's an experimental one of a kind vehicle, and he had to rely on the pilots to tell him if the simulator was adequate for training, and they indicated that it was. Motion based training would have been nice to have, but what they had was adequate.

He did not recall any changes in the SIP from PF03 to PF04. The SIP was not a generic plan. All of the SIPs were built by the Stan/Eval, and the plan that was used for PF02, 3, and 4 was specifically designed to address the permit and CFRs for SS2. He was in training for PF02 and PF03. For PF02, he observed the inspection, and for PF03 he was the assistant safety inspector, and for PF04 he was the lead inspector. For PF02, he observed Jesse Hanson, and possibly Dave Gerlach. Dave was the lead for PF03.

For the waiver, the safety inspector was responsible for ensuring compliance with the waiver. It was his job to make sure they complied with the mitigations they identified in the waiver. He did not recall if those mitigations were in the safety inspections plan.

He inspected for several ELVs and one reusable return from orbit vehicle. Some inspections could take 2-4 hours. When he was not on site inspecting, there was a lot that he did. He would listen in and gain general knowledge of other operations happening in AST, participate in pre-departure briefings, the "hotwash", and other documentation created by the other inspectors. They conducted training exercises for themselves. They had various documentation reviews, working with the common standards working group that included the USAF, NASA, FAA and others that launched vehicles to mirror their standards and sharpen the standards where they could.

At Scaled, he interacted with Bob Withrow as his point of contact, the Scaled chief pilot, and Mr. Mickey. He did not feel any real strain with the relationship.

He could not stop a launch as an inspector. If he observed a non-compliance issue on launch day, he would notify the launch director that they were operating outside the permit, and if they continued outside the bounds of the permit, time permitting he would work with senior management at FAA headquarters. Once it got to them, it was in their bucket.

He did not recall for any non-compliance issues with any of the powered flights.

The only pushback he got from Scaled was when the FAA was required to have unescorted access, and they often do not get unescorted access, and the badges were sometimes not waiting for them. They often change their schedules without notifying the FAA, and had resulted in one or more missed inspections. Their attitude was generally "ok" and cordial from the people at Scaled they worked with.

He said the waiver "definitely" had terms and conditions, but it was not stated in a regulatory fashion in the waiver documentation. The language talked about how Scaled mitigated. For instance using 2 chase aircraft, but it did not say Scaled must use 2 chase aircraft.

They talked with Scaled in the pre-brief regarding the things they were going to need to see for waiver mitigations. There was an Engineering Readiness review, and management readiness review on the Scaled side where the waiver was discussed and the mitigations were also discussed. He did not recall who attended, but all the chiefs and pertinent players were there for the aircraft groups. He did not recall exactly who was in those meetings.

For the thumbs up procedures, he thought from what he observed, the Test Conductor (TC) did not have a chance to look around the room to see if there was a thumbs down, and he did not understand what the process was for a no-go at that point.

For a non-compliance issue, he would walk over to a position and talk to him, or communicate on the comm net. He could not think of a time he could not do that, for instance during boost. He could not think of an issue that would come up during boost. He would wait for a quiet time to address the issue. He did not have a way to stop an operator. Would make it known to the operator about an issue in the best way possible.

For PF04, there were several vehicle changes on SS2, primarily the rocket motor and electronic upgrades in the cockpit. He did not recall the specifics, but was aware of a lot of upgrades with the vehicle.

Regarding simulator upgrades, he did not see anything related to public safety. He did not recall if there were any cockpit procedures that were changed for PF04.

His role helping the Stan/Eval was to take the SIP that was the standard Scaled SIP and he refitted it for the PF04 specific mission. He did most his work from California on calls and telecoms.

The SIP for PF02 and PF03 were modified with different dates and names, but there were no procedural changes.

No specifics of the mitigations from the waiver were included in the SIP for PF04, but there were items in there that led to checking the waiver issues. He looked at the mitigation issues based on his knowledge from reviewing the waiver and the past missions.

Asked if he would want the authority to stop a launch, he said he had it before in the USAF, and in his opinion he would want that.

For expendable launch vehicles he had been a lead inspector awhile, and for SS2, it had been since the past fall.

He said they were such an emerging field, and the commercial side was ever changing.

The spreadsheet action items were for him and his fellow inspectors and their supervisor. It was just an internal check.

The lead inspector and assistant inspector roles were interchangeable, and the lead set the pace with what was going to be done, and coordinated with assistant and headquarters.

The role changed per inspection. There was no movement to have a specific lead for each permit. They only had 10 people, that there were a lot of things going on, and that would not give them the flexibility to move around since the launch schedules changed daily.

He knew of no plans to hire more inspectors, and characterized his workload as heavy since he was the only inspector based at Vandenberg. They had 3 at the cape and one at Wallops, and they got tied up pretty fast. He could be tasked to help out at other locations, and others could come out to help him.

He thought his training was adequate for the FAA role he was hired into. It had changed as the commercial space had changed.

When he said the training in the simulator was adequate, he had to use the pilots as the subject matter experts, and though motion would be good to have, they said the training was sufficient. He based that on his experience in the field. He did not know of any outside entities that he could go to determine best practices for training of a vehicle like SS2. He did not know if anyone spoke with NASA about their training.

Interview concluded at 1226.

25.0 Interview: Schedir Illoldi, Federal Aviation Administration (FAA)

Date: March 12, 2015
Location: NTSB Offices

Time: 1105 EDT
Present: David Lawrence, Lorenda Ward - National Transportation Safety Board (NTSB); Brett Vance (via phone) – FAA; Matt Stinemetze (via phone) - Scaled Composites; David Mackay (via phone) – Virgin Galactic.

Representative: Brad Preamble, FAA Counsel

During the interview Ms. Illoldi stated the following:

Her name was Schedir Nefertiti Illoldi, and she was 33 years old. Her title was Safety Inspector with the FAA Commercial Space Transportation, AST 400. Her background included a Bachelor's of Science degree in aerospace engineering from Texas A&M, with a graduate degree in international affairs. She interned with the FAA (AST 200) in 2002 while still in school and had done several internships until 2006 when she started at the National Science Foundation as a science assistant. In 2007, she started with the FAA in AST 200 until 2011 when the safety division separated from AST 200 and she moved over to become a full-time safety inspector.

As a safety inspector, she monitored and inspected permits and licenses, and also participated in the license and permit evaluation process looking forward to the inspection. The inspectors were the ones who handled the operations and inspections. The license team used the inspectors to learn more about the operation. She said they were the main POCs for the license evaluation team, and their primary role was to conduct inspections. She said the workload varied. All inspectors were trained to perform any inspection on permittees and licensees. She did about 10 inspections each year, and the time for the inspection varied for different vehicles. The number of permits varied each year due to the nature of the permit regime. Last year she inspected 3 permit activities, each suborbital. The inspection styles for those were similar. For licenses, she did only one this year, and last year she did about 5-6 operations inspections, and additional inspections on hardware. They had about 11 inspectors currently in AST 400. They all did the same type of inspections.

The licensee or permittee is responsible to be in compliance with the CFRs and permit or license, and they were there to verify. AST 200 evaluated the application. For a permittee, they inspected every time there was a space flight activity. Typically they would observe other activities like glide flights, but those were not inspections.

When she was at A&M, her senior design project was to build a rocket and test it. That gave her insight to operations and hardware. When she started in AST as an evaluator, she thought it was good training. She went through an AST training program that included classrooms and table tops, console training, and going out as an assistant for observations. They were constantly training in AST 400. The rest of the job was going out on inspections. The training had changed over time since they were a dedicated division and the launch rates increased. The newer inspectors had come from industry, so their training was shorter. They did not need things like console training since they were already experienced. Her knowledge of regulations like 437 and 460 came when she was an intern.

There were several tools she used to do her job. The primary one was the regulations, depending on what they were inspecting. They also had the safety inspection plan that highlighted the regulations. They also had their procedures #8, and the application and permit evaluation, and any products that came from other divisions. They also used the license and permit orders that were applicable to the operation. They could use the safety hazard analysis as well, which would tell them where the risks were like systems risks that they needed to look at.

For PF01, she recalled reading the Scaled hazard analysis as part of the evaluation prior to doing the PF01 inspection.

Her manager in AST 400, Mark Wright, was the one who created the procedures for AST 400 inspectors. It told them the roles and responsibilities for the inspectors for each type of operation. It was procedural and internal to AST 400. The procedures were general for each inspector, and they were constantly updated as applicable for each inspection.

For PF01, her role was to support the lead inspector, Dave Gerlach, on console operations. She took notes and verified compliance according to the safety inspection plan according to the terms and conditions. The safety inspection plan was a spreadsheet with all the regulations and any applicable areas of the application. It was similar to a checklist. It started as a generic plan that was then tailored for each inspection. If there was something specific for the inspector to look at, the plan would include that. They used a safety inspection plan for PF01, and could not remember who created it but said it was typically a team effort. It was the responsibility of the team to review it. For PF01, she was only there for the actual flight, and Dave Gerlach was the only one conducting the inspections leading up to the launch. That was her first spaceship observation. She did not notice any non-compliance issues.

Typically, there were only the two inspectors for a launch operation since they were the only ones trained to do inspections. Sometimes there were others from AST who met with the VIPs or range commander, and they would be present during operations. Those typically came from AST 500, whose responsibility was to foster relationships between AST and industry. AST 500 had no compliance monitoring role, and were liaisons between the operator and AST, and had no role in inspections on day of launch activities.

Inspections were not only a day of flight activities. For licenses, it would take things like hardware installation inspections, monitoring activities involving other installations or activities that could impact the launch. Those could take place weeks before. Prior to the launch, they would attend readiness reviews leading up to the launch.

For permits, it was different. Permits did not have the structure that licenses had. A permit was meant to be an authorization for an operator to conduct experimental flights and test their technology. FAA was aware they were not going to have a finalized product since they were still testing and training their own people. The size of the company mattered as well, and AST accommodated and evaluated individually. For permitted activities, the POC (point of contact) for the evaluation team would go out to the operator ahead of time. When an application came in, representatives from various divisions of AST would get acquainted with the procedures, the application and the vehicle. They were the ones more cognizant of the workings of that vehicle.

They would go out to do the first inspections. As an inspector, they would go out with the other AST divisions, but did not do an evaluation or inspection at that time.

She was not a part of any inspections regarding the Scaled pilot's training program. She did not do any work related to the simulator at Scaled.

She was on the console during the PF01 launch. She was checking to see that they complied with the Scaled terms and compliance issues. If she saw a permittee walking down the line of non-compliance, it was her role to inform the permittee via their designated POC, talk it through, and address her concerns. She had to do that before, but not with Scaled. In that previous event, the risk calculation numbers were not in compliance with one of the "buckets", and the operator asked for a waiver to go higher. As an inspector, she was not authorized to issue a waiver. She did not have the authority to stop them.

She was aware of the waiver during the PF01 launch. It was considered as part of the inspectable items for the inspection, and those were things that the inspector would ensure compliance with. They would read the waiver, and ask for verification with the waiver and proof that they did what was in the waiver. For the Scaled waiver, it was in place, and the time of the hazard analysis had passed. The waived items were a part of the safety inspection plan, but there was nothing for them to do since they were already waived. In other waived conditions with other operators, there may be conditions that the operator had to complete prior to launch that she would ensure were completed.

She said she was not sure where the Scaled waiver was drafted, but typically it came from the evaluation process. Whatever concerns the -200 or -300 division had would be addressed in the waiver, and waivers were signed by AST 200. They were the owners of the regulatory requirements. She did not recall if Scaled asked for the waiver but assumed they had. She said typically AST did not grant waivers unless the operator asked for it. She had never seen a case where the FAA issued a waiver that was not asked for from the applicant. She said it would be a non-compliance, and an operator would not get a license or permit if there were non-compliance items unless the operator requested the waiver or if the operator explained that they were in compliance or should be exempt from the regulation. She could not recall a time when AST denied a waiver for an applicant.

She said the waiver had "conditions", and they typically referred to terms and conditions as associated with the application.

She had not attended a simulator session with Scaled.

For PF01, Dave Gerlach conducted the inspections leading up to PF01, and she only participated in the day of flight inspection. It was unusual to have only one inspector on the run-up to a launch, and they usually had two. For that case, the cadre of inspectors was smaller, and they had limited manpower. Scaled also changed the launch schedule, and it was difficult trying to schedule travel from the east coast to the west coast. And there were also budgetary constraints for travel. To conserve resources, only Dave was sent out, and when the launch date was firmed

up, they sent her out. It was her understanding that AST was comfortable having only one inspector participate in inspections leading up to PF01.

On the console for PF01, her contact with Scaled for any non-compliance issues on the day of launch was Pete Siebold. Alternately it was the test conductor. Typically, she would expect her POC to resolve the issue if she brought up a non-compliance concern, and that was how they were trained. For licenses, it was the safety official, who would have a direct comm line to the launch director.

She said an example of an "actionable" item on a waiver would be if the operator was required to do "x, y, z" prior to launch, and she would ensure that had been done. Those types of items would be included in the mission specific documents, which were provided to all stakeholders, and were brought with them on the day of launch. They would also carry the waiver with them, and there would be a note on the safety inspection plan. It did not matter what the actionable item was, it should be a part of the safety inspection plan.

As an inspector, they prepared by referring to procedure #8, read the application to get acquainted with the operation and vehicle, read the license or permit order terms and conditions, and read any waivers in place. She would also meet with SMEs, and review the safety inspection plan. They had a pre-inspection meeting with stakeholders from other AST divisions to review required items. For example if one of the divisions had just learned something that should be covered in the inspection, it would be covered in the safety inspection plan.

The safety inspection plan was reviewed by the inspection team, and the Stan/Eval would review it. The inspectors were responsible for the safety inspection plan. She could not speak to what other divisions did. AST 400 were the ones on "active duty" prior to launch. AST did table-top exercises constantly throughout the year using different vehicles and scenarios.

One way to get familiar with a vehicle was to be the POC. They would be aware of all the details of the vehicle. Another way was to be a part of the inspection process and read up on everything. Typically if someone was new to a system, they would be assigned to someone who was familiar with the operation who was experienced in that system. If it was the first flight, it would probably be with the POC or someone with similar experience.

For PF01, they had only one inspector. There was one AST 500 inspector, and she did not know if they used that person for other parts of the inspection.

An applicant can apply for a waiver prior to the day of launch if they thought they were not in compliance. Typically, the hazards were identified in the waiver, and if there was anything that needed to be identified it would be included in the inspection plan. A lot of verification and evaluation occurred before an inspector went out. It would typically be up to AST 200 and 300 to inform the inspector of items associated with the waiver that should be included in the inspection plan since AST 200 and 300 were the SMEs in those areas. That process would happen during the management review board, which occurred before a license or permit was granted, which was done prior to PF01 for Scaled. There were three ways to get that information

to the inspector: through the evaluation, the management review board, or the pre-inspection briefing. That briefing involved representatives from each of the divisions.

She never did any other inspections on Scaled due to her own schedules. Since it was a new vehicle, they tried to rotate inspectors to train them on the vehicle and get everyone familiar with the vehicle and activities. It also depended on who was available.

For PF01, she arrived to Mojave the day before the launch. She had not seen their operations previously as an inspector. She did get to observe some of Scaled's operation previously, but that was when she was in Mojave inspecting the airport, and a glide flight happened to occur that day. The day of the launch was the first time she had ever been in the Scaled control room. She did participate in the delta brief the morning of the launch.

She said typically AST 500 would not participate with them when they conducted inspections. In the past, there were 2 safety inspectors in AST 500, and for her Mojave inspection she was assisted by Michelle Murray. It only happened since they had an office in California.

The biggest challenge she faced with her job was the travel budget, which limited them from getting familiar with the operator and its system early on. They were limited in staying on site very long. They had not been unable to do any specific inspection, but there were some missed hardware inspections during the government shut down.

She said safety inspections for permitted operations were required, and it was a CFR. It was in every part of their regulations, including 417 for license operations, as well as 437. All the regulations had a provision for compliance monitoring. Compliance monitoring was a part of inspections of permitted launches.

Internally, permit and license inspections were treated with the same vigor. The license and permit requirements were different, and that was how the inspections differed. The checklist items may be different, but they do not treat permit inspections as a training ground.

If an inspector wanted to be a POC for a particular operation, they could request that through AST 400 management. It depended on inspector availability.

She was a lead inspector prior to PF01, just not specifically for PF01, and only assisted. For a lead, there was training that included classroom and table-top exercises, observations, and then assisting an inspection. There would then be a qualifying inspection to obtain an inspector's qualification. For each specific lead position, there was a qualification course. A "certified" safety inspector simply meant that the person completed all the training and qualifications to become a lead inspector. That inspector would then be issued a credential. A commercial space safety inspector was an internal certification.

Interview concluded at 1220.

26.0 Interview: Jesse Hanson, Federal Aviation Administration (FAA)

Date: March 12, 2015
Location: NTSB Offices
Time: 1510 EDT
Present: David Lawrence, Katherine Wilson, Lorenda Ward - National Transportation Safety Board (NTSB); Brett Vance (via phone) – FAA; Matt Stinemetze (via phone) - Scaled Composites; David Mackay (via phone) – Virgin Galactic.

Representative: Brad Preamble, FAA Counsel

During the interview Mr. Hanson stated the following:

His name was Jesse Paul Hanson, and he was 40 years old. He was an aerospace engineer with AST 400, the safety inspection division. He had been with AST 400 since March 2011. Previously, he was in AST 300 from 2008-2011.

His background included graduate studies at Embry Riddle in Prescott, AZ and obtained a Master's degree in science and safety science and a Bachelor's degree in professional aeronautics. Previously he spent 8 years in the US Army.

His roles and responsibilities in AST were to ensure public safety, national security, and foreign policy interests of the US during permitted and licensed operations. This was accomplished primarily through compliance activities like safety inspections.

He had conducted a number of license and permit inspections over the last number of years, approximately 40-50 inspections on permitted and licensed flights, including preflight activities. His workload was "very busy at the moment", and it depended on the launch tempo, but it varied. Recently his workload had involved mishaps of Antares and SpaceShipTwo. For a given year, his activities would vary from 2-3 inspections a year or greater. They had about 10 safety inspectors, including a couple of new inspectors currently being trained.

It was the responsibility of AST 400 to determine compliance once the license or permit had been issued, through the safety inspection process.

Inspector training varied by position, and they used a qualification matrix that listed the requirements for each position. The typical assistant training would include classroom course on regulations, communication disciplines, and courses at FAA or NASA. They also conducted table-top and on-console training. Prior to being qualified, they went on the job with a lead safety inspector. They also went to on-site launch facilities to observe. For the most part, the training was the same for the new hires, though those individuals had industry experience prior to FAA and had already been on console previously and did not need as much of that training. The qualification matrix listed the training completion requirements, and the Stan/Eval officer monitored and scheduled the training for inspectors. The length of training varied based on operational tempo of launches and operations. Inspectors were evaluated as they were trained, and they had recurrent training requirements and annual requirements that had to be met. Currency was based on the number of inspections conducted within the past year, and "re-

upped" on the regulations. Training was tracked on a large spreadsheet, and was defined in their internal procedures P008. An inspector could fail through an internal process once at the qualification point of their training.

To conduct his job, he used AST internal procedures that spelled out how to do his job, and also used the safety inspection plan. The safety inspection plan was a matrix of items to be reviewed based on the regulations and the license or permit terms and conditions, along with representations made in the application. All of the AST 400 staff had input into the creation of the plan. For Scaled, the inspection plan was created during the permit evaluation process using a generic template that was in place, and modified using the conditions and representations from the Scaled permit application. It was an internally created plan, and could be revised at any time if items needed to be modified or revised.

He was the lead for the launch operations inspection for PF02. To prepare, since he was not a part of the original evaluation team, he reviewed the Scaled application, the technical evaluation, past safety inspection reports, preflight reports, and was part of the pre-inspection meeting that discussed the upcoming inspection and previous inspections. He traveled out the day before the inspection, met with AST 500 to get a briefing, and arrived at about 0400 on the day of launch. The first time he had seen the control room was on the day of the launch. He said it took a period of time for him to get familiar with the layout. Typically, for a launch they would arrive a few days before hand to get familiar with the console. For PF02, they met with a Scaled representative to help get a run-down of the control room setup and displays. For PF02, he was looking at an overlay map to see that SpaceShipTwo (SS2) and WhiteKnightTwo (WK2) remained within their operating areas, listened in on communications, and they were at a table in the back of the room and did not have a dedicated monitor. He also had the safety inspection plan, the flight test data card, and a copy of their procedures that included launch abort criteria. He had reviewed the test card for PF01 prior to arriving for PF02, but had not seen the PF02 procedures until the day of launch.

On his laptop, he had the SS2 handbook along with the normal and emergency procedures. Prior to the launch, he had not had an opportunity to observe any pilot training or simulations prior to his inspection of PF02. He said it was a challenge not to have observed Scaled procedures prior to having to conduct an inspection on their procedures for PF02. The reason he was not there prior to PF02 to observe simulations or Scaled operations was due to manpower limitations and limited resources.

He was familiar with the SS2 pilot operating handbook (POH). The POH was not an FAA approved document, and was accepted as part of the initial evaluation process. Approved would have meant there was an official sign off by the FAA. It was required for Scaled to have normal and emergency procedures. He did not remember if the POH was specifically called out as part of the safety inspection plan, but they did have a general records requirement that would include the POH. The records inspection for PF02 was done about a week before launch, and he did review that inspection report before the launch.

He knew that inspectors had observed simulations prior to PF02, and that included Sherman Council, Dave Gerlach and Jeff Claxton. Inspectors also looked at WK2 and Extra training

leading up to powered flights. He reviewed the post-inspection reports, and was part of a review leading up to PF02. He had since sat in on informal training sessions at Scaled. For other inspections not involving Scaled, he had sat in on training before, though Scaled was unique in that they were manned flights and the others were autonomous operations. He would review that training prior to going out and conducting an inspection.

He was not involved in PF04 inspections. He was familiar with the Scaled waiver but was not involved in its development. AST 200 was responsible for the waiver, and he said all divisions in the front office had input into the waiver. He did not know the involvement of the program team lead in the development of the waiver. For PF02, at that time he did not consider the rationale for the issuance of the waiver requirements. His understanding at the time was that those were not intended to be requirements. As part of the safety inspection plan, they did look at their training and flight test plan, and he did notice the use of chase planes during the launch.

Being on console, it would have helped if he had been able to see an integrated simulation prior to conducting his PF02 inspection. He was aware that the waiver said that Scaled was running their simulator at 1.4 times speed, and to the best of his knowledge Scaled was doing that based on his review of the safety inspection reports and what people had told him.

He did not recall if the PF02 safety inspection plan included a section for non-compliance issues. He had reviewed PF04's safety inspection report, and did not know why the non-compliance part of the report was removed or revised. Scaled was operating under the same waiver that was initially given. Each time the permit was re-issued, the waiver was re-issued. There were no additional requirements waived.

He said he interacted with other AST divisions almost daily, depending on the assignments he had, including AST 200 and 300. AST 500 was their liaison division, and he would interact with them on things like data requests. AST 500 did not have a role in compliance monitoring, with the exception that some in AST 500 inspectors could, since they had their safety inspector credentials and could be utilized from time to time based on staffing needs. AST 500 was the liaison between AST and the operator. When asked if it was a potential conflict to have someone from AST 500 previously acting as a liaison between AST and the operator then come in and conduct an inspection, he said "that was a potential, yes." He had not seen that as an issue before, and typically because of the location of AST 500 out in California, that was the only situation where that would occur. AST 500 would observe the inspections, but were not involved in the safety inspection process.

Any changes to the plan for PF02 would have occurred following PF01, and was reviewed leading up to PF02. He was a part of the changes for the plan following PF02, but did not recall what those changes were. Once a change had been made to the plan, the old document was discarded.

AST 400 was responsible for ensuring Scaled was in compliance with the waiver. There were a number of simulator sessions leading up to PF02 to review if the simulator was being run at 1.4 times speed. When observing the simulations, they would follow along with the procedures. They would rely on the input from the operator to determine the run time for the simulator.

There were no non-compliance issues for his inspection of PF02. They had a debrief with Scaled following PF02 regarding pilot observations and a vehicle involved during hazardous operations. They met with Scaled to express their concerns and had a coordinated meeting regarding clear zones.

His typical work week varied greatly, but could be preparing for another launch. Recently it had been mishap work and NTSB requests for data. After an inspection, they looked forward to the upcoming activities and required inspections. Other times they would conduct training or catch up on office work.

He had no concerns about PF02 leading up to the launch, or no concerns going into the future flights. On other launches with other operators, any concerns were adequately addressed by his management. If he saw a non-compliant issue, he would notify the operator's POC that proceeding would result in a non-compliance. He had done that before with other operations, and they were addressed by the operator, since they (AST) cannot stop a launch operation.

He had participated in unofficial simulations that were more typical to demonstrations. He said the waiver at the time of PF02 did not have terms and conditions. Closer to PF04 he said that changed and the waiver did have terms and conditions.

The pilot observations following PF02 involved the co-pilot not having adequate braking force and had to turn over control to the pilot. The pilot also commented that visually the display of the trim indicator was far away, making it difficult to look at. That was not included in any future inspection plan, but was discussed during post-flight debrief that Scaled held. Scaled considered it a training issue.

For PF02, he monitored the display through the big-board display in the control room. Arriving the day before presented some challenges to getting familiar with the display, but they had a Scaled person walk them through it prior to the actual launch taking place. During the launch, he looked at aircraft position, heading, IIP remained within the required areas.

The process to ensure compliance came from the safety inspection plan involving the AST 400 inspectors. When asked if the waiver mitigations made it into the safety inspection plan for PF04, he said "in this case they did not." The waivers were typically discussed in the pre-inspection meeting and there were cases where the waiver mitigations made it into the safety inspection plan, but in this case it did not. The way to capture that on the day of launch would be their knowledge of the waiver itself.

If there was a violation, it could result in counseling, a fine, or suspension of the license or permit. They have had to counsel and fine other operators before, but to his knowledge they had never suspended a license or permit.

He did not recall if the safety inspection reports for the simulator work for PF02 specifically addressed the 1.4 times speed for the simulator.

He had previous experience with other RLVs, and those were all autonomous operations. His Army experience involved hydraulics and pneumatics on helicopters.

For AST 400, the primary inspector with knowledge of Scaled was Dave Gerlach prior to his departure. Since then, they had assigned 2 other inspectors for SS2.

For mishap work within AST 400, he managed their mishap role. He was the mishap coordinator, and that involved making sure all of their notification requirements were in place when a mishap occurred, and coordinated their response. At the moment, he was the only mishap coordinator, and they were training 2 other individuals within AST 400.

For AST 400 training, the Stan/Eval was responsible for monitoring currency. That information was communicated during staff meetings.

Ed Springer was his assistant for PF02, and he did not recall if Ed had worked with Scaled previous to PF02.

He did not recall if PF02 was the first time the pilots were using the 0.8 callout, and did not recall if he had been briefed on it. For PF04, he did not know why Scaled included the 0.8 callout out when it was not on the test card for PF02 or PF03.

He was not a pilot, but was aviation maintenance technician.

He was not specifically aware of the hazards associated with unlocking the feathers early, but there were others within AST who were. It was likely the license and evaluation team that were aware of it.

He was not involved in the permit application, and he was not specifically aware of concerns from AST 200 and 300 evaluators concerning their questions to Scaled being filtered by management or AST 500.

He said the biggest challenge of his job concerned his workload. Others within AST 400 would also include the manpower and budget issues, and not being able to go out prior to an inspection to get more familiar with an operator.

He said he did not know if it was unusual for the FAA to write a waiver if the applicant did not request it, but the FAA retained that option if the intent of the regulations had not been met. He did not recall ever seeing the FAA write a waiver for an operator. If AST did not issue a waiver, the applicant could either ask for the waiver or AST could decide not to renew the permit. He did not recall seeing that occur before.

For the new inspectors going through training, he thought they were likely hired based on their background and experience.

For inspector assignments specific to ELVs and RLVs, AST used to have that specific assignment. Currently, most inspectors were cross-trained for various operations, but current staffing did not allow for specific assignments based expertise in ELV and RLV operations.

Interview concluded at 1612.

27.0 Interview: David Gerlach, Federal Aviation Administration (FAA)

Date: March 31, 2015
Location: NTSB Offices
Time: 1007 EDT
Present: David Lawrence, Katherine Wilson, Paul Misencik - National Transportation Safety Board (NTSB); Brett Vance (via phone) – FAA; Matt Stinemetze (via phone) - Scaled Composites; David Mackay (via phone) – Virgin Galactic.

Representative: Brad Preamble, FAA Counsel

During the interview Mr. Gerlach stated the following:

His name was David Allen Gerlach, and he was born in 1964. His current title was FAA Air Safety Accident Investigator in AVP 100. He previously was in AST 400 as a Safety Inspector. He was a Safety Inspector for about 3-4 years in that division, but his entire time within AST he was a Safety Inspector and had multiple roles. His 9 years with AST were all as a Safety Inspector. His background included 13 years at NASA with the space shuttle and International Space Station (ISS) programs, where he held positions as an engineer, manager, and flight test and flight crew operations. He left NASA and flew for several freight operations before coming back to the government in October 2005 where he started working for AST.

As an AST Safety Inspector, his role was to evaluate through compliance monitoring the performance of different operators that were licensed and permitted. They also did safety approval monitoring as well for launch sites. Safety approvals were designed to allow an applicant to use a system, person, or hardware that had previously been approved, like a component that had previously flown on a vehicle being allowed to fly on multiple vehicles.

The tools he used to perform his job included Safety Inspection Plans (SIPs), and a procedures document (P008) for generic guidance. The SIPs were generated within the division, and created for various operations which were then tailored for specific operations. The initial SIPs were developed by AST 400 with the oversight of the division manager. Other individuals could be used to help guide the plan.

When asked who ensured that an operator was in compliance with their permit and regulations, he said the operator is responsible for complying with the regulations. AST did not ensure compliance; they monitor the operator for compliance. They monitor when and where they could for compliance. AST 400 did the monitoring when they were assigned to a specific operation. He was unaware of AST 500 having any operational responsibility of monitoring during mission with respect to compliance. He said everyone within the agency is responsible

for raising compliance concerns to the appropriate organization. Inspections of a permitted operator are not required. When asked why AST did inspections of permitted operations, he said you would have to ask Dr. Nield that question since he did not have a specific answer.

Most of AST inspector work was not centered around launch activities, but also included activities leading up to launch. Once the launch activity was complete, their launch monitoring activities were complete. They had two safety inspectors in the control room during a launch, and their responsibility was compliance monitoring of the permitted operation. They used the SIPs for that role. The inspectors had a responsibility to observe the operator, review the SIP, and identify when and where they were compliant with the plan, and if they observe a non-compliance issue they would document that as well. Completion of the SIP was their primary role. The SIP was a "tool" and "memory jogger," and there were many other regulations they would consider that could not be covered in the SIP. The P008 outlined what the inspector did during inspections and launch activities.

Inspectors were certified positions. There were multiple tiers in the training for different levels of inspection activities. They received training on regulations, and on-the-job training with someone with more experience. The Division Manager would then approve the inspector as competent once he had completed the training matrix, and would then be cleared to conduct inspections.

He said he was familiar with the 14 CFR 460 regulations. When asked why the training syllabus for inspectors did not include a module on the 460 regulations, he said he did not believe they had a specific class on 460 regulations because human space flight was "brand new" and they had not seen operators taking flight crews and passengers into space yet. SpaceShipOne was the first permitted human space flight activity AST was involved with, but that was before his time and 14 CFR 460 had not come out yet.

He held a commercial and ATP license, CFII, MEI, ground instructor and type ratings. When asked if any of the other inspectors were pilots, he was not aware of any that were current pilots. There were some people in the office who were pilots, and there were some inspectors in the past who were pilots, but he was not sure about the current cadre. When asked if inspectors should be pilots if they were conducting inspections of simulators, pilot training and pilot qualifications and experience, he said they trained their inspectors so that anybody was capable of performing the tasks outlined in the SIP. Evaluating the simulators was included in the evaluation period prior to the safety inspection plan oversight, and was part of the application process. He was not aware of any evaluation of the simulator during an inspection. The simulator was evaluated by the permit team during the evaluation period. If there was a change to the simulator between the evaluation period and when a safety inspection was conducted prior to launch, he said the inspector would likely not have insight to that change. It would be up to the applicant to advise AST of any changes to the simulator, and it would be related to public safety and whether or not a change in the simulator changed the risks to public safety. They could make changes to the simulator, but it was up to the applicant to determine whether or not there was a change to public safety, and the applicant would have to bring that up to AST. AST asked the applicant to identify the hazards and how they were mitigated, and present those to AST. AST would then determine if the mitigations were appropriately applied.

He said the 460 regulations were developed as a result of the change that came to the commercial space launch amendment, the act as amended. It required a specific set of human space flight regulations, and Ken Wong led the development of those regulations. He said he started working for AST after the NPRM was issued for those regulations. He had input to the division manager, but not specific to those regulations. He recommended many changes to the regulation, but since he was brand new to AST, he came in as a person who just left NASA and aviation and had a lot of recommendations without understanding the limited oversight and statutory responsibilities AST had at the time. The 460 regulations applied to both licensed and permitted operations, and essentially meant that a pilot would only require a Private pilot certificate with an Instrument rating and a Second Class medical. When asked, based on his experience, if the 460 regulations for pilot qualifications and experience were sufficient for human space flight, he said the regulation was written such that they captured those things that the agency recognized were specifically needed with respect to commercial space flight operations. There were no ratings or certificates that could cover every type of vehicle or operation. They looked at what things that a person may basically need to understand, and that was why they selected those requirements. It did not mean that those would be the requirements for an operator for a specific vehicle. AST fully expected each applicant to identify the experience requirements for their specific operation. When they wrote the human space flight recommended safety practices, they reviewed the 460 requirements and considered the different licenses issued for aviators and made the same conclusions that it was up to the applicant to determine the requirements for their operation in training and expertise. It was hard to take an aviation paradigm and apply it to space with the various vehicles. On review, the agency determined that what they currently required was adequate. When asked again if he felt the regulation was adequate, he said you would have to look at all the regulations in totality before you could make that determination. The regulations as a whole provided for an appropriate level of regulatory need for protecting the public with that operational paradigm. He believed the permitted regulations were adequate for protecting the public safety. When asked if a private pilot should be flying a vehicle into space, he said it was not up to him to determine that. If he was a Private Pilot with an Instrument rating, "I would love to fly a space ship." When asked if he should be flying a space ship as a private pilot, he said it was not his job to make that determination, and the agency wrote the regulations. He said AST had discussed crafting a special certificate for space flight, but it was difficult for one certificate to cover all the different aspects of space flight. The agency would love to do that, and they may visit that over the next few years, but as a brand new industry, the agency cannot craft a certificate to cover all the bases. He said you would have to ask what the certificate would do for the agency, pros and cons, and how it would protect the public and if you needed a certificate to do that. The current answer is no, not yet.

He was familiar with the Pilot Operating Handbook (POH), and it was not FAA approved or accepted like an aircraft. It was accepted as part of the Experimental Permit. The vehicle received an Experimental Airworthiness Certificate (EAC), and on glide flights it operated under the limitations of the EAC. For glider operations, it did not need to have a POH. For the POH on SS2, when Scaled made changes to the POH with respect to public safety, Scaled was required to advise AST of those changes, and could change the POH as often as they wanted. The SIP did not include a review of the POH. As an inspector, you did not have to have in-depth knowledge of the POH to conduct an inspection, and inspectors were aware that the vehicle was

required to be operated in accordance with the POH. They did not look at detailed procedures from the POH on launches, but rather looked at the operation of the vehicle with respect to public safety. It was similar to when an air carrier inspector did a line check and he was not type rated in the airplane, he would rather inspect based on specific items he wanted to look at. When asked if an inspector should have an in-depth knowledge of the POH, he said the inspectors were adequately aware of those things germane to the permitted operations.

When asked if he was aware of the technique to use the 0.8 Mach callout used for PF02 and subsequent flights, he said he was not aware that they were using that callout. He remembered seeing that 0.8 Mach callout on the PF04 flight test data card. When asked if the 0.8 Mach callout included on the test card was a required procedure, he said that would be left to the operator to decide that, not the agency. "Required" to AST meant "regulated." He said flight test cards were tools for the pilots, and was not the checklist to perform the tasks to operate the vehicle. The oversight of the flight test was not something the agency had insight to, other than from a public safety standard. It was the choice of the operator how to operate the vehicle.

Scaled's standards for successful completion of training would be in the pilot training records, and he had seen some of those and they identified those standards. They included the training syllabus and the standards by which each pilot had completed the training. Unlike an ATP standard, AST did not define the standards for commercial space flight pilots, the operator defined those.

He did observations of the simulator, primarily to learn how the vehicle operated. There were specific failure modes he looked for to see how the pilots performed, and tasks as they were related to public safety. Regarding single-point failures, he was not familiar with the fact that unlocking the feather during the transonic region would result in destruction of the vehicle. He did not know if anyone else in AST was aware of that hazard, and he said he did not know why the feather was required to be locked during the transonic region.

For the 1.4 Mach unlock procedure, he was aware of it and it was explained to them by Scaled to ensure a higher probability that the feather would unlock prior to 1.8 Mach and avoid a unfeathered reentry. Prior to PF04, it was never discussed within AST about early unlocking the feather prior to 1.4 Mach. Scaled had talked about it, but it was not part of their [AST] compliance monitoring. He knew now that the simulator did not model an early unlocking of the feather system, but did not know that when he was conducting inspections.

He did not remember much about the waiver for Scaled, who wrote it and why. He knew now based on the NTSB investigation and it had since biased his memory. He could not talk too much about it other than what people had talked to him about it. For his inspection of PF01, he did not give consideration to the mitigations identified in the waiver. In subsequent inspections, he could not remember if they talked about the waiver, though he believed they reviewed it. He could not remember if they highlighted it during those inspections.

The safety inspection final reports were created from a computer program, and the absence of the waiver consideration section of the final report for PF04 may have been an oversight.

He said safety inspector did not have to be there for a launch operation to occur. They tried to accomplish all the items on the SIP, and sometimes they would not get to all the items on the SIP since it was difficult to do with only two inspectors. They would look at what they could, then check off that item. They did the best they could, given the circumstances, and they changed every single flight, and they may or may not get to all the items they wanted to do. For the airlines, they'd love to have the manpower to ride on every flight to capture everything, but could not. They relied on the operator to be compliant with the regulations to the extent necessary.

AST 500 did not participate in the safety inspections, and the plan was for inspectors only. AST 500 was not with them in the control room, however AST 500 was typically at Scaled when the inspectors were there. Sometimes AST 500 people would join them during the inspections as observers there to learn. When asked if AST 500 personnel ever answered inspector's questions to Scaled on behalf of Scaled, he said absolutely not, and that would not have been acceptable to their division.

When asked if he ever heard AST analyst and evaluators having their questions to Scaled filtered or scrubbed prior to going to Scaled, he said yes. The scrubbing was similar to when letters would be sent out from AST and management or general counsel would review those prior to distribution. Typically no one at the lower engineering level would send out inquires unless it had been reviewed by the agency and management. He said "the content was reviewed based on its applicability to the content it was intended." He had heard concerns from analysts and evaluators about their concerns of their questions being filtered, but would have to ask them for specifics.

When asked what changes he would suggest making within AST, he said he would recommend AST continue to grow in size with more subject matter experts, work with industry to develop closer relationships, grow the field centers to embed AST with all the operators, and work toward the continued partnerships and continued interest in public safety. For the inspectors, he would continue to add more people with expertise, provide an abundance of training, and increase the funding for travel to learn and watch. He thought the safety inspection division was an outstanding division but constrained by government funding.

What he meant by more expertise for AST was that you could never have enough smart people, like propulsion experts and human factors experts, but AST was part of the government and it was hard to get people to come to DC with the funding they had to attract people.

He did not do the analysis on the unlocking of the feather single point failure so he was not an expert, but you could have a failure that was critical to those people onboard but not to the public, and there was a difference.

Inspectors loved to be out in the field doing inspections, and he was fortunate to be able to do the Scaled inspections. They all wanted to go out and do the various inspections, and they were never overloaded and worked well together. It was not the kind of place where you struggled to get your work done. For specific inspections, there would be a plan but sometimes could not get to everything. When you were learning a new operation with a new tempo, you tried to capture

what you could along the way. You followed the operational flow and captured what you could, but it was not a workload overload issue. They typically would get there a couple of days in advance, and worked with Scaled's schedule to capture what they could. The launch day was an early day, and an 8-10 hour day. He did not remember the total number of inspections he had done since there were so many different types of inspections, both for licenses and permits. When not doing inspections, he was the mishap coordinator with AST and would help prepare the office and industry for managing mishaps. He also participated in license and permit evaluations. He was a part of Scaled's initial and subsequent permit evaluation. He started early on with the permit evaluation team to see if there was appropriate material to see if Scaled met all the application requirements. He did not write the waiver and was not part group that participated, but clarified that every time a renewal came up there was a reevaluation of the permit to look at those things that changed, and perhaps they saw a need for the waiver. The system safety folks were the ones that looked at the waiver issue.

AST did not do inspections for glide flights since those were the responsibility of the Flight Standards District Office (FSDO). He conducted Scaled inspections that included observing simulations leading up to powered flights, and the training activities and pilot and maintenance records. He did the initial inspection of the vehicle as part of the 437 regulations. He was the lead inspector on PF01 and PF02. During the simulator sessions he observed, he never had insight to the timing of the simulator, and never saw a simulator run faster than normal and never saw a simulator run at 1.4 accelerated time.

He said sometimes waivers had terms and conditions, but could not recall if Scaled's waiver had those. For his observations of the flight simulator, he said he sat through about 4-5 days' worth of simulator sessions total as an inspector, and each included about 4-5 simulator runs. For each of the first two powered flights, he observed integrated simulations but could not remember the number of times.

His observations of the pilots in the simulator were related to how they performed relative to public safety. During some simulator sessions, he asked to observe specific failures to see how the pilots managed the vehicle to protect the public. One failure was to observe the pilots have a complete electrical failure and go from boost to runway by solely looking out the window. It was not a single point failure, and he wanted to see if the flight crew could fly the vehicle back since Scaled said the rocket motor controller was the only critical electrical system on the vehicle. When asked if an inspector asking for specific failures was beyond simply observing an operator for compliance, he said they looked at the hazards and mitigation measures, and they looked at whether the hazards had been mitigated appropriately. For the electrical failure, he wanted to see if that indeed was not a critical system.

The tailoring phase of an SIP included areas of concerns, and they would put those as priority items. Post-flight, they identified items that may be of interest in future inspections. It was done with respect to the regulations, and the regulations were used as the guidance. If a waiver had terms and conditions, those could certainly be added as items included in the SIP, and that would be up to the inspectors and management to determine if it were necessary. During the pre-flight, they briefed the plan for things that were germane to the inspection. If the waiver mitigations had a priority, they could make it into the plan. For the 1.4 times simulator runs, that was never

placed into an SIP. They did not have the authority to make a "knock it off" call since that was the responsibility of the test conductor. Should an inspector believe an operator was approaching a non-compliant issue, they would bring that to the attention of the operator to alter or change their operation to become compliant. They were given a Point of Contact (POC) with the operator to raise that issue with.

The regulations concerned protecting the public, and the agency and industry were keen on the risks of space flight. They released a safety recommend practices document to help the industry. It was an attempt to help the agency and industry with what they had learned. With respect to writing regulations, Dr. Nield had stated that AST would not be writing regulations for protection of space flight crew or participants. The recommended practices document was available on the FAA website, and was presented to the industry in various forums. He was not sure if that document was provided to current applicants, but encouraged it.

As an explanation of commercial space flight, he said the industry went to the government and said they wanted to carry people into space but did not want all the regulations they had for commercial aviation. They wanted to allow themselves to operate and not hurt anyone on the ground as they conducted experimental permitted operations. Industry wanted a regime to also inform participants of the risks and buy into the risks and not be sued should things go wrong. That was why the folks in the back of the vehicle were referred to as participants and not passengers since they had bought into the risk of the operation. It was a different paradigm than a commercial flight where a passenger had an expectation of traveling with regulatory protections. You did not have the same slices of Swiss cheese in commercial space operations that you had in commercial aviation.

When asked if he personally had any of his questions scrubbed or filtered when he participated in the evaluation process, he did not think any of his particular questions were changed, and the answers came directly from Scaled, sometimes verbally and sometimes in writing. No manager ever told him that he could not talk directly with Scaled if he had a question. He was aware of managers who did ask evaluators and analysts in AST 200 and AST 300 not to direct their questions directly to Scaled.

He had never seen a pilot unlock the feather early during his simulator observations, and had never heard of anyone doing that. He could not recall if he ever observed a simulator session where a pilot made an incorrect action at the 0.8 Mach callout.

Both accident pilots were colleagues in the industry and he had worked with both when he did inspections at Scaled. He may have observed the pilot in the simulator at some point but could not remember. He did not believe he ever observed the co-pilot during a simulator session.

He believed the agency, Scaled and Virgin Galactic were aware of the issues surrounding the accident and were taking the appropriate actions to ensure it did not happen again. He had complete faith in the organizations to see that those appropriate actions would be taken.

Interview concluded at 1215.