NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

February 21, 2015

Attachment 4 – Control Room Statements

OPERATIONAL FACTORS

DCA15MA019

COPY

DEBRIEF STATEMENTS

STICK to Security...Eliminate Risk!

Eagle Alliance

Tim Bourgeois Account of 552 Accident

10/31/14

The following is my account of what I saw on PF04. The L-10 and L-4 checks all seemed normal up to drop. The only anomaly noted in the flutter station was a little bit of signal hunting on the Left Boom Top2 accel (my scales were set to ±.6 g so the hunting was on the order of (less than ±.1 g). This is typical behavior of what we have seen before for accels although this hunting was very small. The Drop, Arm and Fire seemed normal the boom noise was typical of what we see with a rocket motor but a bit noisyer than the rubber motor. By noisyer I mean the g level was about the same but the frequency content seemed to vary a lot more. At about Mach .9 I saw a linear increase in accel signals (no distinct frequency that I could pick out from the time history). This increase grew to about 8 g's. (it grew very slowly, about 1 second) This appeared to me to be related to Transonic bobble/Pitch up so I didn't think it was a problem. After the signal grew to 8 G's it immediately went to what looked like a solid line of signal. Upon later examination of the data and zooming in it looked like the noise was on the order of the sample rate. I thought this might be a TM problem so I hesitated to say anything for the next second. after about a second I heard multiple Abort - Abort - Abort calls and saw the noise stop and the accels asmptote back to zero, the type of signal we see when accels loose their connection. I then heard TC trying to contact the vehicle and the chase vehicles. I heard a response on com 2 that they had departed. I then heard on com 2 that the vehicle was in an inverted spin. I heard That there was a parachute but only one. Later after the flight I heard from Stabs that they heard Feather unlock at about Mach .8. I think I heard something

about the feather during boost but I was so focused on looking out accels that I'm not sure. Also when the motor lit I heard the pilots grunting and it was hard for them to talk.

CJ STURCKOW, PILOT OF EXTRACHASE

OBSERVED A NORMAL ROCKET IGNITION AND APPROXIMATELY 5 SECONDS OF NORMAL BURN. FLAME SHUT DOWN BUT SS2 CONTINUED UPWARD. SAW ONE MORE BRIGHT FLASH ABOUT THE TIME OF THE "KNOCK IT OFF" CALL. THOUGHT I SAW TWO DARK OBJECTS FALLING FASTER THAN THE DEBRIS. ONE OF THOSE POPPED A CHUTE. STAYED WITH THE CHUTE AND ASSUMED THE DUTY OF ON SCENE COMMANDER. CIRCLED DOWN WITH SURVIVOR. GOT A GOOD HAND WAVE AND ANOTHER WHEN HE WAS ON THE GROUND. LOCATED BOTH TAILS AND EVENTUALLY THE CABIN. VECTORED IN HELO TO PICK UP THE SURVIVOR.

SpaceShipTwo Accident 10/31/2014
Clint Nichols WhiteKnightTwo co-pilot

There were some delays for DAU1, and N_2O M.O.T. temperatures. Winds were forecast to be out of limits. (runway 30 for SS2 landing). We took off and started the climb to altitude. After the 30,000 ft cabin leak checks Dave Mackay gave me control of the aircraft. I flew the westbound leg and the turn onto the run-in. Once established inbound Dave took the controls, we were above our minumum launch altitude on the baro altimeter and I switched briefly to inertial which showed even higher. II was pleased we were above the minimum altitude The L-10 and L-4 checks went well. I called the countdown 30, 20, 10, 5, 4, 3, 2, 1, release, release, release ~~with~~ getting off the transmit switch between calls. I pushed the release button. The spaceship released with a beautiful mighty clunk. We pitched up, climbed, and slowed down. I heard base call "supersonic" and then a very enthusiastic "Knock it off, knock it off, Knock it off" After a few moments I heard "TM lost" We were directed the look for the spacecraft. I was expecting to see the vehicle rise ahead of us like PF01. I never saw the spacecraft,

Ed Springer
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Pre-launch notes & observations captured in FAA/AST Safety Inspector / Duty Officer chat log. A copy of the log was e-mailed to Bob Withrow.

After SS2 was released from WK2 I observed the video feed displayed in the Control Center. SS2 dropped from WK2 as planned & as called on the net. SS2's engine ignited on call ~4 sec post seperation. The SS2 vehicle appeared to level out but then pitched up abruptly. Shortly after the pitch up (~1-2 sec) the video was lost. I then looked at the data displays projected on the front wall of the Control Center and all data feed was lost. Beyond these observations all data I heard came from other sources... discussions in Control Center & comm on the nets.

Best to Scaled Composites & all touched by this accident.

Edward P. Springer IV
FAA/AST-400

Jeff Claxton - FAA/AST-400
805-478-9802

Pre flight - Team appeard to be very thorough in addressing safety and ops related items.

These are from memory and observed over the net.
- DAU showing intermentant failures
- PSE showing inconsistent data thought to be ok.

Flight -
Good drop
Good lite
Motor looked good for about 3 sec
Pitch up looked normal
Violent pitch-up or feather movement occured
plume changed in both shape and color
all data was lost

Chris Turk - Notes for Debrief 10/30 1/3

I have minimal additional info to add to the notes submitted in the control room.

STATION - Flutter Bravo (Backup)
Primary was Tim B

Mission Plan Concerns were focussed on Envelope Expansion of supersonic boost + Transonic Reentry. From flutter / structures perspective, the initial boost to vertical was a repeat of earlier flights + of minimal concern.

Mission Prep was nominal.
Mission was postponed 1 wk for review of loads - I was aware of that work but had no direct involvement.

TO Pay - Mission was delayed due to MOT temp below limit. Forced Air cooling was deployed ~~(I was~~ (was briefed to team)

Once on station, all flutter params seemed normal / nominal as noted in my primary notes, some typical "ticks" appeared on Boom Accels. This has

CHRIS TURK

2/3

TAKEOFF + CLIMBOUT WERE NOMINAL FOR FLUTTER

→ THE PSC DID HAVE APPARENT INDICATION ERROR DURING GROUND CHECKS. SEE MY PRIMARY NOTES BOOST + TC + RMC CONCURRED INDICATION ERROR - NO FACTOR PROVIDED NOMINAL to DROP.

DROP + IGNITION APPEARED NOMINAL AND AS SIMMED (SIMULATED)

TIM (FLUTTER PRIMARY) MADE CALLS (STATION ONLY) OF "LITE" "STABLE" "STABLE" "TRANSONIC" → IMMEDIATELY AT THIS POINT I HEARD "DEPARTURE" DATA WAS NONSENSE - FILLING CHARTS FOR 0.5-1 s SIMULTANEOUSLY OR JUST BEFORE "DEPARTURE" CALL AND WENT DEAD.

I SAW NO ~~OBVIOUS~~ OBVIOUS NEGATIVE TRENDS ON ACCELS PRIOR TO EVENT. CONCUR W/ TIM B's LIVE CALLS.

DID IMMEDIATE PLAYBACK - SAW POSSIBLE PEAK G INCREASE IN 1/2 s PRIOR TO "NONSENSE" DATA, BUT STILL IN LIMIT + NOT CLEARLY A FLUTTER INDICATION.

10 of 11

CHRIS TURK 3/3

STAYED IN MCC ON COMS
BUT HAD NO INPUT OR SA
TO SITUATION BEYOND ROOM COMS.

<END>

Statement of Ken C. Baker, 2014-11-06

Age: 33

Manufacturing Engineer

SCALED Composites – 5 years

My role in mission control surrounds rocket motor operations. In the days leading up to SS2 flights, it is my job to oversee the pre-flight process from motor igniter installation, injector installation, motor harness wiring installation, motor installation in the ship, propulsion system functional checks, Gas boosting, N2O loading, and finally overseeing the 'BOOST' station in mission control.

In the days leading up to PF-04, the installation sequence was as follows:

- **CTN Installation Prep**
  - CTN igniter installation + wiring installation (all nominal – no squawks or non-standard items of note.)
  - CTN Injector and cavitating venturi installation (all nominal – no squawks or non-standard items of note.)
  - CTN pressure transducer installation, (b) (4) and check-valve installation. Pressure transducer installation was visually off on one port, requiring re-work prior to final transducer installation and seal integrity testing. Final checks on all ports were nominal.
- **CTN Installation in SS2**
  - The motor installation sequence went smoothly. Final checks showed that an aft-support strut showed signs of binding. The installation required removal and refitting of a replacement strut. Clearances on replacement strut checked out nominal by crew chief and engineering.
- **Propulsion System Pre-flight Checks**
  - This is a functional check of all of the valves in the SS2 propulsion system. Valve command and switching is verified against MFD (Cockpit Multi-Function Display) indications, and control room indication. Proper function and health of pneumatic valves are determined through pressure traces. Proper function of the Rocket Motor Controller (RMC) is verified, pressure transducer physical positions are verified and response is tested. The Propulsion System checked out nominal with one non-grounding squawk: electrical command to the backup N2O dump valve caused a small pressure transducer off-set to the RMC. This was discussed amongst the team. Because the valve in question, by design, is not actuated during the firing sequence, and because the off-set was small, it was dispositioned as nuisance-level non-grounding to be looked into following the flight.

- **Data System Pre-Flight**
  - A modified version of the normal flight procedures are run through in order for the control-room team and flight-crew to verify proper function of the data system parameters that are transmitted to the control room during the flight. All checks were nominal. In addition, for this flight we sequentially took each DAU (data acquisition unit) offline by pulling the circuit breakers in order to verify that each control room station was registering proper DAU fault indications. All checks nominal.
- (b) (4) **Tank Fill**
  - The FPT (forward pressurant tank) was pre-filled from a ground (b) (4) source and boosted to (b) (4) psia over the course of two days. This sequence took place at VG's FAITH facility. Operations were nominal, no squawks.
  - The Wing (b) (4) Tanks were boosted to (b) (4) psia (b) (4) over the course of two days. This sequence took place at VG's FAITH facility. The propulsion team had performed this operation numerous times on our ground test-stand, and through dress rehearsals and leak-checks on SS2. New elements to this boosting operation involved additional ground support equipment to aid in bay venting to mitigate the possibility of (b) (4) accumulation.
- **COM Checks**
  - Communication checks in the control room to the ground support crew and flight crew were verified from Scaled Mission Control. No anomalies.
- **N2O Fill, Morning of Flight**
  - Prior to tanking operations, the team had decided to attempt using VG's Mission Control Facility in the FAITH hangar for N2O transfer. This was to be contingent on good communications and good data receipt. In testing the system prior to N2O load, we were not able to establish good communications, so we reverted to the previously tested Scaled Mission Control for tanking operations.
  - In the early morning leading up to PF04, Nitrous Oxide is pump transferred to SS2. The pumping operation itself went smoothly from a mechanical and operational aspect. Nitrous conditions were -16F – slightly colder than anticipated. Due to the temperature, the team discussed that it was highly likely that we would have to effect a ground-hold before takeoff to bring our temperatures within our operational envelope.
  - During the N2O transfer, I noticed that DAU 1 functions had failed, along with an explicit CAS message of DAU failure. I called the Scaled and VG avionics leads to inform them of the situation. Following the N2O load the crew chief pulled breakers to the DAU in question, while corrective actions were determined.

Following the pre-flight operations sequence, the team adjourned to the pre-flight delta-brief. I briefed the flight-crew and test-team that our Nitrous temperatures were out of range for take-off and that a hold would be needed. We discussed the ramifications of a temperature condition hold, and the possibility of increasing winds through the morning pushing us out of limits. The forecast was discussed in detail between the flight crew, test team, and weather consultants on scene with the aid of weather balloon data sent up earlier that morning. The team consensus was to continue with the remainder of

the pre-flight sequence, and to re-assess weather conditions before commiting to take-off when N2O was on-condition for the flight. DAU #1 was also discussed – my understanding is that a replacement unit was installed, and was functioning normally.

During SS2 flights, my job is to monitor the BOOST station, as station primary. This entails monitoring the health of the propulsion system and to apprise the Test Conductor of the state of the propulsion system, and any out-of-limits conditions, or readings that are trending out-of-limits. Before committing to takeoff the morning of PF-04 the bulk of my time was spent assessing the rates of temperature change of the N2O load, and helping make predictions and assessments on when we would be on-condition in order to give the team a better idea of predicting winds at touch-down. My assessments indicated a roughly two hour hold. The Test Conductor conferred with myself and the flight crew. The determination was made to continue with the "man-up" and flight-crew ground checks in order to prepare the ship for take-off at roughly the same point that N2O was expected to be on-condition.

We worked through the pre-takeoff evolution up to the point where the Main Oxidizer Tank is manually pressurized using a ground (b) (4) source. At this point we held for approximately one additional hour for temperature conditioning before pressurizing the tanks. The flight-crew then entered the vehicle and started their pre-checks. Roughly 30 minutes before take-off our N2O temperatures came within limits. At this point all parameters at the BOOST station were green for take-off.

Leading up to take-off the test conductor advised the ground-control team to make certain of any station-specific DAU #1 parameters that might be of concern leading up to our commit-to-launch. DAU #1 specific parameters for the BOOST station include (b) (4) tank pressure and temperature indications, and status indication for the Pressurization System Controller (PSC).

Just prior to take-off we functionally check the performance of the PSC by enabling the system and pressurizing the Main Oxidizer Tank (MOT). The system checked out healthy, but gave a momentary unpowered indication. We performed a second functional check, and the system displayed nominal. This triggered a discussion between the BOOST station and the Test Conductor (TC) on the nature of the indication. I apprised the TC that the nature of a DAU failure would not affect the function of the PSC, but we could lose indications of the PSC status. However, proper indications of PSC health at the BOOST station can be indirectly obtained by pressure transducer readings.

TC and flight crew discussion centered on wind and weather forecast for touchdown. A take-off determination was reached, and WK2 launched at some point after 9am. I don't recall the time specifics. During the ascent, I was heavily focused on the BOOST station. At one point during the ascent, I remember hearing Pete Siebold say over hot-mike, "There it is" in response to an apparent center Multi-Function Display (MFD) blackout. The MFD came back on shortly thereafter.

At some point in the ascent I noticed a fuel-grain temperature sensor (TT-Mx) trending towards an out-of-limits condition. This sensor is a surface patch thermocouple inside the rocket motor to help give an indication of fuel temperature. This indication has a redundant sensor in another location (TT-My). TT-Mx appeared to be trending significantly colder than TT-My. My assessment of the situation was that TT-Mx had separated from the fuel surface and was reading ambient air indications inside the motor, rather

than fuel surface. I apprised the Test Conductor of the reading, explained my theory, relayed the reading on the redundant sensor, and recommended that we continue.

Leading up to the commit-to-launch decision, the Back-up Oxidizer valve is opened, and the PSC is again enabled. Both systems functioned nominally. Discussion in the control room centered on winds at touch-down. Winds were within limits, and the decision was made to proceed with release.

Following SS2 release from WK2, I verified:

- Clean vehicle separation
- Good cycling of the (b) (4) and injector plenum system purges
- Good stroke of the Main Oxidizer Valve
- Good ignition, followed by a good indication of motor chamber pressure reaching nominal startup values. At this point I called "GOOD LIGHT" To the control room.
- Good rate of (b) (4) pressure decay indicating good PSC function.
- Steady Main Oxidizer tank pressure indicating good PSC function.
- (b) (4) injection valve cycling open, coupled with good pressure decay, and good delta-P across the (b) (4) regulator indicating good flow.
- Continued steady combustion chamber pressures

At some point during the burn I heard a "KNOCK IT OFF, KNOCK IT OFF, KNOCK IT OFF" call, along with the RMC station calling "RMC COMMANDED SHUTDOWN." Very shortly thereafter, all of my indications for chamber pressure and Main Oxidizer Valve actuation pressure dropped to zero, at which point I called "CLEAN SHUTDOWN." Momentarily afterwards, or possibly concurrent with my call, I showed a number of erratic values across the propulsion system and the control room lost its telemetry stream.

For several seconds I tried to digest what could be happening, before the Telemetry Ground Control Station (TM station) relayed to the TC that Edwards range cameras had visual of SS2, "In an inverted flat spin."

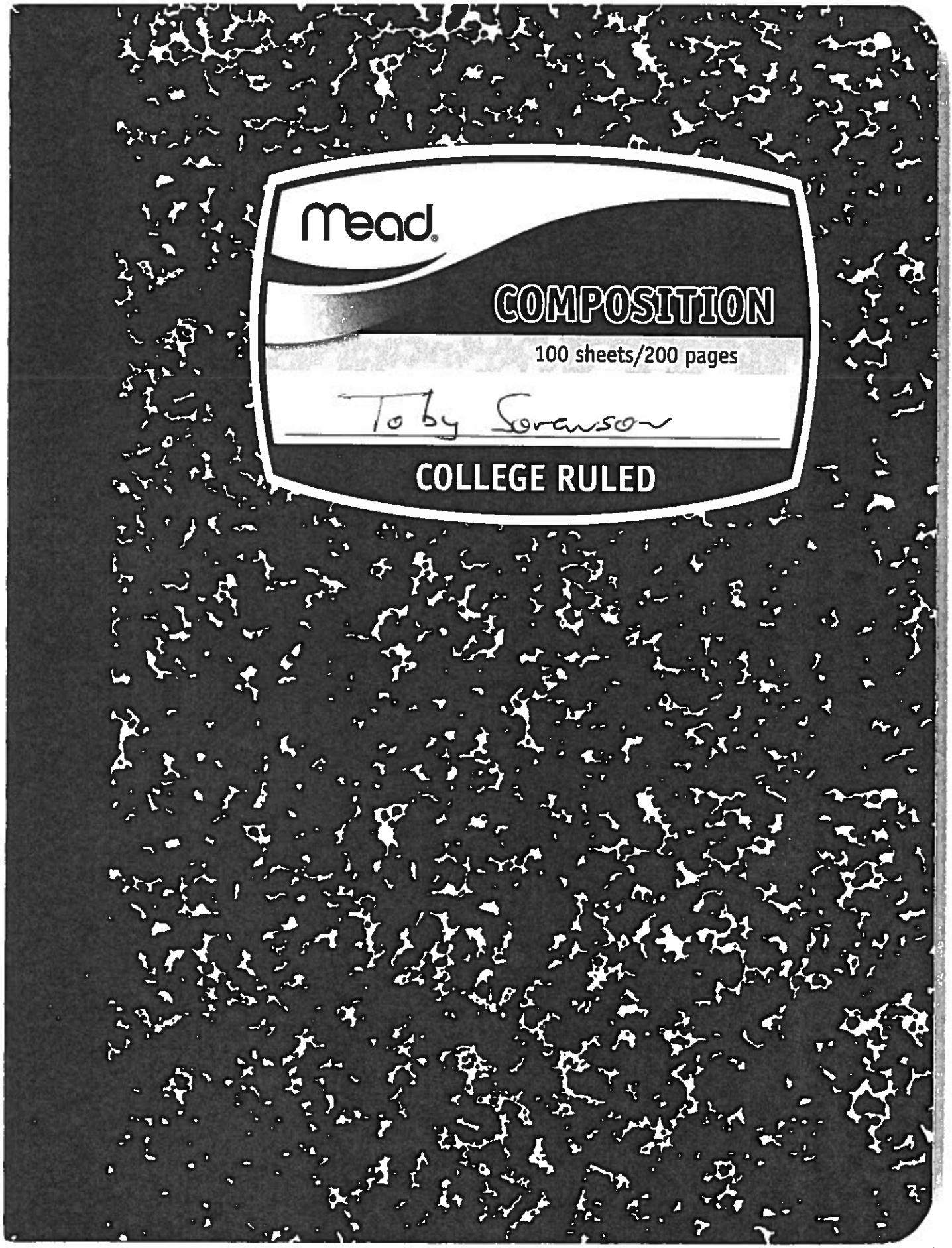
A number of actions were prompted – I don't recall the specific order: calls for emergency services support, calls for helicopter support, calls for low-chase to help identify SS2 during its descent, relayed calls to WK2 when Low-Chase was out of comms. Many others.

At some point after the telemetry stream was lost, the secondary station-keeper on the BOOST station rewound the data stream to the initial boost phase. We conferred to see if there was anything we had missed indicating a possible Propulsion malfunction. Indications showed a healthy rocket startup and healthy continued burn-in-progress before G in the vertical direction (Nz) rapidly increased, followed by loss of telemetry data.

While helicopters and emergency services were dispatched to the area of the flight, the TC began procedures to make sure that the flight data was secure, and that mission notes were saved. He also advised that each station begin writing up their notes of the flight while it was fresh in everybody's

head. My notes were recorded in my flight-test data card. These notes were retained by Scaled Security.

At some point, the SS2 pad manager, who had joined us in mission control, departed to connect with the ground crews. The rocket motor ground crew was being dispatched to help locate the crash site in order to help determine the safety of any pressurized or otherwise energetic components in the propulsion system.

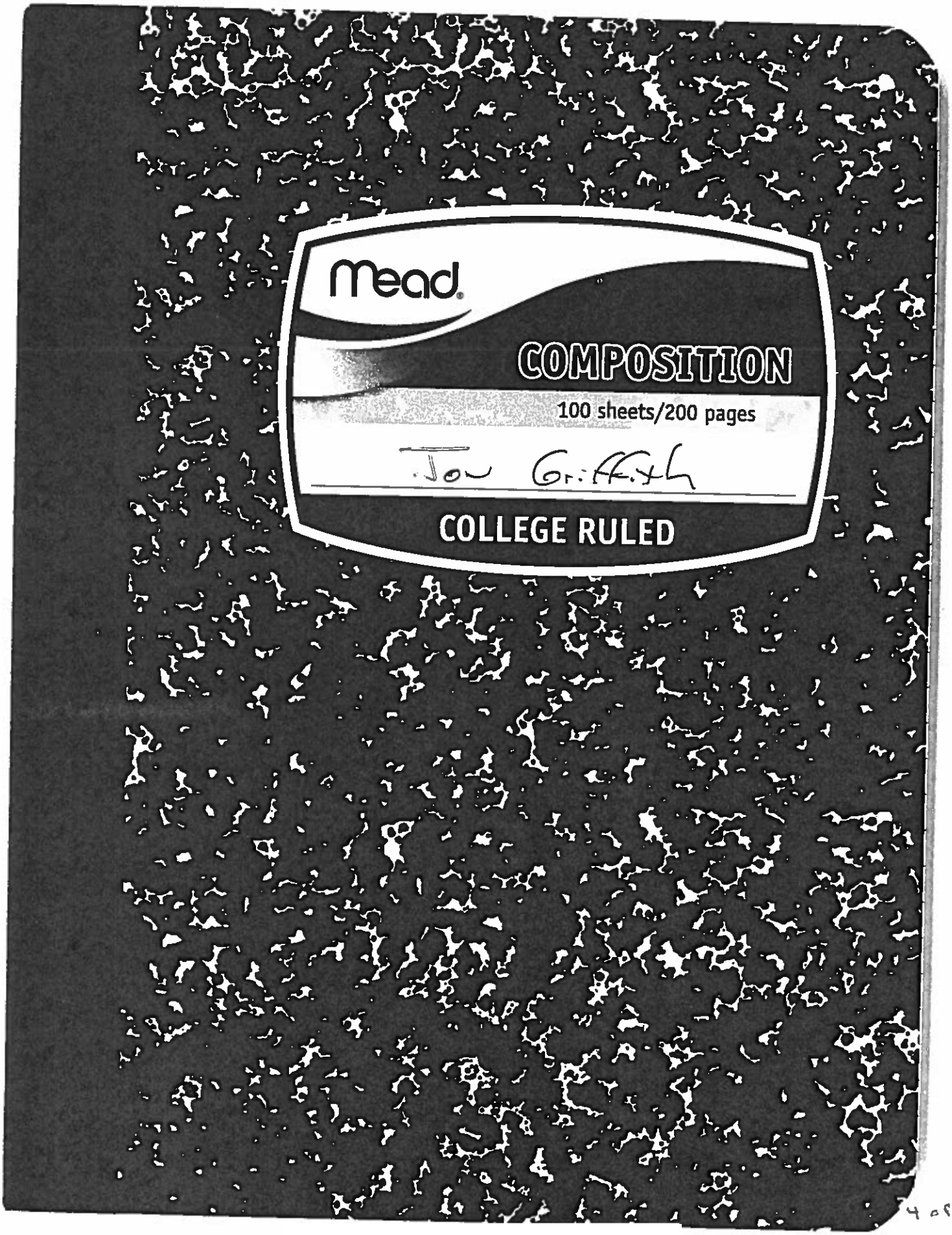

Mead
COMPOSITION
100 sheets/200 pages
Toby Sorenson
COLLEGE RULED

Toby Sorensen · Stabs PF04 10/31/14

At release
I was watching the stab positions after a few seconds I heard pilots ~~g~~ronting of g forces and a "hands" call. In the corner of my eye I saw the feather locks unlock - which confused me that it happened earlier than in training. (did not hear the crew call)
I called "Good unlock" to TC then looked at stabs positions that were still at -10° wh. at this time I was calling TC for a "set trim" and "Lock Feather" call ~~even~~ when TM was lost. ~~from~~ I estimate from the time of my "good unlock" call to lose of TM was about 2 to 3 seconds. At lose of TM I heard Aero call "Depart" & TC call "knock it off, KIO, KIO" Recall Galactic 03 call "One shoot" & EDW call ship in a spin
Pray for the families & everyone
Ron

~~Aero~~ L-10

Before release, All my systems looked good. I had one squawk, that the left stab string pot ~~drop~~ would move like noise in the system. I suspected the Stb. string pot to be bad as I had good paired Stab positions indications.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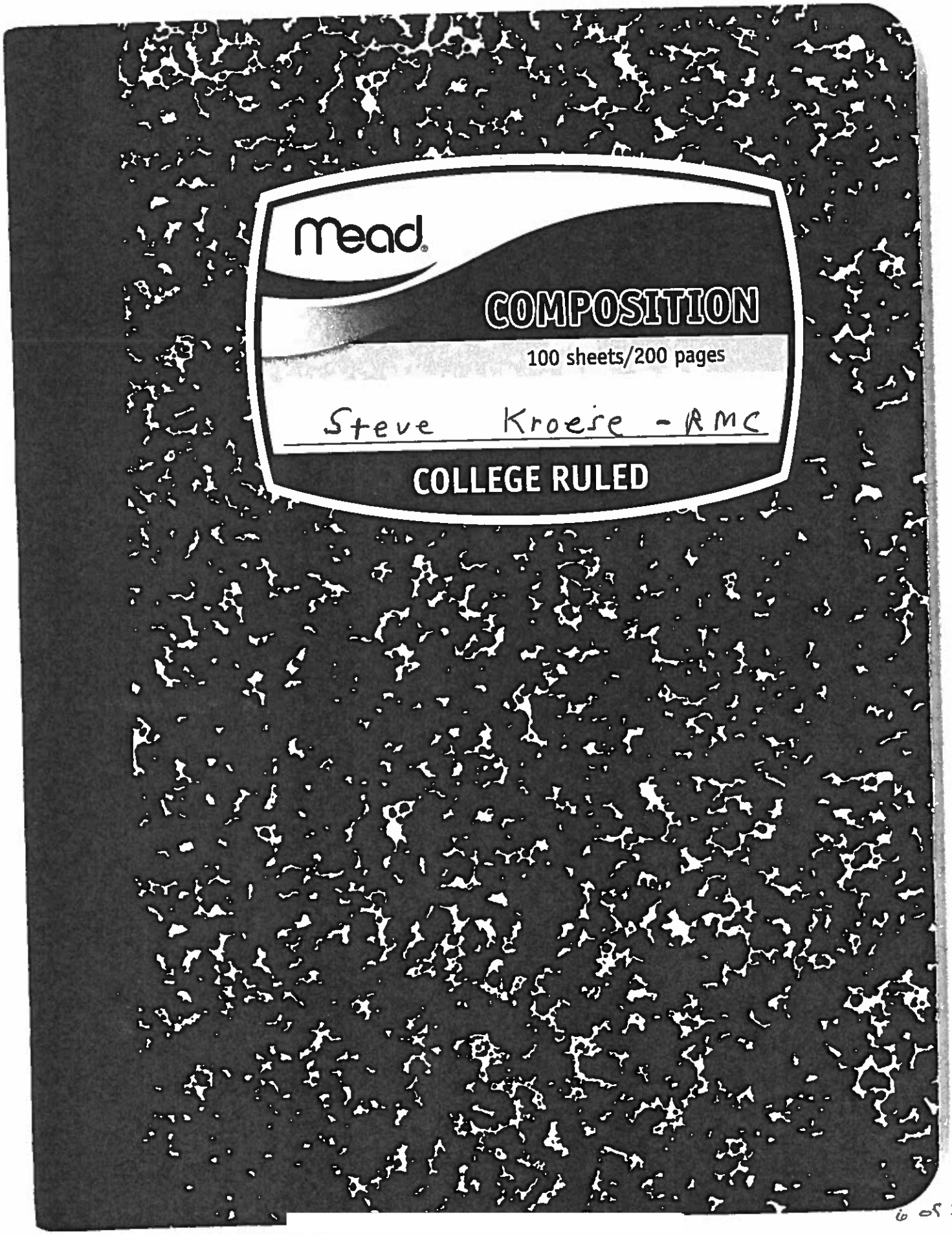
Jon Griffith
COLLEGE RULED

position was standing behind boost console, next to systems console.
PSC indications showing ~~PSS~~ PSC state between standby and unpowered intermittently but problem cleared during ascent.
All smooth during ascent to drop altitude.
Release and ignition were nominal from my standpoint and after talking with boost primary.
During boost, pilots sounded strained against the g-force but all nominal. At 1.4M, as per procedure, the feather was unlocked.
By observing the boom camera video, it became obvious that the feather had started to extend, motor still firing.
Video lost, data lost.
Vehicle next reported in inverted flat spin.
Chase calls one chute visible.
Chase reports two tail sections in debris

Jon Griffith.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COMPOSITION
100 sheets/200 pages
Steve Kroese - AMC
COLLEGE RULED

I came into work at about 3:15 AM. I noted at that time pressure offsets on several pressure sensors. Offset was about (b) (4) psi on the (b) (4) PSI sensors. When the ullage vent was closed all sensors returned to normal values. This is a known problem with the ullage vent circuit. Probably a grounding issue. It was not considered a safety factor for this flight.

Every thing on my console appeared to be completely nominal for the remainder of the flight up to the event.

An hour or so before takeoff I noted one breach detect sensor was indicating high / breach. It was on the left front side of the motor. I queried Boost station about this. Ken asked if it was on the left front of the motor. I confirmed that it was. He said it was the forced air heat going into the aft bay. After the heat was turned off, I immediately saw that sensor drop back to normal.

Throughout the morning [redacted] Jeremy (Backup RMC) was making excessive conversation [redacted] about trivial matters. He had a tendency to do this during Sim sessions as well. I would get distracted by this. This morning I briefed him twice to "keep the chatter down". Once before take off and once just before release. It helped a little, but there was still too much inappropriate [redacted] Conversation. I should have briefed him during the Sim sessions.

After release * I saw a nominal ignition sequence. [redacted]
Separation → Arm → Fire
No errors on my console - all nominal. After I heard the "Mach 1" call, I glanced down at the breach detector data window. All sensors [redacted] were dark blue - nominal. I [redacted] gave the "cold case" call over TC loop. I then looked back at my main window. I was hearing a lot of grunting or strained voices coming from the pilots. Then I heard some kind of commotion on coms and suddenly my screen was full of fault

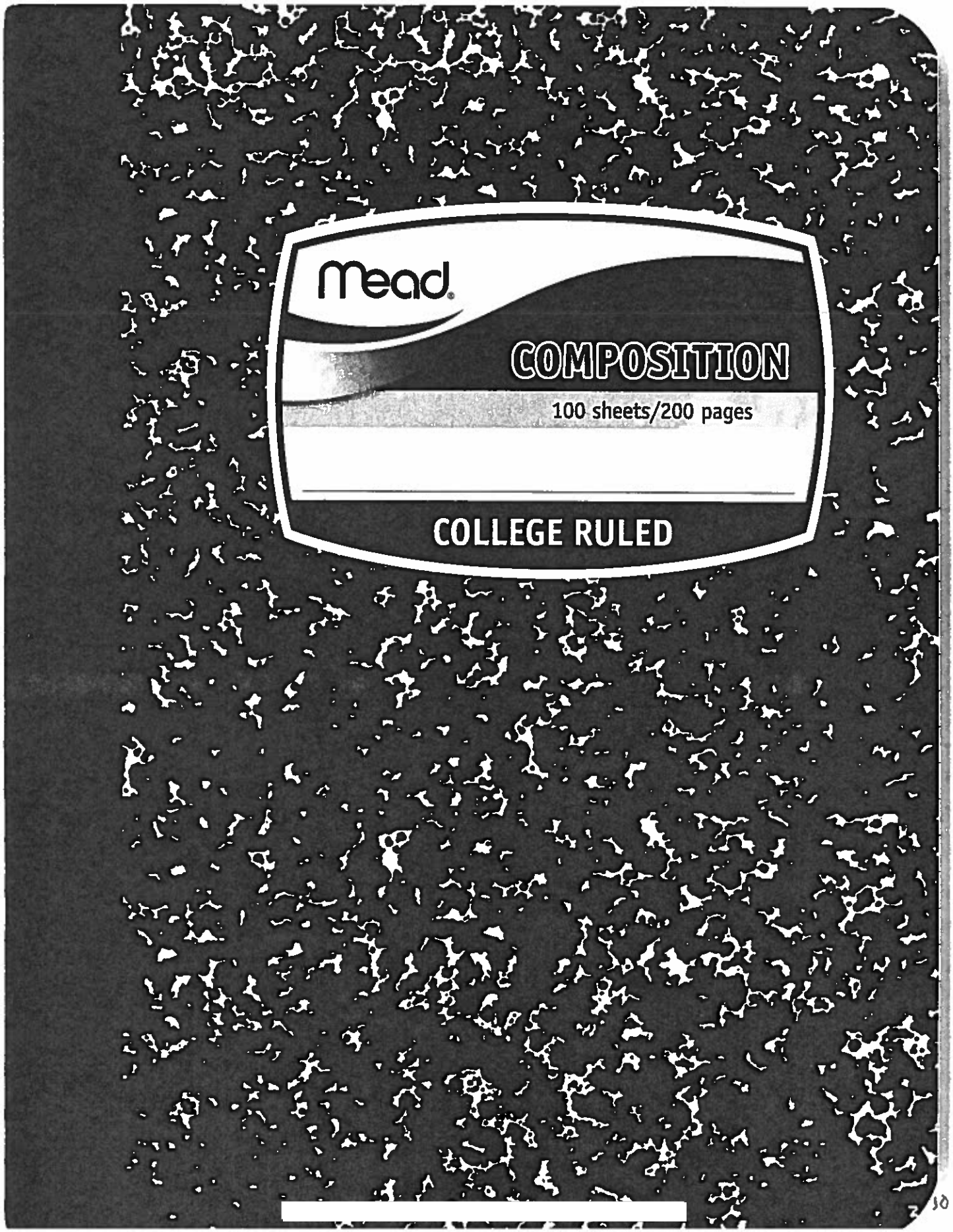
messages. Then my main screen went red, indicating loss of RMC data.

My screen froze in this condition. Some of my data was clearly invalid but some of it looked real.

These are the indications I think were real:

- The RMC commanded an ABORT at T+ 11.3 seconds
- The abort was due to the PT-M3 (MOV-CTN seal health) sensor being in a faulted condition. The fault could be caused by an extremely high pressure (over (b) (4) PSI). Or it could be some kind of electrical spike.
- I also saw many errors that looked like wires disconnected. It reminded me of the PF-07 hot fire test.

I can't think of any thing else right now.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BRIGHTON
10/31/14

FLIGHT CONDITIONS AND AIRCRAFT APPEARED NORMAL AT 20 BASE.

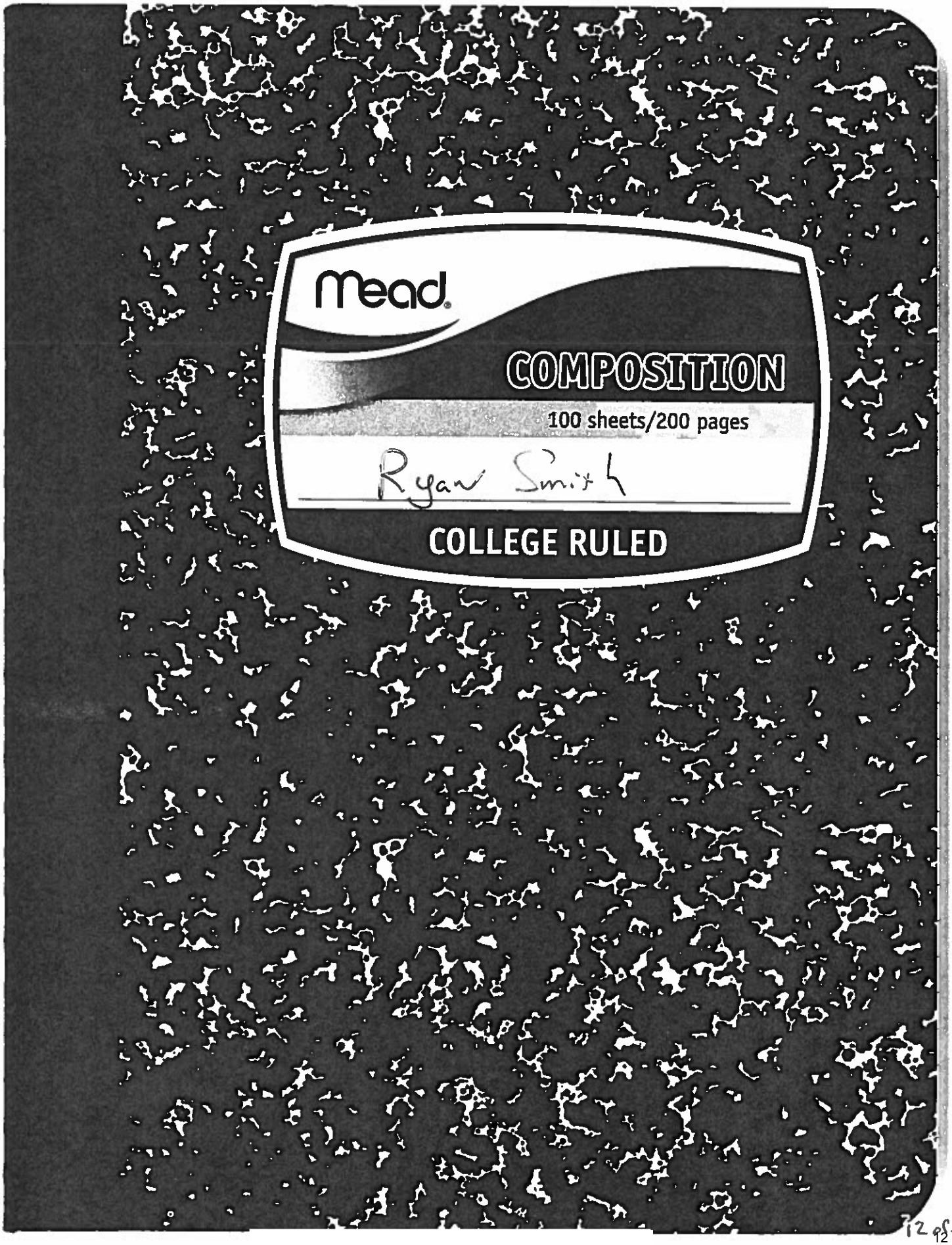
While training VEHICLE GOING INTO GAMMA TURN SAW THE EXPECTED CURRENT DRAW FROM THE ASTATS DID NOTICE ~~[illegible]~~ CURRENT OSCILLATIONS THAT CORRELATE TO TURN COMMANDS A BIT MORE THAN TYPICAL WHILE MONITORING THAT CONDITION, SAW THE LOFT BUS GO LOAD FOLLOWED ALMOST IMMEDIATELY BY A COMPLETE LOSS OF TM. AFTER LOSS OF TM WE HAD NO SITUATIONAL AWARENESS OF ANY THING IN THE VEHICLE.

DID NOT NOTICE ANY COMMS THROUGH EITHER HOST MIC OR UHF.

CHASE CALLED OUT VISUAL OF ONE CHUTE ONLY. CALLED OUT COLOR THAT THEY SAW

2 EXITS BUT ONLY ONE Chute

N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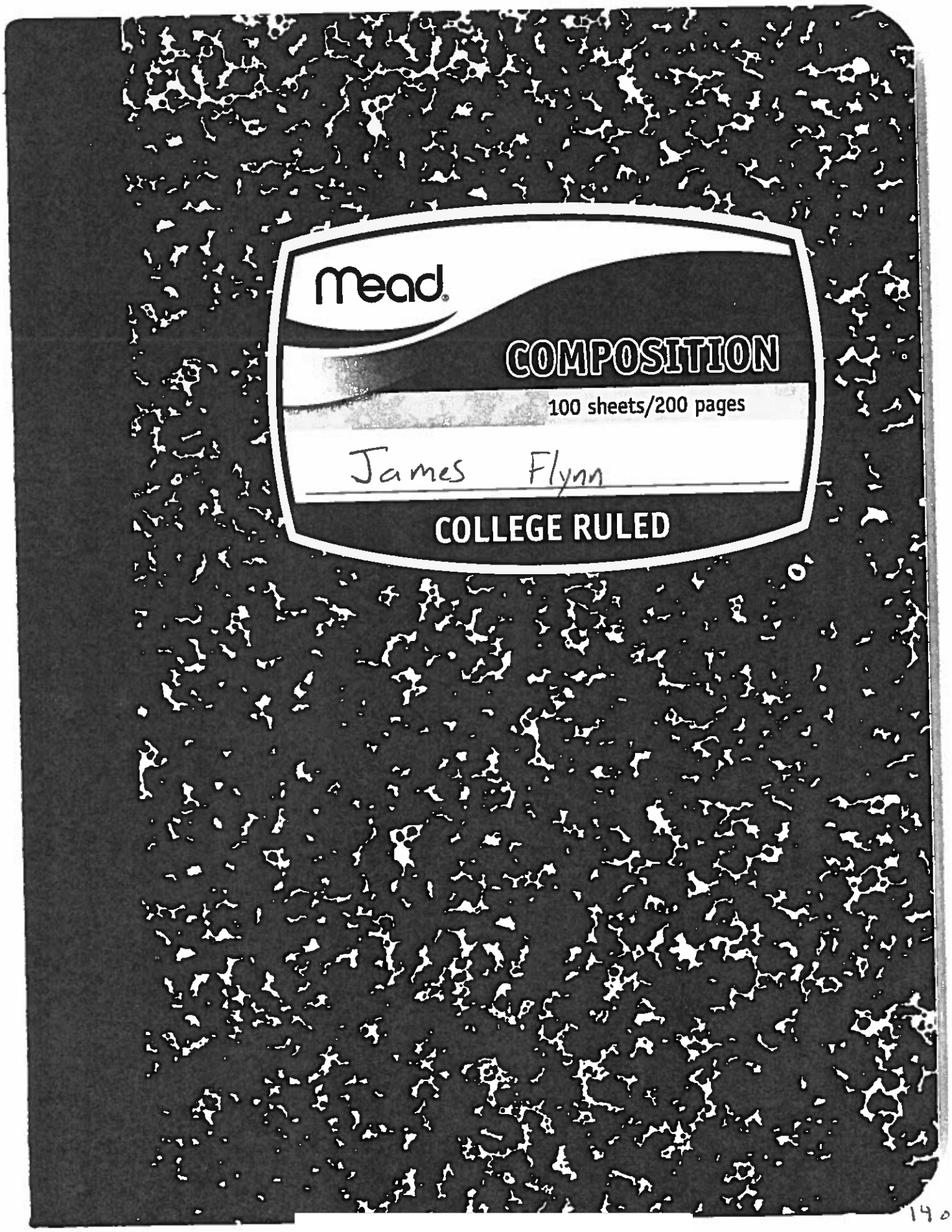
Ryan Smith
COLLEGE RULED

- Struts went well at least apparent as ready as any after fit.

- See Fit Card notes for info on only 6 tabs Station Squeak - left Stub Strut pt. Only point not in those notes is on GEZT @ touchdown. This Strut pt jumped in position on body. The 6 tab did not move, checked up to instr. Thus further evidence to support [redacted] Conclusion That strut pt offset discussed was instr only.

- [redacted]

- [redacted]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COMPOSITION
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James Flynn
COLLEGE RULED

James Flynn
TM/Avionics station

I didn't notice anything anomolous before the event. The first sign of anything was a complete loss of TM data. I thought I saw the feather folding up at the last instant but the video went away so fast I'm not sure.

~~Early in the flight~~ Before takeoff there was a PSC indication error. We tracked down the indication to a single discrete signal that was toggling between high and low. This signal is generated by the PSC and monitored by DAU 1.

Before the flight we had a failed DAU 1 and we replaced the power supply section with a spare unit and reinstalled in the vehicle. Not sure if the PSC indication error noted above could be related to this.

STAPLES

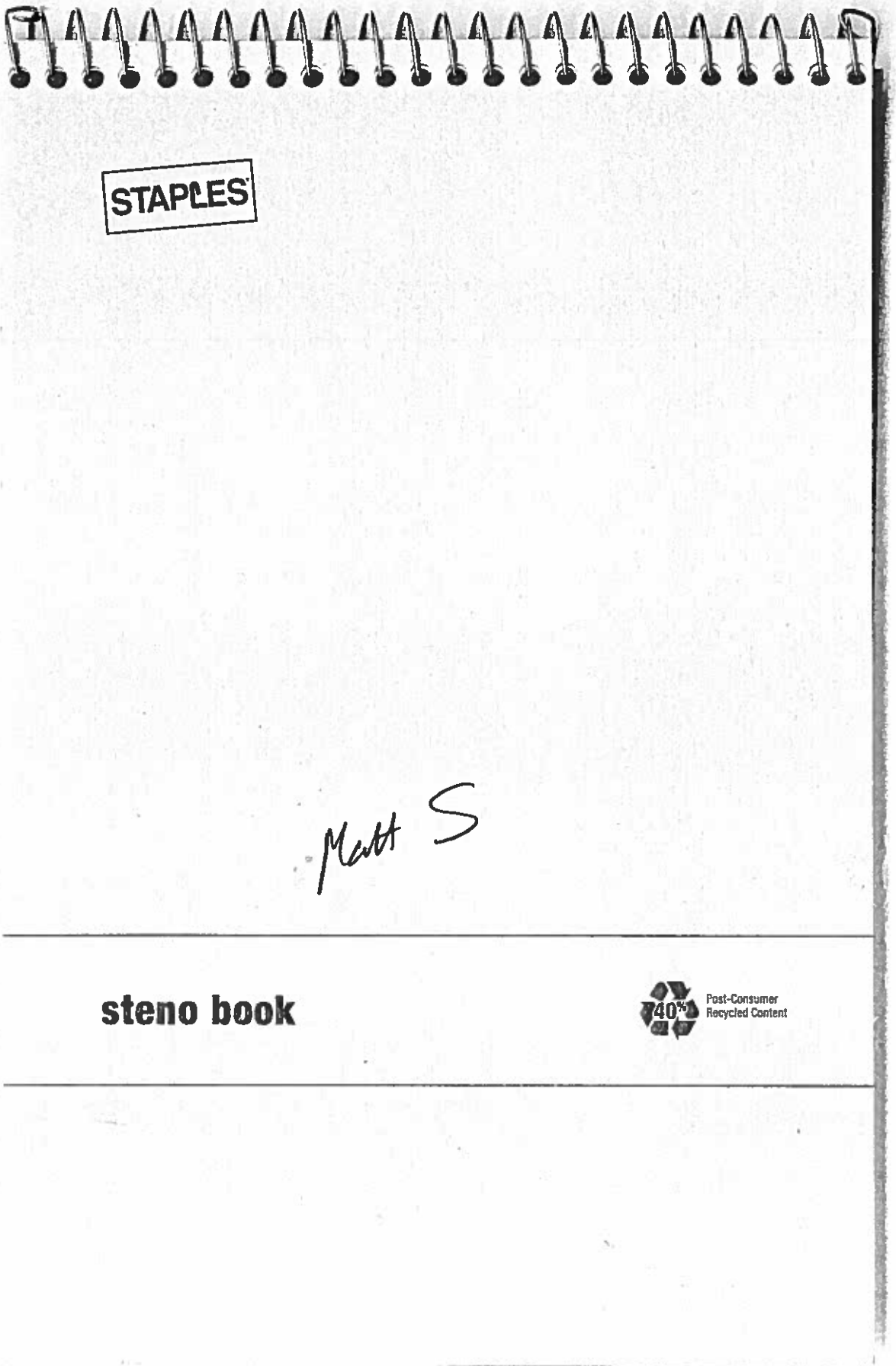
DNA MACKAY

steno book

40% Post-Consumer Recycled Content

We then heard the Extra calling that he had rolled and that it was in a spin. We searched the sky for any signs of the vehicle but saw nothing.

The Extra took over the scene commander role and followed the parachute down. We stayed above 10,000 ft and eventually spotted some wreckage. SAR seemed to be slow to reach the scene. We endured up to the point the first helo arrived and then had to return to Mojave due to low fuel state.


STAPLES
Matt S
steno book
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Matt Stinemetze Position WK2 FTE

+ Probably nothing ... Approx 30 sec prior to release felt what was interpreted as turbulence. It was light, but presented as a beating rumble in the airframe. I was standing looking out the window to film SS2 being dropped / Had video of release)

My feeling at the time was ~~that~~ I didn't recall the airframe - turbulence exciting a mode - that would beat (That is come and go). It wasn't overly noteworthy so when I asked Dave (Pilot) "do you feel that" and he commented "turbulence", I reasoned that made sense. I also noted the TTOP & SS2 tails & didn't see any activity (like flutter) so I put it out of my head.

* Following release we pitched up etc. All per normal
- All essay from that point forth was via comms. We didn't see the spaceship from that point forth.

- When "Lost TM" & other calls were made - the pilot started to maneuver to get visual.

- After approx 30 sec I caught glimps of the plume & could tell it was a short burn. We never recaptured the SSL, After lots of comms our last inding of what was happening was Galactic (O²) call of "ship in sight" & later "/chute"

- We orbited the crash site until Helos were on deck

STAPLES

Kalogiannis

steno book

Post-Consumer Recycled Content

Peter Kalogiannis — Tim

- DAV 1 anomalies morning of.
  - ~~Rec~~ Call @ 3am that DAV 1 had died
  - txt from Flynn asking if I was on the
  - Got in @ 4
  - DAV 1 still dead
  - Swapped Power Supply Section
  - Came up & started up
  - Saw RSC Analog - Status bits
  - ~~Eng~~ indicating off when in standby
  - Normal release
    - Reached to Charge waypoint
    - After M[illegible] Call
    - No TM - seemed like after initial radiation
    - "Broken Arrow"
    - Coordinated w/ WOS
      Called Inverted Flat Spin
    - 1 chute

STAPLES

Zachariah
Swetky
PF04

steno book

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Zachariah Swetky 10/31/14
Mission Control Center Engineer
Aero Console Secondary

PF04

Preflight: (~~Friday~~ prior)
noted discrepancy between Left HStab position indications. Stringpot and actuator positions disagreed ~~2~~ -2° depending on actual position. Actuator position was shown to be accurate based on compass ~~one~~ boom skin. Since indications ~~are~~ were redundant, and pilots set trims based on actuator position, this was acceptable for flight. Calibrations were re-checked, and shown to be done as well as possible.

Preflight went otherwise well for aero station. Flight controls looked good. all within tolerances.

Flight:

Winds looked to be within launch and landing limits through 11a.m per 1am balloon sounding.

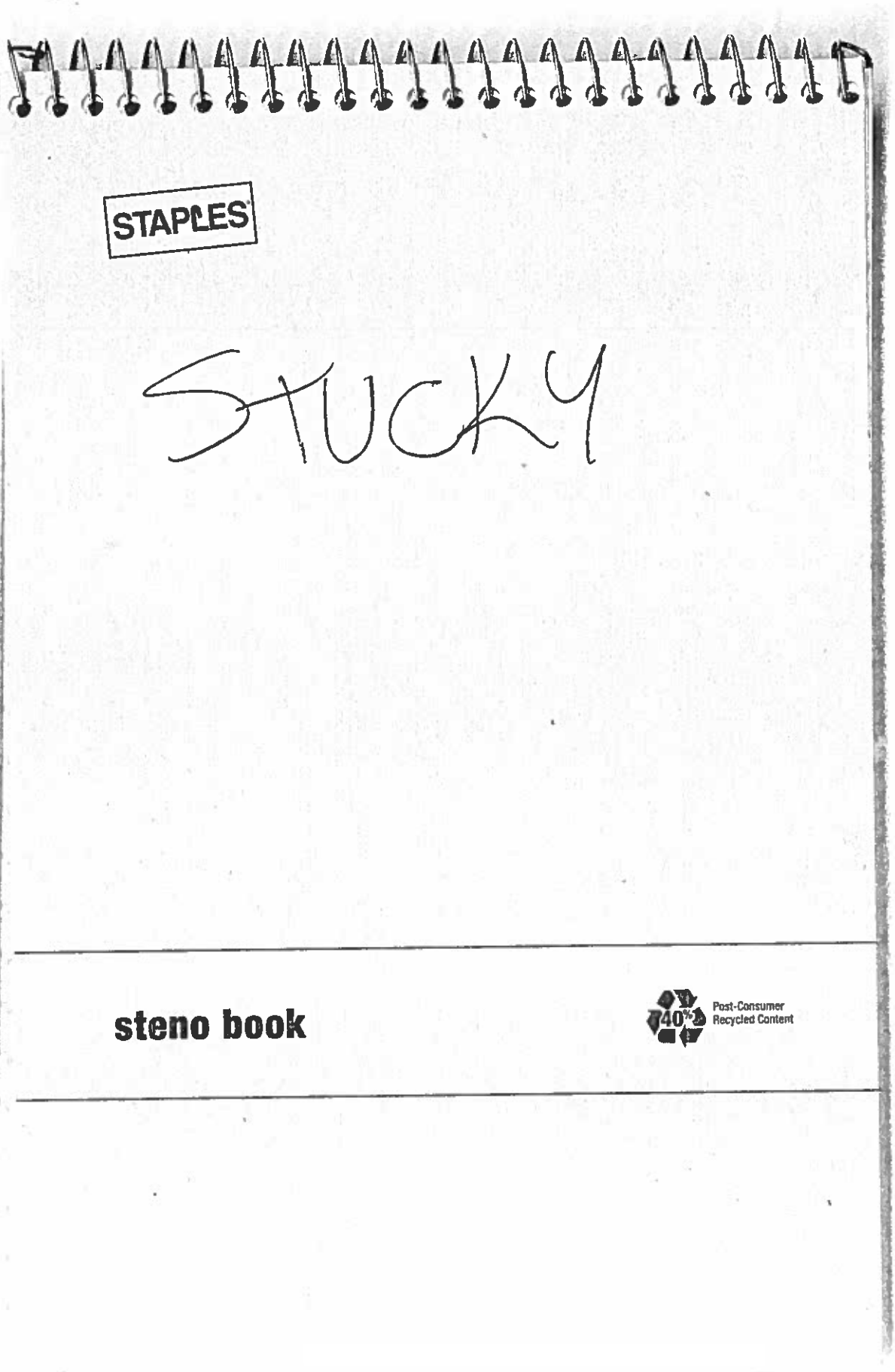
DAU1 had failed prior to the flight. It was replaced and appeared fully functional during T/O & climb. PSC showed intermittent switching between "standby" & "unpowered" modes, but functioned correctly during "pre-pres." This demonstrated that it was an intermittent indication failure with no impact on safety of flight.

Aero station checked "commit to" criteria at each stage leading up to the accident. Prior to release, winds were good, rudders were faired (-1.2L, +1.2R approx), dampers on, trims set per prev. powered flights, stick fwd, roll boost on. Wer released and fired the motor.

I watched angle of attack (alpha) vs. burn time and HStab position vs burn time. I first noticed that we passed through the transonic regime without incident. As expected, alpha jumped up briefly along the predicted curve almost exactly and came back down to nominal. A few seconds later, I noticed that the HStab pitch setting was not moving toward the nominal (b) (4) position. It remained at a less negative value. As I started to inform Mark (Aero primary), I noticed alpha rapidly increase out of range. At this point, we lost ~~TM~~ telemetry and communication with the cockpit. Maybe 30s later, Wes P. called us from Joshua (EDW) indicating the vehicle was in an inverted spin. Joshua (EDW) saw with the telescope.

Chase then saw one parachute before EDW saw SS2-001 hit the ground.

also saw feather lock come open.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The drop & ignition appeared nominal. I made the "good plume" call & watched for the transonic pitch-up at 0.9 Mach. The moment that occured I expected to hear Pete call "trimming" but instead heard "unlocking the feather." (I thought it was Mike's voice). That really surprised me and I looked at the Mach & noted 0.94 M. The TM immediately terminated at that point and the last cockpit frame of video was both pilots slumped forward under high G.

Mark P. Stucky
10/31/2014

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Jerney Gajadhar

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Jermey Gajadhar 10-31-14

- Initial issues on ground with PSC indication
- Pre pressurization verified that it was just a DAU1 indication
- In climb we have center MFD reset
- Nominal release
- Rocket Motor fire (NO issues)
- Heard normal mission script call till "Feather Unlock"
- Then lost TM and RMC data went invalid. There were status information from the RMC : Breach Detect with two hot sensors
  : Nozzle temps were high over limit
  : Seal temp was over temp
  : RMC shutdown commands
  : RMC discrete logic board failure
- Not sure all data is valid due to TM drop out and data was locked down.

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T / 6.4E

Preflight

DAU 1 Fault
PSC UNPOWERED / FLICKER
(NO FAULT IN FLIGHT)

Climb

No Issues

Release

Good light
~ 10° sec
Φ: normal pitch up
14 alpha (nominal)
40 Roll
80 theta
loss of Comm

STAPLES

Mark Bassett

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Mark Bassett 10-31-2014
Radio calls of release, arm fire, normal indications accelerating towards Mach 1. Call "Mach 1 on energy" to control room. ADI Snaps inverted. Call "Pitch up" Telemetry lost. N_z last shown off scale positive. feather motion indicated briefly before data loss Stab + Elevon hard over.
No communications w/ 552 Wes (Phone w/ EDW) says vehicle is in inverted flat spin.
One parachute called
Wes looses view of 552 below horizon
CJ (extra) says he sees a thumbs up from parachuted crew.
CJ begins search for wreckage, at least 3 pieces found on N edge of Mohen dry lake

feather halves + fuselage
largest components.
No word on 2nd crewmember.

STAPLES

Will Robertson

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Will Robertson - Systems cons. (Brave)

Nothing anomalous for pneumatics was noted.
All but one Tc appeared normal.
Tc on right wingtip was reading with a 70C offset high. Although reading high, this sensor is not associated with any a # commit limit.

Drop appeared nominal. It appeared to me ~~the~~ after reflection that the feather locks may have been unlocked early. This is speculative on my part as I have no telemetry to provide insight. This is based off of the timing of events I'm used to in training.
Immediately following unlock TM dropped. TC called abort abort abort within seconds. - END Notes -


SCALED
COMPOSITES

Statement of Scot Story, 2014-11-04

Age: 47

Project Engineer

I started at Scaled Composites in the fall of 1991. I left the company to pursue other interests in 1996. I rejoined the company in the summer of 2006. I was the Structures lead for the spaceship vehicle during the build from 2006 to 2010. I then transitioned to the Spaceship Project Engineer when flight testing began in 2010.

My control room duty was the Systems Station. This station monitors the Environmental Control System (ECS), Pneumatic System pressures, and various temperatures related to the Bleed Heat System. My job duties were to monitor the health of the cabin environment by watching the cabin altitude, monitoring the pneumatic system pressures for anomalies such as leaks, and watching the bleed heat temperatures to ensure the bleed system from the mothership was working. In addition, this station had signals for the dampers, the speedbrake, and the landing gear. The Pneumatic System includes the wing leading edge bottles which power the feather locks, feather acutators, speedbrakes, gear deploy, ECS, and Reaction Control System (RCS).

Prior to the release, all the systems I was monitoring were operating normally. The feather locks were cycled before flight and behaved normally as did the bottle and regulated pressures. The cabin leak check showed that the cabin was well sealed and ready for flight. All temperatures were also normal. In addition, the landing gear was up and locked, and the dampers were operating properly.

Prior to the loss of the telemetry data, my systems were behaving normally. I heard the call ‘unlocking’ and saw pressure indications that showed that the locks had opened just before the loss of telemetry.

After the loss of telemetry, the TC repeatedly tried to contact the crew. As it became apparent there was a major problem, the TA began to call in the emergency teams for search and rescue. The chase plane relayed back the crash site and the location of the survivor to aid the search and rescue teams. Once the site was secured and the survivor taken to the hospital, the control room staff was asked to record any observations they might have and give those and their notes to security. I didn’t feel I had any unique observations that would identify the cause of the accident, so I didn’t make note of anything.

Statement of Cedric Gould, 2014-11-03

Age: 31

Design Engineer

SCALED Composites

Since shortly after starting at Scaled in May 2008, my responsibilities on the Tier1B program have included performance predictions and analyses of the propulsion system, data acquisition, reduction, and analysis of ground testing results. Once the propulsion system matured sufficiently to be integrated within SpaceShipTwo, the natural segway was to continue these types of functions in support of flight test operations.

For the mission in question, my role and responsibility was Secondary for the Propulsion System Mission Control Ground Station, referred to within Mission Control as the 'Boost' Station. This means that my function was to support the Primary 'Boost' station keeper in maintaining situational awareness and proper functionality of the propulsion related systems on board SpaceShipTwo.

The morning of the mission, prior to takeoff, one propulsion subsystem indication anomaly was noted – that one of the Pressurization System Controller (PSC) state status indications (a discrete electrical signal) was dithering. Based on the other propulsion system data, it became apparent that the status indication was a misleading one and that the other propulsion system health indications within the system showed that the PSC was, in fact, healthy and operating normally. The decision was made to continue with normal flight operations, noting the indication issue. As I recall, the status indication stopped dithering and was indicating nominally after takeoff through to the loss of telemetered data.

All propulsion system pre-launch checks were completed nominally prior to release from WhiteKnightTwo. Once released, I observed a nominal rocket motor ignition by way of the telemetered data displayed at the 'Boost' station and the SS2 Boom Camera view, also telemetered to the ground control station. The pressure data indicated good motor stability and the rocket motor plume was clear and steady, all indicating expected in-flight performance of the propulsion system.

Things happen in a near-simultaneous timeframe within the control room as with SpaceShipTwo. Once the rocket motor pressure reaches the nominal expected value and the nozzle plume is steady and clear, the Primary 'Boost' station keeper declared 'Good Light' to the Test Conductor communication loop in Mission Control to validate that the propulsion system has started nominally. The last internal ground control communication call I remember hearing was 'Mach 1, On Energy' from the 'Aero' station, nearly coincident with my observing the SpaceShipTwo feather deploying and the motor still running. At this point the telemetry feed of data into the control room ceased and the last frame of SS2 Boom Camera footage remained frozen on the 'Boost' console screen.

In the immediate few minutes following the event, I don't explicitly recall many of the specific control room communications. I do remember the gist of what was going on – the Test Conductor was handling radio communications with WhiteKnightTwo and the low altitude chase vehicle, an Extra 300, in an

effort to get some insight as to what they could see happening and going on with SpaceShipTwo. The Technical Assistant was primarily handling outside communications via the emergency phone, I believe talking with Emergency Response and other responders. At one point there were calls made to, I believe, China Lake and offers of assistance from the National Test Pilot School with helicopters to help find the crew members and debris from the vehicle.

At the 'Boost' station, my focus turned to reviewing the data with the Primary 'Boost' station keeper, trying to determine whether the propulsion system had contributed to what had, at that time, appeared to be an in-flight breakup of the flight vehicle. A cursory review of the data indicated nothing abnormal about the operation of the propulsion system. It was shortly after this determination that an effort to secure the telemetry data was made, thereby removing access to any further in depth review of said data.

Once the situation was more or less established, we were asked to make notes about our observations of what we saw occur with the flight. My post-flight notes reside on the right-hand half of Card 7 of my Flight Test Data Card.