http://www.columbiadisaster.info

Megalightning and The Demise of STS-107 Space Shuttle Columbia

A Fresh Look at the Available Evidence

(aka davesmith_au, davesmith1au)

The Launch of STS-107 on January 16, 2003

Contents

Reading notes:

- Quoted text is in colored font and quoted image captions are in *colored italics*.
- All images in this pdf can be "clicked" to view a larger and/or better resolution copy of the image from the columbiadisaster.info site.
- Click on a contents item to go to the section listed, and click on any heading in the body to return to the contents.

Introduction

Section 1.a

Since the unfortunate demise of the Space Shuttle *Columbia* on 1 February 2003, there has been much public debate particularly on various internet sites and forums, over the cause of the disaster, despite the release of the official report of the Columbia Accident Investigation Board (CAIB) in August of 2003.

Most of this debate has centered on two main questions.

- *Did damage caused by a foam strike on launch cause the disaster?*
- *Did an electrical discharge event now known as "megalightning" occur in the upper atmosphere upon reentry contributing to the demise of the shuttle?*

The suggestion of the second of these options was motivated by a curious photograph taken by an amateur astronomer during the orbiter's reentry as reported in the San Francisco Chronicle dated Wednesday 5 February, 2003.

It is not the intention of this paper to offer 'the truth' or a 'better theory' than other commentators, but to compare some of the published materials in the hope of coming to a better understanding thereof.

The official summary from the CAIB report (Vol 1 page 49) is as follows:

> The physical cause of the loss of Columbia and its crew was a breach in the Thermal Protection System on the leading edge of the left wing. The breach was initiated by a piece of insulating foam that separated from the left bipod ramp of the External Tank and struck the wing in the vicinity of the lower half of Reinforced Carbon-Carbon panel 8 at 81.9 seconds after launch. During re-entry, this breach in the Thermal Protection System allowed superheated air to penetrate the leading-edge insulation and progressively melt the aluminum structure of the left wing, resulting in a weakening of the structure until increasing aerodynamic forces caused loss of control, failure of the wing, and breakup of the Orbiter.

The second possible scenario is that of a megalightning strike as suggested at thunderbolts.info, holoscience.com, superforce.com, several media outlets, and on a number of internet forums.

From the Thunderbolts site:

> ... Did a super-bolt of lightning--called "megalightning"--strike Columbia, causing the breakup of the craft?

> Shocking evidence that this is so includes the image above, taken from the TV program "Megalightning." It shows a purplish corkscrew trail of "something" merging with the ionized plasma trail of Columbia early in its descent, while Columbia was still 63 kilometers above the earth. One might have expected this image to catch the attention of media around the world. But before that could happen, both the camera and the photograph were examined by NASA scientists.

These two scenarios are considered here. The foam strike is the official version of events and the megalightning possibility has been offered in several public arenas as there is emerging evidence that megalightning can occur in clear sky conditions.

These arenas include www.thunderbolts.info and www.holoscience.com.

I will present evidence that includes information from telemetry and records that are not likely to have been altered or faked post the demise of Columbia. That evidence would fulfill the legal requirements of established fact if presented in a court of law. That is to say, it is beyond **reasonable** doubt.

There has been much other speculation involving varying conspiratorial scenarios. These are not discussed here, as there has been little if any published material of any validity offered in support of them.

From information in the CAIB report I have developed two précis of relevant events.

The first is a comprehensive summary of launch events and in-flight data relevant to the possibility of a foam strike causing damage to the space shuttle on launch. The second, to be discussed later in this paper includes a reentry timeline incorporating telemetry from the orbiter and ground tracking stations and a list of known communications drop-outs, and also a discussion about megalightning events.

The Foam Strike

Vision of the Impact

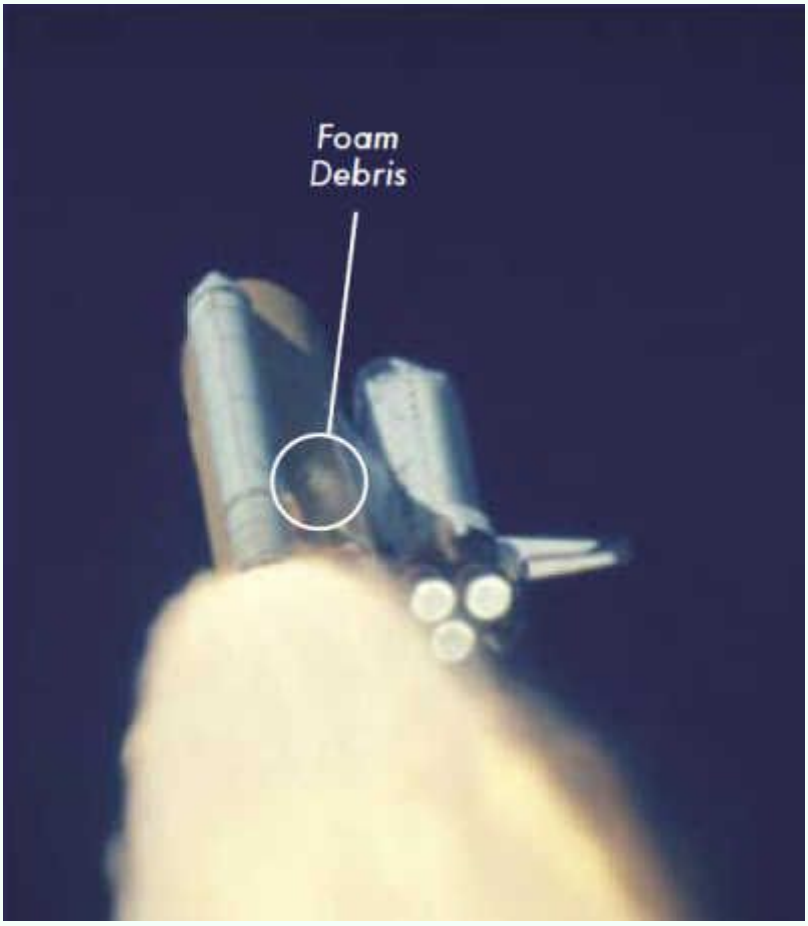
Section 2.a

81-82 seconds from launch of STS-107, at around 65,850 ft a "briefcase sized" piece of foam called the "left bipod ramp" shed from the External Fuel Tank and struck the leading edge of the orbiter's left wing, with a relative impact velocity

of around 545mph.

CAIB report Vol 1 page 34:

> Post-launch photographic analysis showed that one large piece and at least two smaller pieces of insulating foam separated from the External Tank left bipod (–Y) ramp area at 81.7 seconds after launch. Later analysis showed that the larger piece struck Columbia on the underside of the left wing, around Reinforced Carbon-Carbon (RCC) panels 5 through 9, at 81.9 seconds after launch (see Figure 2.3-2). *Further photographic analysis conducted after launch revealed that the large foam piece was approximately 21 to 27 inches long and 12 to 18 inches wide, tumbling at a minimum of 18 times per second, and moving at a relative velocity to the Shuttle Stack of 625 to 840 feet per second (416 to 573 miles per hour) at the time of impact.
>
> [*Original sentence corrected as per Errata Vol 2 Appendix D.b page 19.]



A shower of foam debris after the impact on Columbia's left wing.
The event was not observed in real time.
[Figure 2.a.1]

CAIB Report Vol 3 Appendix E.2 Page 55

> Only Object 1 was confirmed to impact the left wing. There is no conclusive evidence of more than one debris impact to the Orbiter. A large, light-colored cloud, which emanated from the underside of the left wing due to debris

impact (Figure 4.3.2.1f), was first observed at 016:15:40:21.863 UTC. Within the post-impact cloud, at least two large pieces of debris were observed and measured (see Section 4.3.2.6). There is no conclusive visual evidence of post-impact debris flowing over the top of the wing.

Debris impact cloud seen on E-212 (Frame 4924)
[Figure 2.a.2]

Further Evidence of the Impact

Section 2.b

For further evidence that the impact did take place, and that there was some concern for the amount of damage such a strike could inflict, we need only to go to Chapter 6 of the CAIB Report, particularly section 6.3.

CAIB Report Vol 1 page 140:

6.3 DECISION-MAKING DURING THE FLIGHT OF STS-107
Initial Foam Strike Identification

As soon as Columbia reached orbit on the morning of January 16, 2003, NASA's Intercenter Photo Working Group began reviewing liftoff imagery by video and film cameras on the launch pad and at other sites at and nearby the

> Kennedy Space Center. The debris strike was not seen during the first review of video imagery by tracking cameras, but it was noticed at 9:30 a.m. EST the next day, Flight Day Two, by Intercenter Photo Working Group engineers at Marshall Space Flight Center. Within an hour, Intercenter Photo Working Group personnel at Kennedy also identified the strike on higher-resolution film images that had just been developed.
>
> [...]
>
> Because they had no sufficiently resolved pictures with which to determine potential damage, and having never seen such a large piece of debris strike the Orbiter so late in ascent, Intercenter Photo Working Group members decided to ask for ground-based imagery of Columbia.

Sadly, the requested ground-based imagery never eventuated. The Report goes on to discuss several requests for imagery, and the "missed opportunities" to properly assess the damage and possibly effect a repair/rescue mission.

From Flight Day Two and onward through the mission, the Board identified no less than three requests for ground/satellite based imagery and no less than eight missed opportunities for further action.

CAIB Report Vol 1 pages 166/7:

> **IMAGERY REQUESTS**
>
> 1. Flight Day 2. Bob Page, Chair, Intercenter Photo Working Group to Wayne Hale, Shuttle Program Manager for Launch Integration at Kennedy Space Center (in person).
>
> 2. Flight Day 6. Bob White, United Space Alliance manager, to Lambert Austin, head of the Space Shuttle Systems Integration at Johnson Space Center (by phone).
>
> 3. Flight Day 6. Rodney Rocha, Co-Chair of Debris Assessment Team to Paul Shack, Manager, Shuttle Engineering Office (by e-mail).
>
> **MISSED OPPORTUNITIES**
>
> 1. Flight Day 4. Rodney Rocha inquires if crew has been asked to inspect for damage. No response.
>
> 2. Flight Day 6. Mission Control fails to ask crew member David Brown to downlink video he took of External Tank separation, which may have revealed missing bipod foam.
>
> 3. Flight Day 6. NASA and National Imagery and Mapping Agency personnel

> discuss possible request for imagery. No action taken.
>
> 4. Flight Day 7. Wayne Hale phones Department of Defense representative, who begins identifying imaging assets, only to be stopped per Linda Ham's orders.
>
> 5. Flight Day 7. Mike Card, a NASA Headquarters manager from the Safety and Mission Assurance Office, discusses imagery request with Mark Erminger, Johnson Space Center Safety and Mission Assurance. No action taken.
>
> 6. Flight Day 7. Mike Card discusses imagery request with Bryan O'Connor, Associate Administrator for Safety and Mission Assurance. No action taken.
>
> 7. Flight Day 8. Barbara Conte, after discussing imagery request with Rodney Rocha, calls LeRoy Cain, the STS-107 ascent/entry Flight Director. Cain checks with Phil Engelauf, and then delivers a "no" answer.
>
> 8. Flight Day 14. Michael Card, from NASA's Safety and Mission Assurance Office, discusses the imaging request with William Readdy, Associate Administrator for Space Flight. Readdy directs that imagery should only be gathered on a "not-to-interfere" basis. None was forthcoming.

The information which led to the above summary was gathered from various logs of meetings, telephone conversations, personal conversations and emails, all of which occurred before Columbia's demise. It is therefore impossible (bar for the wildest of conspiracy theorists) to suggest that the foam strike was falsified after the event to "cover up" the "real" cause of the disaster.

Debris Strike Analysis

Section 2.c

CAIB report Vol 1 page 37:

> As is done after every launch, within two hours of the liftoff the Intercenter Photo Working Group examined video from tracking cameras. An initial review did not reveal any unusual events. The next day, when the Intercenter Photo Working Group personnel received much higher resolution film that had been processed overnight, they noticed a debris strike at 81.9 seconds after launch.
>
> [...]
>
> The object's large size and the apparent momentum transfer concerned Intercenter Photo Working Group personnel, who were worried that Columbia had sustained damage not detectable in the limited number of views their tracking cameras captured.

> [...]
>
> After discovering the strike, the Intercenter Photo Working Group prepared a report with a video clip of the impact and sent it to the Mission Management Team, the Mission Evaluation Room, and engineers at United Space Alliance and Boeing. In accordance with NASA guidelines, these contractor and NASA engineers began an assessment of potential impact damage to Columbia's left wing, and soon formed a Debris Assessment Team to conduct a formal review.

CAIB report Vol 1 page 36:

> Flight Day 8, Thursday, January 23
>
> [...]
>
> Mission Control e-mailed Husband and McCool that post- launch photo analysis showed foam from the External Tank had struck the Orbiter's left wing during ascent. Mission Control relayed that there was "no concern for RCC or tile damage" and because the phenomenon had been seen before, there was "absolutely no concern for entry." Mission Control also e-mailed a short video clip of the debris strike, which Husband forwarded to the rest of the crew.

It is demonstrated quite clearly by all of the **pre-incident** information above that there is *no doubt* that a foam debris strike occurred during the launch of Columbia. Whether or not the strike caused any *significant* damage is discussed in the following sections.

Foam Strike Damage

The "Flight Day 2 Object"

Section 3.a

CAIB report Vol 1 page 35:

> Not known to Mission Control, the Columbia crew, or anyone else, between 10:30 and 11:00 a.m. on Flight Day 2, an object drifted away from the Orbiter. This object, which subsequent analysis suggests may have been related to the debris strike, had a departure velocity between 0.7 and 3.4 miles per hour, remained in a degraded orbit for approximately two and a half days, and re-entered the atmosphere between 8:45 and 11:45 p.m. on January 19. This object was discovered after the accident when Air Force Space Command reviewed its radar tracking data.

CAIB report Vol 1 pages 62-63:

> Immediately after the accident, Air Force Space Command began an in-depth review of its Space Surveillance Network data to determine if there were any detectable anomalies during the STS-107 mission. A review of the data resulted in no information regarding damage to the Orbiter. However, Air Force processing of Space Surveillance Network data yielded 3,180 separate radar or optical observations of the Orbiter from radar sites at Eglin, Beale, and Kirtland Air Force Bases, Cape Cod Air Force Station, the Air Force Space Command's Maui Space Surveillance System in Hawaii, and the Navy Space Surveillance System. These observations, examined after the accident, showed a small object in orbit with Columbia. In accordance with the International Designator system, the object was named 2003-003B (Columbia was designated 2003-003A).
>
> The timeline of significant events includes:
>
> 1. January 17, 2003, 9:42 a.m. Eastern Standard Time: Orbiter moves from tail-first to right-wing-first orientation
> 2. January 17, 10:17 a.m.: Orbiter returns to tail-first orientation
> 3. January 17, 3:57 p.m.: First confirmed sensor track of object 2003-003B
> 4. January 17, 4:46 p.m.: Last confirmed sensor track for this date
> 5. January 18: Object reacquired and tracked by Cape Cod Air Force Station PAVE PAWS
> 6. January 19: Object reacquired and tracked by Space Surveillance Network
> 7. January 20, 8:45 – 11:45 p.m.: 2003-003B orbit decays. Last track by Navy Space Surveillance System

CAIB report Vol 1 page 63:

> In the Advanced Compact Range at the Air Force Research Laboratory in Dayton, Ohio, analysts tested 31 materials from the Orbiter's exterior and payload bay. Additional supercomputer radar cross-section predictions were made for Reinforced Carbon-Carbon T-seals. After exhaustive radar cross-section analysis and testing, coupled with ballistic analysis of the object's orbital decay, only a fragment of RCC panel would match the UHF radar cross-section and ballistic coefficients observed by the Space Surveillance network. Such an RCC panel fragment must be approximately 140 square inches or greater in area to meet the observed radar cross-section characteristics. Figure 3.5-1 shows RCC panel fragments from Columbia's right wing that represent those meeting the observed characteristics of object 2003-003B.[10]
>
> Note that the Southwest Research Institute foam impact test on panel 8 (see Section 3.8) created RCC fragments that **fell into the wing cavity**. These pieces are consistent in size with the RCC panel fragments that exhibited the required physical characteristics consistent with the Flight Day 2 object.

[Emphasis added]

CAIB report Vol 1 page 64:

> F3.5-1 The object seen on orbit with Columbia on Flight Day 2 through 4 matches the radar cross-section and area-to-mass measurements of an RCC panel fragment.
>
> F3.5-2 Though the Board could not positively identify the Flight Day 2 object, the U.S. Air Force exclusionary test and analysis processes reduced the potential Flight Day 2 candidates to an RCC panel fragment.

RCC Panel Tests

Section 3.b

Due to the observed foam strike on launch and the Flight Day 2 object's discovery, the CAIB set up a sophisticated test regime designed to ascertain if in fact a piece of foam could, under launch separation conditions, seriously damage an RCC panel. From video evidence, telemetry data, computer modeling and debris recovery analysis it was found that the most likely place of the proposed breach was on or around RCC panel #8.

A device was constructed to replicate, as near as possible, the approximate velocity and trajectory of a piece of bipod ramp foam striking the orbiter as seen in the launch video. Test foam blocks of the appropriate estimated weight and dimensions were constructed using the same techniques and materials as used in actual bipod ramp construction.

CAIB report Vol 1 page 79:

> - RCC panel assemblies were limited, particularly those with a flight history similar to Columbia's.
> - The basic material properties of new RCC were known to be highly variable and were not characterized for high strain rate loadings typical of an impact.
> - The influence of aging was uncertain.
> - The RCC's brittleness allowed only one test impact on each panel to avoid the possibility that hidden damage would influence the results of later impacts.
> - The structural system response of RCC components, their support hardware, and the wing structure was complex.
> - The foam projectile had to be precisely targeted, because the predicted structural response depended on the impact point.

Nitrogen-powered gun at the Southwest Research Institute used for the test series.
[Figure 3.b.1]

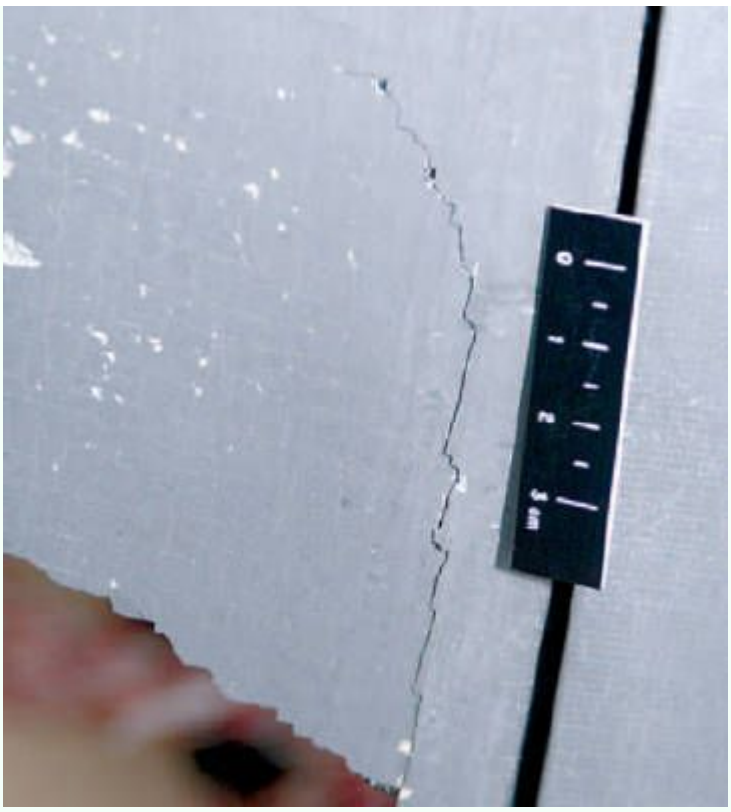
[Figure 3.b.1 incorrectly refers to a "30 foot gun barrel" when the actual barrel length was 35 feet, as per Errata Vol 2 Appendix D.b page 19.]

Test foam blocks were fired at mock-ups of left wing leading edges, first of fiberglass for analytical device adjustments, then at actual RCC panels and finally at an RCC #8 panel which had flown 26 missions, from the shuttle Atlantis. STS-107 was Columbia's 28th flight.

The final test results, to this author, were both surprising and alarming:

CAIB report Vol 1 page 82:

The large impact hole in Panel 8 from the final test.
[Figure 3.b.2]



Numerous cracks were also noted in RCC Panel 8.
[Figure 3.b.3]

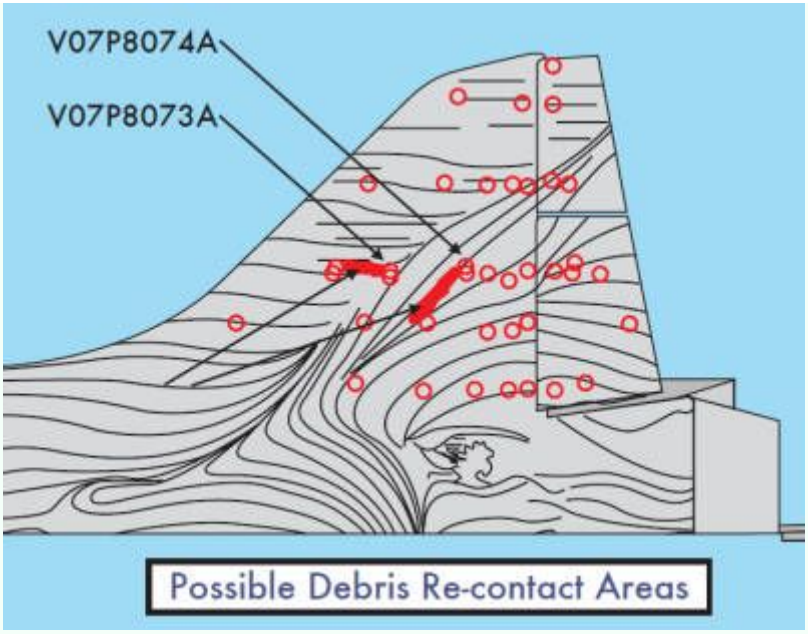
Ascent Data Anomalies

Section 3.c

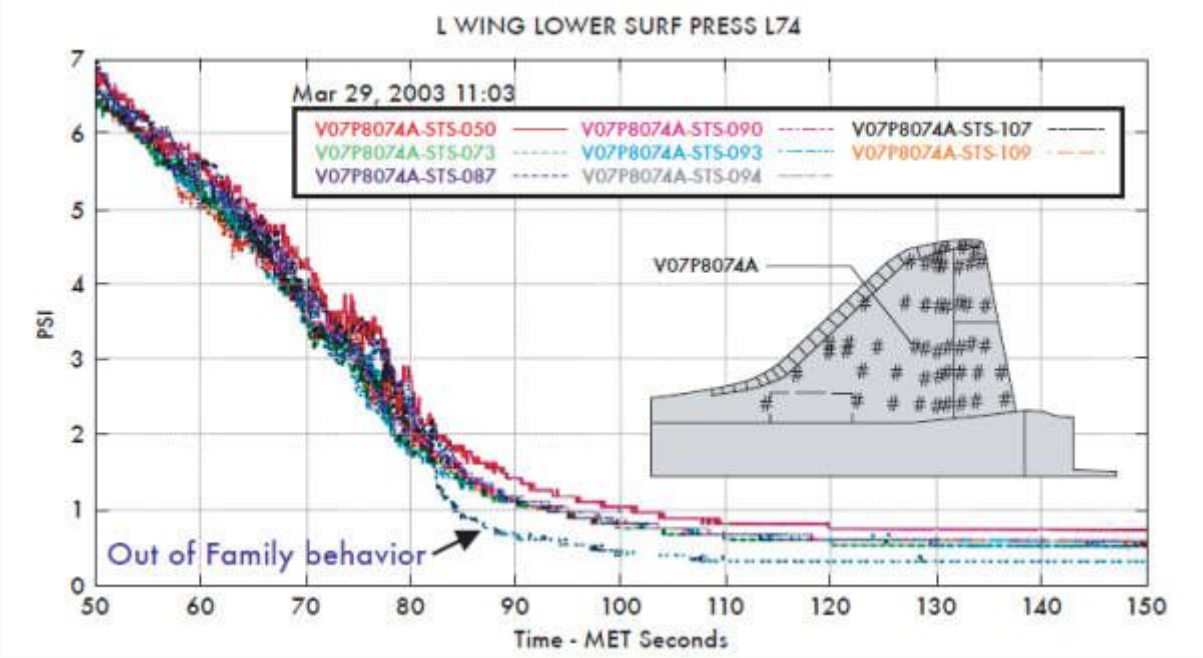
Whilst some commentators have expressed doubt about the testing processes and analyses, there are small anomalies within the ascent data which tend to support the foam strike scenario, however this data is buried in the CAIB report Volume 2, Appendix D.7.

CAIB report Vol 2 page 173:

> There are two other indications that the foam impact occurred in the panels 6 through 8 area. Two Modular Auxiliary Data System (MADS) lower surface pressure measurements behaved anomalously immediately after the time of the impact. Figure 3-13 shows the location of these measurements along with possible areas for post-impact debris re-contact in the vicinity of the sensors. The unusual behavior of one of the sensors is shown in Figure 3-14.



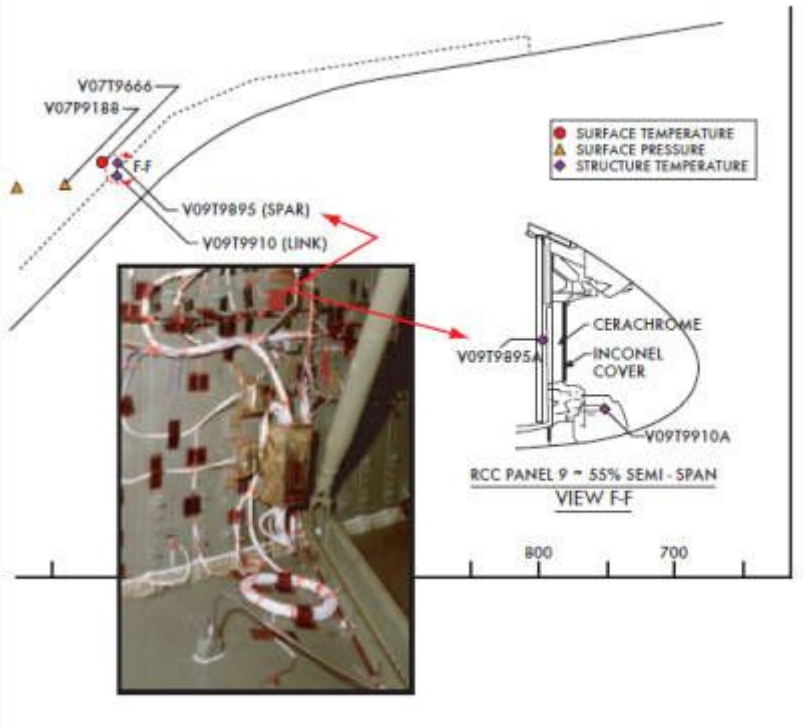
CFD surface flow with lower left wing pressure sensors.
[Figure 3.c.1]



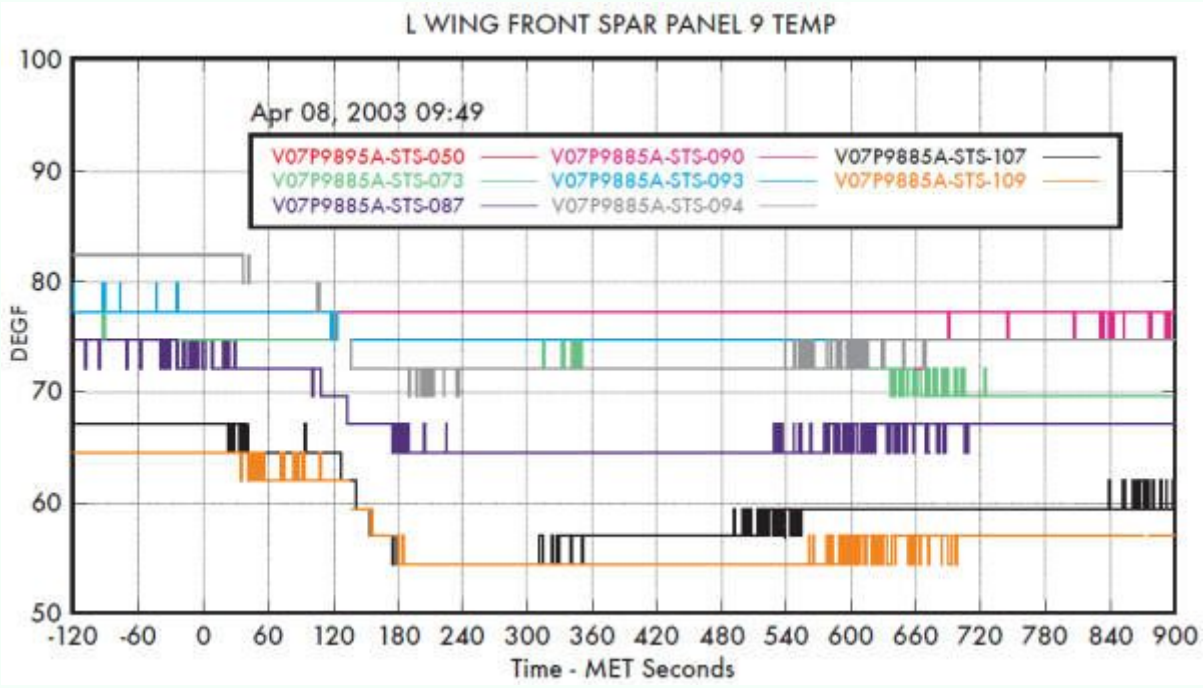
Unusual behavior of pressure sensor V07P8074A.
[Figure 3.c.2]

CAIB report Vol 2 page 174:

> Additionally, there is another MADS measurement that had an off-nominal signature during the ascent timeframe. The temperature sensor on the leading edge spar behind RCC panel 9 showed a slightly higher temperature rise than seen on any previous *Columbia* flight. Figure 3-15 shows the location of the temperature sensor behind the wing leading edge spar inside the wing. The slight temperature rise can be seen in Figure 3-16. Note that most flights show a small rise in this temperature during ascent due to aerodynamic heating.



Close-out photo shows RCC panel 9 wing leading edge temperature measurement.
[Figure 3.c.3]



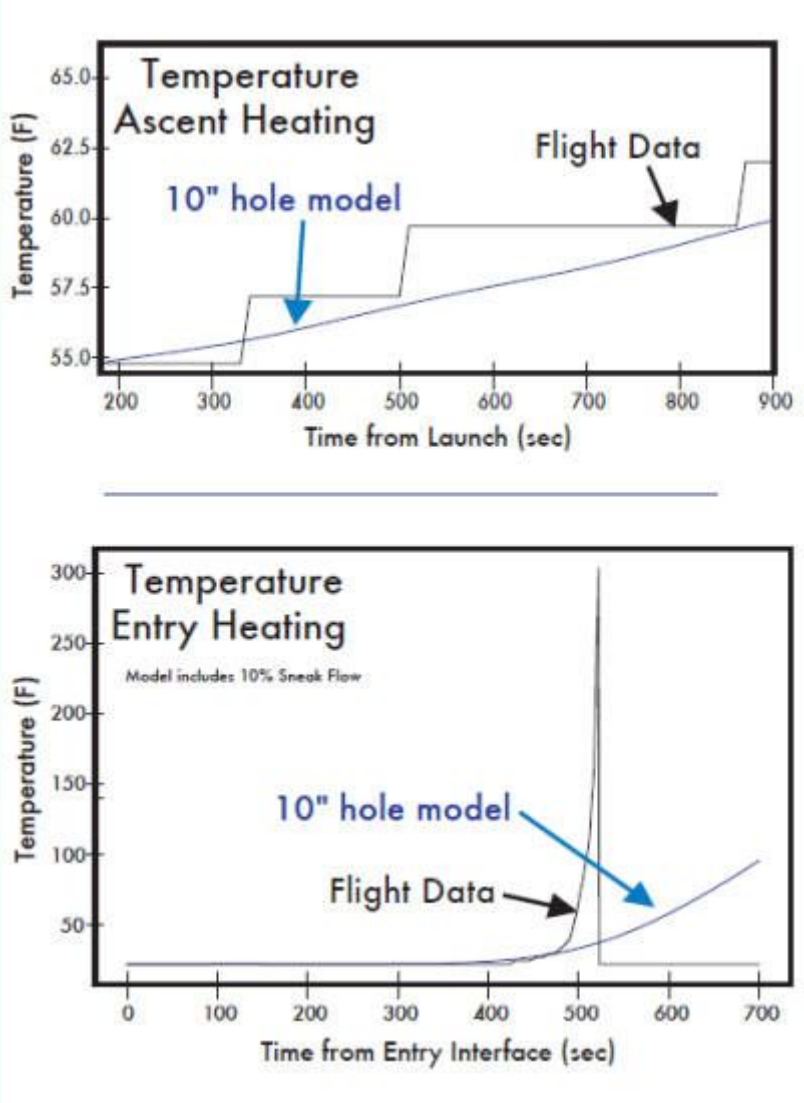
Three-bit rise (7.5 degrees F) on MADS wing leading edge spar temperature measurement (V09T9895A) during ascent.
[Figure 3.c.4]

The black line in the graph above denoting STS-107 shows a rise in temperature of 7.5 degrees F, for comparison other flights show a maximum of 2.5 degrees F for the same period of ascent.

CAIB report Vol 2 page 175:

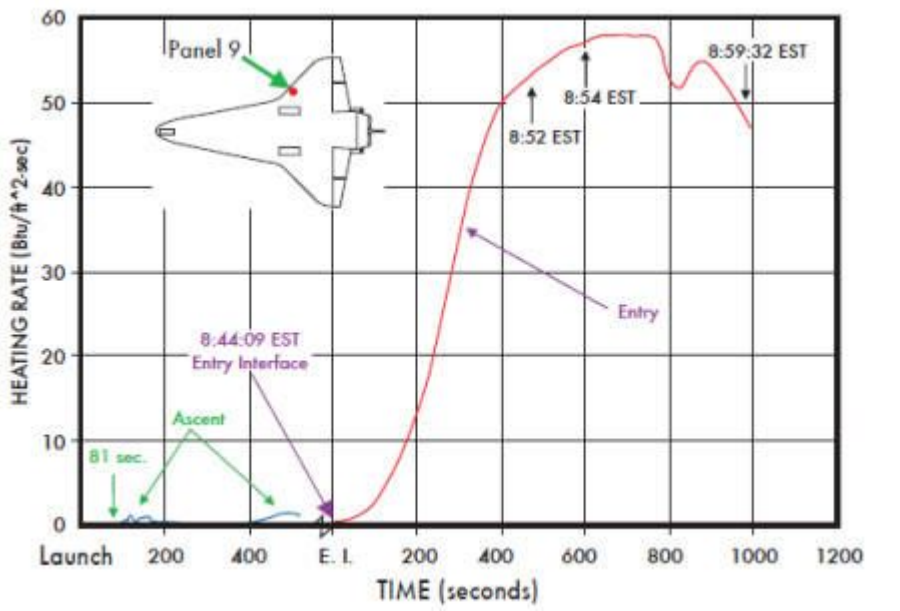
STS-107 had a 7.5 degree Fahrenheit rise that started very early during ascent (five to six minutes after launch). Although the data do not prove that the RCC was breached during ascent, the data are consistent with a possible flow path into the RCC cavity via damage in the RCC panels 6 through 8 area. A simplified thermal math model was constructed and verified with flight data from STS-5. The model was then correlated to the flight data from STS-107. Assuming the equivalent heating from a 10 inch diameter hole in RCC panel 8, this model nearly predicts both the ascent and entry temperature profiles for the wing leading edge spar temperature sensor. Figure 3-17 compares the model with the flight data for both ascent and entry. For comparison, Figure 3-18 shows the overall heating rate of the STS-107 ascent and entry environments on RCC panel 9. As shown, the heating on the wing leading edge is much greater during the entry profile than during the ascent profile.

[This graphic from page 174]



Correlation between simplified thermal math model and STS-107 ascent and entry flight data.
[Figure 3.c.5]

CAIB report Vol 2 page 175:



STS-107 ascent and entry heating environments on RCC panel 9.
[Figure 3.c.6]

Although the ascent anomalies were small in nature, they were 'out of family' in comparison to all previous Columbia launch data, further strengthening the case for the foam strike damage scenario.

So did the foam strike damage the orbiter? Of course the CAIB report goes into far more detail than is shown here, I have simply gleaned from it a small portion of the most compelling data to show readers that not only could a bipod ramp damage an RCC panel on a space shuttle, **in all likelihood** in this case it did.

That is not to say it has been unequivocally proven, even the CAIB report acknowledges this, however on balance I think it highly likely that this did happen as proposed in the report, a view which is further strengthened by some of the reentry data, to be discussed in the next section.

None of this disproves the theory that a megalightning bolt may have struck the orbiter during reentry, however it does establish little doubt that Columbia was significantly damaged prior to reentry, in all likelihood **contributing** to it's demise.

Proposed Megalightning Strike

"That" Photo

Section 4.a

Now we enter a much more controversial area of this study. The original picture mentioned in the introduction of this paper has never been released to the public to allow any independent analysis thereof.

However it was obviously interesting enough for NASA to have taken it and the camera for further analysis, and one can only speculate as to why neither it nor a report on it has not been released if it was found to be of no significance to the demise of *Columbia*.

A copy of the picture is reproduced here for the purpose of discussion, it must be realised however that this is not the high-resolution copy which NASA has, but a "screen grab" from the documentary "Megalightning" released in the UK in 2004. Megalightning is a David Monaghan (dmptv) production and images from the documentary are reproduced here with permission.

A low resolution copy of the photo under current discussion.
Credit: dmptv/Peter Goldie.
[Figure 4.a.1]

Note the purple hue of the anomaly. Further discussion of this image will be undertaken later in this paper.

Initial Media Reports

Section 4.b

In the following pages are excerpts from several media outlets, the first of which was published after the accident but **before the authors knew of the controversial photograph,** and discusses the poorly understood nature of the ionospheric atmosphere in general. **Some scientists speculated about the possibility of Columbia's plasma trail drawing an electrical charge to it.**

USA Today February 2, 2003:

> Posted 2/6/2003 10:33 PM Updated 2/6/2003 10:33 PM
> **Upper atmosphere may hold clues in Columbia mystery**
> By Dan Vergano and Tim Friend, USA TODAY
>
> The space shuttle Columbia's troubles began as it dropped like a meteor from orbit into a **mysterious and poorly understood atmospheric region** that scientists have dubbed the "ignorosphere."
> [Emphasis added]
>
> [...]
>
> As NASA proceeds with its investigation, scientists will have to ponder the many mysteries of the "ignorosphere." **A report by NASA scientists released last fall describes concerns about the impact of upper atmospheric phenomenon on the space shuttle**:
> [Emphasis added]
>
> - Transparent clouds, called "noctilucent" clouds, float 50 miles above Earth and are visible only at twilight. These silvery cirrus clouds form at the edges of much larger clouds. Models of shuttle impacts with them "vary from trivial to catastrophic" according to the report, which says "the most severe effect of entry through a noctilucent cloud would probably be the erosion of the thermal protection system during the most critical heating region." That critical heating region is where Columbia was destroyed. The agency plans its re-entry paths to avoid regions thought prone to these clouds.
>
> - Red sprites are electrical discharges in the upper atmosphere. They occur over thunderclouds and have been considered to pose less than a one in 100 risk to the shuttle. Some rainstorm clouds did appear over Northern California during re-entry last Saturday but no lightning was reported on the ground, says atmospheric scientist Walter Lyons, of FMA Research Inc. in Fort Collins, Colo.
>
> - Density shears are patches of thicker-than-expected air that can increase the shuttle's roll and pull on one wing. On a Columbia mission in 1992 and an Endeavor mission in 1993, hitting such patches forced them to use up its fuel for the thrusters that help keep it on course during re-entry.

- Blue jets are upward lightning strikes. In 1998, Lyons and a team of scientists reported one that was sparked by a meteor. **"The safety implications are just a gaping hole in our knowledge,"** he says.
[Emphasis added]

As the space shuttle streaks through the upper atmosphere, it leaves a wake in the air just as a boat leaves a wake behind it in the water. The shuttle's wake becomes electrified. **Lyons says some scientists are speculating that its electrified wake acted as an antenna and drew a blue jet to the Columbia.**
[Emphasis added]

NASA and the Air Force have been losing interest in studying the uppermost atmosphere. Meanwhile, Lyons says scientists are still discovering unexplained phenomenon. "We're nickel-and-diming to do our research," he says. **"And there is all sorts of electrical foolishness going on up there that we still don't know anything about."**
[Emphasis added]

Further articles explored both the photograph in question and also some of the various characteristics of megalightning, the study of which is even now still in its infancy.

San Francisco Chronicle February 5, 2003:

Mysterious purple streak is shown hitting Columbia 7 minutes before it disintegrated
Sabin Russell, Chronicle Staff Writer

Top investigators of the Columbia space shuttle disaster are analyzing a startling photograph -- snapped by an amateur astronomer from a San Francisco hillside -- **that appears to show a purplish electrical bolt striking the craft as it streaked across the California sky.**
[Emphasis added]

The digital image is one of five snapped by the shuttle buff **at roughly 5: 53 a.m.** Saturday as sensors on the doomed orbiter began showing the first indications of trouble. Seven minutes later, the craft broke up in flames over Texas.
[Emphasis added]

[...]

Late Tuesday, NASA dispatched former shuttle astronaut Tammy Jernigan, now a manager at Lawrence Livermore Laboratories, to the San Francisco home of the astronomer to examine his digital images and to take the camera itself to Mountain View, **where it was to be transported by a NASA T-38 jet** to Houston this morning.
[Emphasis added]

A Chronicle reporter was present when the astronaut arrived. First seeing the image on a large computer screen, she had one word: "Wow."

Jernigan, who is no longer working for NASA, quizzed the photographer on the aperture of the camera, the direction he faced and the estimated exposure time -- about four to six seconds on the automatic Nikon 880 camera. It was mounted on a tripod, and the shutter was triggered manually.

In the critical shot, a glowing purple rope of light corkscrews down toward the plasma trail, appears to pass behind it, then cuts sharply toward it from below. As it merges with the plasma trail, the streak itself brightens for a distance, then fades.
[Emphasis added]

"It certainly appears very anomalous," said Jernigan. "We sure will be very interested in taking a very hard look at this."
[Emphasis added]

San Francisco Chronicle February 7, 2003:

Cosmic bolt probed in shuttle disaster
Scientists poring over 'infrasonic' sound waves

Sabin Russell, Chronicle Staff Writer
Friday, February 7, 2003

Federal scientists are looking for evidence that a bolt of electricity in the upper atmosphere might have doomed the space shuttle Columbia as it streaked over California, The Chronicle has learned.

Investigators are combing records from a network of ultra-sensitive instruments that might have detected a faint thunderclap in the upper atmosphere at the same time a photograph taken by a San Francisco astronomer appears to show a purplish bolt of lightning striking the shuttle.

Should the photo turn out to be an authentic image of an electrical event on Columbia, it would not only change the focus of the crash investigation, but it could open a door on a new realm of science.

"We're working hard on the data set. We have an obligation," said Alfred Bedard, a scientist at the federal Environmental Technology Laboratory in Boulder, Colo. He said the lab was providing the data to NASA but that it was too early to draw any conclusions from the sounds of the shuttle re-entry.

[...]

SEEKING EVIDENCE

NASA officials have stressed the importance of photographic, video or debris evidence from the earliest moments of the shuttle's distress, which sensors indicate began at **about 5:53 a.m.** above California. That's when sensors in a wheel well blinked out, in the words of NASA investigators, "as if someone cut a wire."
[Emphasis added]

That is also roughly the time during which the amateur photographer snapped his image of Columbia as it streaked across the sky north of San Francisco. A precise time may be mapped by matching the photo and the strange electrical signature to the **crisp background field of stars.**
[Emphasis added]

Physicists have long jokingly referred to the lower reaches of the ionosphere -- which fluctuates in height around 40 miles -- as the "ignorosphere," **due to the lack of understanding of this mysterious realm of rarefied air and charged electric particles.**
[Emphasis added]

The family of "transient" electrical effects occupy this part of the sky, including sprites, which leap from the ionosphere to the tops of thunderheads, and blue jets, which leap from thunderhead anvils to the ionosphere.

Streamers of static electricity can travel these realms at speeds 100 times that of ground lightning, or 20 million miles an hour.

Ten years ago, Walter Lyons, a consultant with FMA Research Inc. in Fort Collins, Colo., conducted a study of sprite danger for NASA. **"We concluded that there is about 1 chance in 100 that a shuttle could fly through a sprite**. What impact, we didn't know for certain. It didn't appear **at this time** that the energy would be enough to cause problems."
[Emphasis added]

But Lyons conceded that the "ignorosphere" is a mysterious place that has yielded startling surprises. **"Since then, with research on electrical streamers, the discovery of blue jets, the doubt has gone up,"** he said.
[Emphasis added]

"There are other things up there that we probably don't know about," Lyons said. "Every time we look in that part of the atmosphere, we find something totally new."
[Emphasis added]

[...]

Hearing a description of the purplish, luminous corkscrew in the San Francisco photograph, Lyons said, **"This was not a sprite event . . . but maybe it is another electrical phenomenon we don't know about."**
[Emphasis added]

Whether or not an electrical discharge might be involved in the demise of Columbia, **there is precedent for an event like this**.
[Emphasis added]

Scientists have observed interaction between a blue jet and a meteor. And in December 1999, Los Alamos National Laboratories researcher David Suszcynsky and colleagues, including Lyons, published an account of a meteor that apparently triggered a sprite. Their account is published in the Journal of Geophysical Research.

"It was a singular observation that had us all scratching our heads," said Lyons. In the strange world of sprite and elf research, scientists have documented one event in which some sort of high atmospheric event "shot down" a high-altitude balloon over Dallas.

On June 5, 1989, before the first sprite was ever photographed, a NASA balloon carrying a heavy pack of instruments suffered "an uncommanded payload release" at 129,000 feet, according to Lyons. It landed in an angry Dallas resident's front yard.

Investigators found scorch marks on the debris and considered it one of the first bits of solid evidence that sprites exist. As a result of the accident, NASA no longer flies balloons over thunderstorms.

WorldNetDaily February 2, 2003:

CATASTROPHE IN THE SKY

Photos: Mystery flashes spotted near shuttle
Astronomer captures 'electrical phenomena' near Columbia's track

Posted: February 2, 2003
8:05 p.m. Eastern

An astronomer who regularly photographs space shuttles when they pass over the San Francisco Bay area has captured five "strange and provocative images" of Columbia as it was re-entering the atmosphere.

The San Francisco Chronicle reports the images **"appear to be bright electrical phenomena flashing around the track of the shuttle's passage."**
[Emphasis added]

"They clearly record an electrical discharge like a lightning bolt flashing past, and I was snapping the pictures almost exactly ... when the Columbia may have begun breaking up during re-entry," the photographer, who asked not to be identified, told the Chronicle.
[Emphasis added]

The photos were snapped with a Nikon camera using a tripod.
Though the space scientist is not making the pictures public immediately, he invited the newspaper to view the images on his home computer this weekend.

David Perlman, science editor for the Chronicle, calls the photos "indeed puzzling."

"They show a bright scraggly flash of orange light, tinged with pale purple, and shaped somewhat like a deformed L," Perlman writes. "The flash appears to cross the Columbia's dim [white trail formed in the wake of the craft], and at that precise point, the [white trail] abruptly brightens and appears thicker and somewhat twisted as if it were wobbling."

WorldNetDaily February 16, 2003:

CATASTROPHE IN THE SKY

Earth monitors recorded explosions on Columbia
Experts won't say if infrasound readings coincide with 'electrical zap' on camera

Posted: February 16, 2003
9:47 p.m. Eastern

As NASA continues its probe into the precise cause of the space shuttle Columbia disaster, government researchers are confirming the recording of explosions as the orbiter broke apart during its fatal descent.

According to a report in the Toledo Blade, some scientists believe the recordings could shed light on the theory that an electrical phenomenon called a "blue jet" knocked the shuttle out of the sky.

"We have detected sounds from shuttle re-entries in the past," Dr. Alfred Bedard Jr. of the National Oceanic and Atmospheric Administration said when asked about the content of infrasound recordings from Columbia. "But we've been asked not to discuss the results publicly, and we will honor that request."

Bedard, part of a panel of scientists who reported on infrasound research at the national meeting of the American Association for the Advancement of Science in Denver, says the recordings have now been sent to NASA for analysis.

[...]

A second infrasound expert, Dr. Eugene Herrin of Southern Methodist University in Dallas, said his sensors also detected explosions on Columbia. His infrasound array for the U.S. Air Force is located near Terlingua, Texas.

> In six minutes of recordings from Columbia, Herrin describes seven large, distinct explosions that were initially heard over eastern New Mexico.
>
> He says a preliminary look at data collected by another array of instruments outside Mina, Nev., show "unusual" patterns when compared to data from other shuttle flights.
>
> "There was something about this one. I am not going to speculate. What we see are oscillations in the shock wave that we don't normally see. Whether that's diagnostic or not, that's a NASA call," Herrin said.

Add to this the CAIB report of ground observations, which match, as well as can be ascertained, the time at which the anomalous photograph was taken.

CAIB report Vol 1 page 39:

> Now crossing California, the Orbiter appeared to observers on the ground as a bright spot of light moving rapidly across the sky. Signs of debris being shed were sighted at 8:53:46 a.m. (EI+577), when the superheated air surrounding the Orbiter suddenly brightened, causing a noticeable streak in the Orbiter's luminescent trail. Observers witnessed another four similar events during the following 23 seconds, and a bright flash just seconds after Columbia crossed from California into Nevada airspace at 8:54:25 a.m. (EI+614), when the Orbiter was traveling at Mach 22.5 and 227,400 feet. Witnesses observed another 18 similar events in the next four minutes as Columbia streaked over Utah, Arizona, New Mexico, and Texas.

The Official Line

Section 4.c

That such a photo was taken is without doubt. Some commentators have stated that the photo was never considered or mentioned in the CAIB report. This is incorrect, though the levels of consideration and mention both seem surprisingly low, considering the level of public interest and commentary on the topic, and the nature of the photograph itself.
I have personally read all of the six volumes of the CAIB report, and have only found two brief mentions of the photo.

(1.) CAIB Report Vol 2 appendix D.5 - cover:

> **Space Weather Conditions**
>
> This appendix provides a detailed discussion of space weather (the action of highly energetic particles, primarily from the Sun, in the outer layer of the Earth's atmosphere) and the potential effects of space weather on the Orbiter

> on February 1, 2003. This investigation was originally prompted by public claims of unusually active space weather conditions during the mission **and by a photograph that claimed to show a lightning bolt striking** *Columbia* at an altitude of 230,000 feet over California during re-entry. The report concludes that space weather was unlikely to have played a role in the loss of *Columbia*.
> [Emphasis added]

(2.) CAIB report Vol 3 Appendix E.2 page 114

> **6.4.3 Special Still Imagery Analyses of Alleged "Lightning" Image**
>
> A still image taken from California was submitted to NASA by a member of the public. A superficial look at the image suggested that it might record an anomalous re-entry event that was claimed to be lightning striking the Orbiter. Our analysis suggested that the pattern was due to camera vibrations during a long-exposure. A separate upper atmospheric scientific team also investigated the image. The results of those analyses are being reported separately.

I find it very curious the authors chose the words above to discount the validity of the image, as clearly its authenticity has not been ruled out by this statement. First, notice twice the use of the word "suggested".

"A superficial look at the image **suggested** *that it might record an anomalous re-entry event that was claimed to be lightning striking the Orbiter. Our analysis* **suggested** *that the pattern was due to camera vibrations during a long-exposure."*

The second occurrence of the term 'suggested' in no way negates the first and does not convey proof nor even any certainty that "the pattern was due to camera vibrations during a long-exposure."

I also take issue with use of the word 'pattern', as this conveys a mental image of some sort of ordered and repetitive structure, as may be expected of a vibration. However though the anomaly appears to 'corkscrew' through parts of its existence, it also has several straight segments and changes 'direction' several times.

This paragraph also mentions a "separate upper atmosphere team" had investigated the image to be reported elsewhere, however no mention of this other investigation of the image can be found in the CAIB report, nor does it appear to have been reported elsewhere.

All things considered I find the official explanation of the photograph wanting of substance and as such hopelessly inadequate under the circumstances of an official investigation into a major disaster of catastrophic consequence.

Let us consider here these aspects.

- The photographer concerned is reportedly an amateur astronomer and shuttle buff, and has taken similar photographs of shuttle reentry in the past.
- He took five photographs on this particular occasion, each a long-exposure with the camera mounted on a tripod, and the shutter open for a period of some four to eight seconds.
- Of the five shots taken under essentially the same conditions, only one records such an anomaly.

Megalightning - The Documentary

Section 4.d

In 2004 a documentary was released titled "Megalightning" (to which some media outlets appended the phrase "Stranger than Fiction") in which among other things, the Columbia disaster was featured. But more than that, the film explores much of the research into megalightning and has eyewitness accounts of pilots and others who have seen such phenomena.

> (Narrator) Few cloud to ground strikes are longer than three kilometers, and text books always used to say no lightning could exist above the clouds. But then weatherman Walt Lyons aimed his camera across the Colorado plains on July the 6th, 1993. What he saw, overturned 200 years of "scientific certainty", in an instant.
>
> He filmed these video images, showing lightning 80 kilometers high and 40 kilometers wide, firing above the clouds. Their existence had been dismissed as fantasy. Now their discovery has shed new light on what has been causing airplanes, to fall from the sky.

Previous to this photographic scientific evidence, many were reluctant to report sightings of megalightning for fear of being thought of as having hallucinations, or worse, yet eyewitness accounts date back to the late 1960s.

> (Narrator) The discovery of megalightning, began with ordinary people seeing extraordinary things. In 1969 Stuart Beecher was defending a mortar pit outside Saigon in South Vietnam, when a storm broke.
>
> (Beecher) There was this giant flash of lightning that reached from the ground, through the base of the cloud, completely illuminated the cloud, and out the top in this absolutely beautiful double-helix that seemed to just go on forever. ... It was just like it was going straight into space ...

There was even some early photographic evidence such as this photo taken at Mount Ida, Australia back in 1968.

Taken at Mount Ida in Australia in 1968
Image credit: dmptv/Tudor Williams
[Figure 4.d.1]

Notice the slight "wobbly" or helical appearance of this bolt:

Close-up of the above image
Note the helical shape of the lightning, slightly easier to see in the color-inverted image.
[Figures 4.d.2 & 4.d.3]

On March 26th 1987 NASA had to destroy a rocket after its telemetry had been knocked out by a bolt of lightning. Then in 1989 the first "official" photograph of

megalightning was surreptitiously captured by University of Minnesota physicists Franz and Winckler whilst testing a new camera.

After this, NASA turned to (Lt. Col. USAFR-Ret) Otha H. "Skeet" Vaughan Jr., a senior engineer with NASA and an experienced pilot, to investigate this new phenomenon.

Earlier, Vaughan had met with a pilot who had witnessed "giant lightning" in 1981. He had then written an article in a magazine asking other pilots to convey similar experiences to him, and he received some 19 responses.

Vaughan pored over many hours of NASA shuttle footage to see if he could find other instances of megalightning not previously recognised. He identified a further 19 instances of "this thing".

NASA then turned to Walt Lyons, a world expert in distance lightning strikes and the person who had helped them make launches safer since the 1987 mishap, to investigate the possibility that this new lightning could pose a threat to shuttle missions. On his first night of filming above a distant storm specifically looking for these phenomena, he recorded around 250 of them. He and a friend later named them "sprites".

Only relatively recently, in the 1970s, had "positive lightning" been identified. Until then, it was thought that all lightning bolts were negative strokes. Positive lightning though has as much as six times the power of negative lightning, and its duration up to ten times longer, and is now thought to be the cause of a good many aircraft accidents. Aircraft had only been constructed to withstand the damage sustained from regular, negative lightning.

After further research, Lyons found that for every sprite identified above cloud, a positive lightning bolt issued below cloud.

> (Narrator) Positive lightning and sprites were one continuous force that stretched **from the edge of space**, to where ordinary planes fly. [Emphasis added]
>
> [...]
>
> (Lyons) We're learning that there's a whole subclass, of extremely energetic positive cloud to ground lightning. That ... lowers maybe ten times more current to ground, than the old textbooks said you should get.

In 1993 NASA funded the first of many sprite hunts, and one of the 200 or so experiments on board STS-107 was to film sprites above thunderstorms.

Dr. Alfred Bedard had been the first to confirm "sprite thunder", using the same

infrasonic detection equipment which he had used for many years to listen for rogue atom bomb testing anywhere around the globe. His equipment was listening when the shuttle went down.

> (Narrator) The detectors had heard a sinister sound before the shuttle's breakup.
>
> (Bedard) ... What you're hearing are the bursts of energy early ... and then that hollow thud.
>
> (Narrator)The signal showed there'd been an energy burst outside the shuttle before it disintegrated. Like the sound of a distant gunshot. This was evidence other forces were in play.
>
> (Bedard) It had the characteristics of a geophysical kind of an event of some sort. And as I said ... at this range in the past we've had signals quite similar that were associated with fairly good-sized earthquakes.
>
> (Narrator) The bomb detectors had measured a hugely powerful event. The force of an earthquake high in the sky. It's epicenter was estimated to be in the flightpath of the doomed shuttle.
>
> (Bedard) Best guess would be it would be right in - somewhere around in here. Perhaps San Francisco, perhaps a little bit south of there.
>
> [...]
>
> (Lyons) The chances are the sprite *per se* is not going to be a threat to the space shuttle but there are other creatures up there which we maybe shouldn't be so sure about.
>
> [...]
>
> There's just a lot of things happening above the cloudtops that we never knew ten years ago and perhaps have not yet designed properly for.

"That" Photo - Again

Section 4.e

Now with what we know of megalightning in mind, let's take a closer look at the image about which there's so much disinformation and conjecture.

Some more screen grabs from the documentary "Megalightning". These are the five images which Amateur Astronomer Peter Goldie took of Columbia's reentry, presented here in the order in which they were taken. The anomaly under

discussion is on the third image of the sequence.

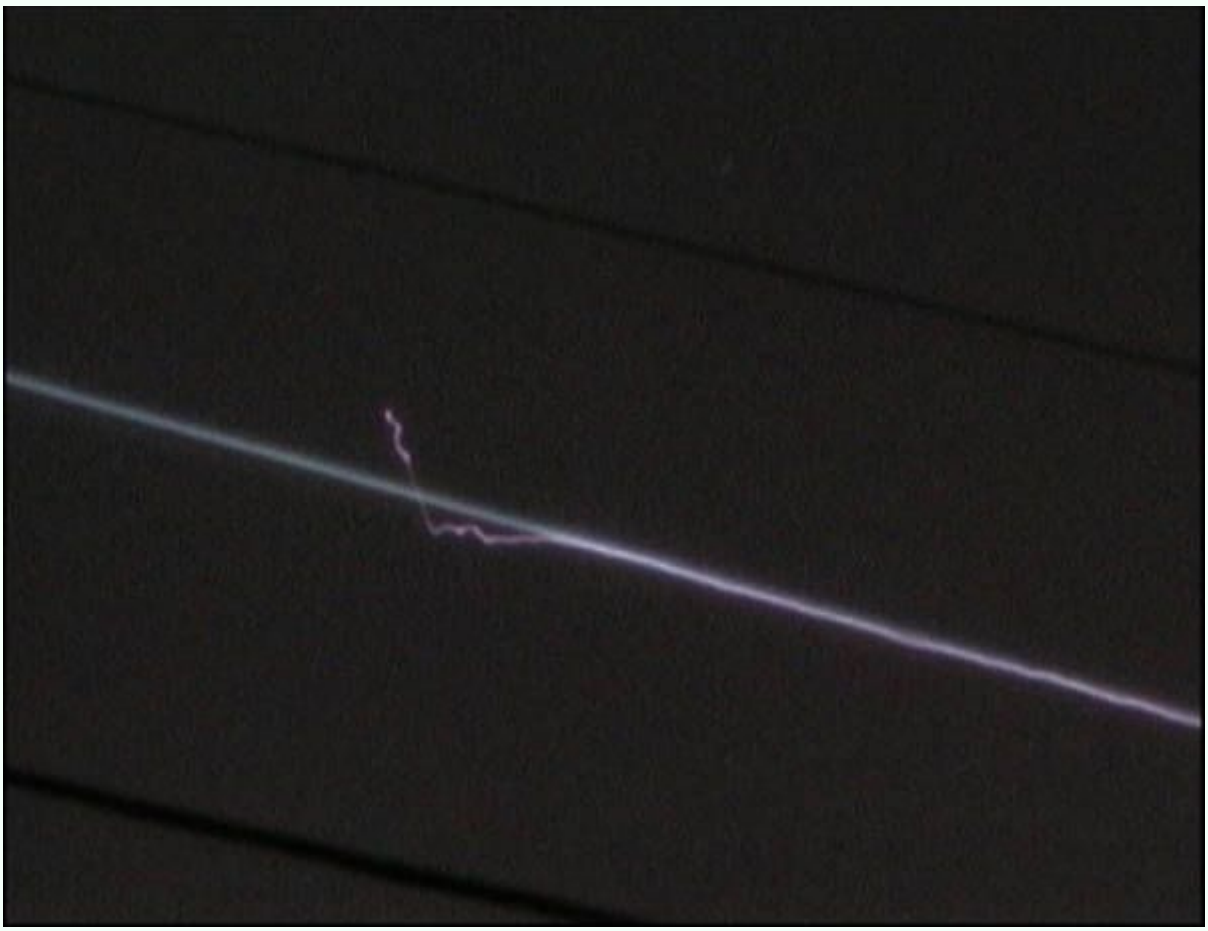
Goldie images 1 and 2 of 5
Credit: dmptv/Peter Goldie
[Figures 4.e.1 & 4.e.2]

Goldie images 3 and 4 of 5
Credit: dmptv/Peter Goldie
[Figures 4.e.3 & 4.e.4]

Goldie image 5 of 5
Credit: dmptv/Peter Goldie
[Figure 4.e.5]

[Note: The horizontal 'banding' in these images is an artifact of the video production.]

Here's a larger copy of number three, the image under discussion, cropped to show the anomaly more clearly.



Goldie image #3, close-up and cropped
[Figure 4.e.6]

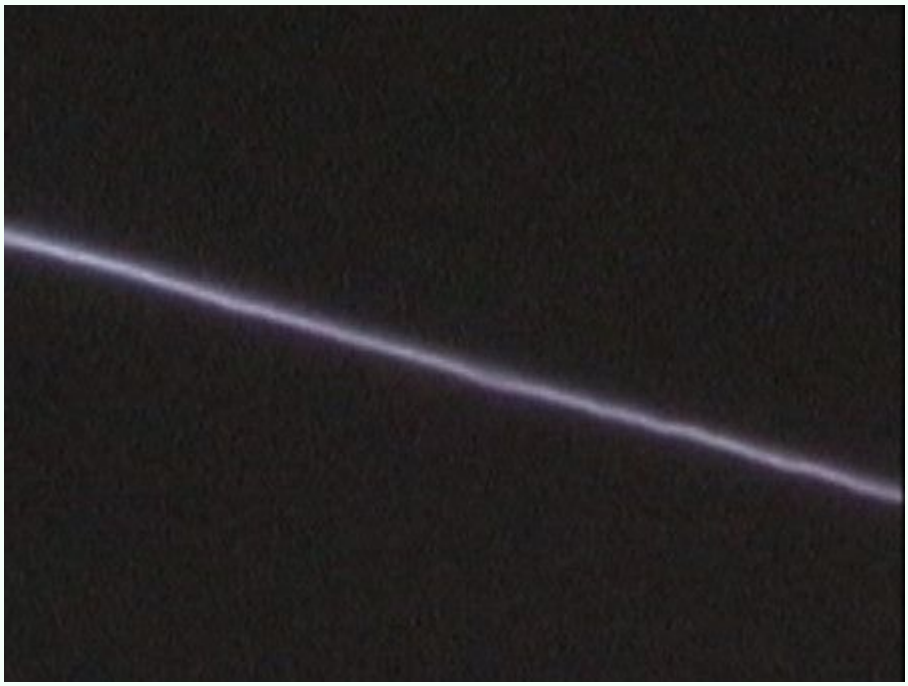
The dark lines roughly parallel to the plasma trail are powerlines in the foreground. Note the purple hue of the anomaly, and also the apparent "corkscrew" shape to it.

> (Goldie) When I saw the picture, and heard the television in the background suggesting that things were amiss, the hair on the back of my neck stood up.
>
> [...]
>
> I didn't know what it was. But by all appearance, it appeared to be a lightning bolt.

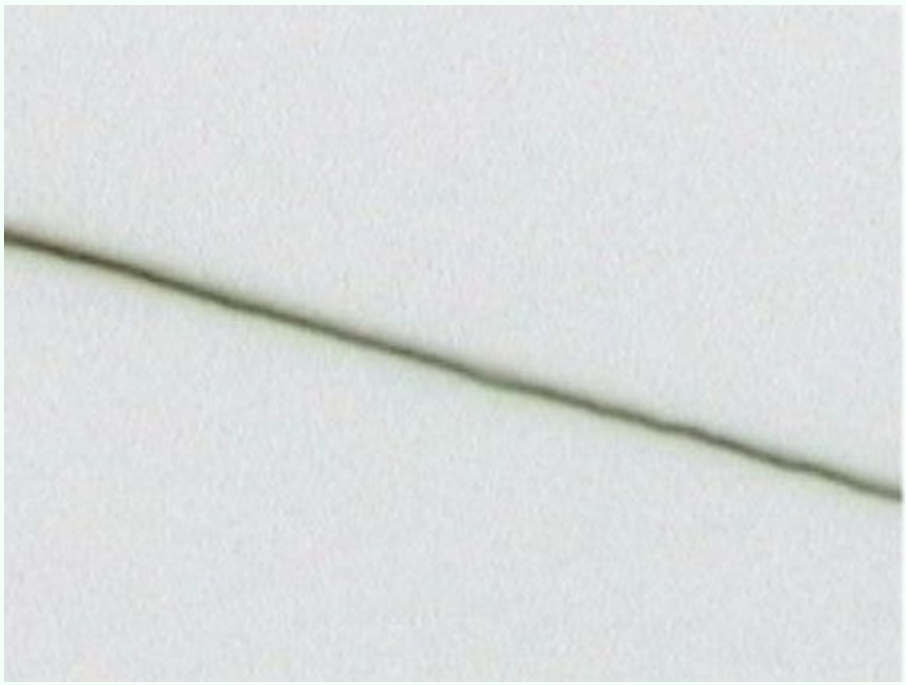
Worth noting here that this was not a 'first time' for Goldie in capturing shuttle reentries. As an amateur astronomer, photographer and shuttle-buff, he had taken similar pictures in the past. He himself did not consider camera-shake as a likely candidate for the anomaly, instead saying it looked like a lightning bolt.

Now here's the "clincher", at least for this author, it's a close-up of the last

section of the plasma trail, the right-hand portion of the image above.



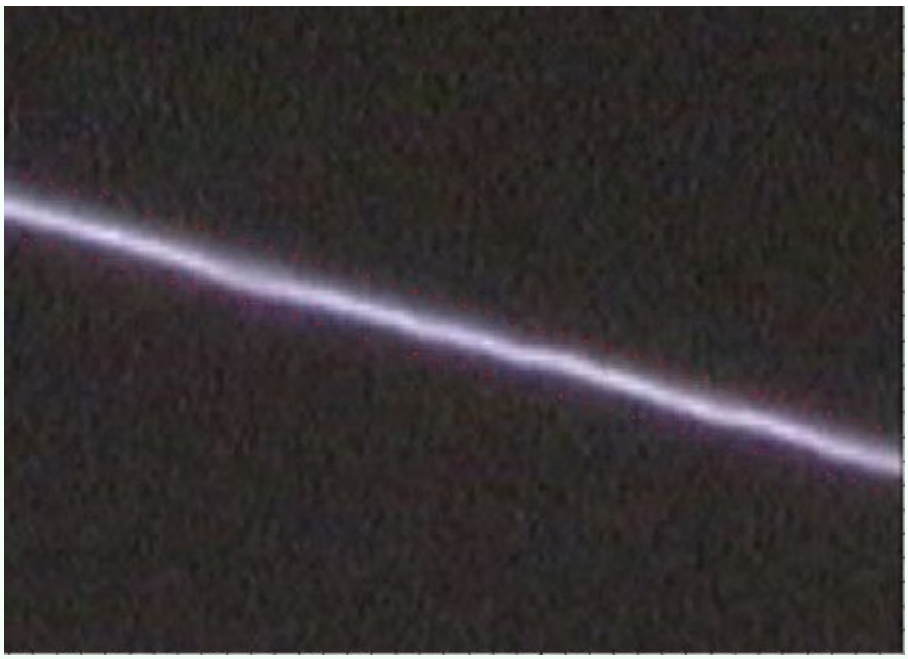
Plasma trail from Goldie image #3.
[Figure 4.e.7]



The same image with colors inverted.
[Figure 4.e.8]

It seems that in no other image of the plasma-trail left by Columbia, does it exhibit the "wavering" which is seen in this image.

Given that the anomaly was written off as "camera shake" by NASA, the shake should have settled down and stopped, not continued on as is clearly visible in this image.



Close-up of the right-hand extreme of the plasma trail, annotated.
[Figure 4.e.9]

On examination of the image above, it becomes quite clear that the anomaly continues right to the edge of the image. The two red dotted lines superimposed on the image above indicate the straight edges of the plasma trail itself, of more or less consistent width for the entire image. Yet it is clear that the brighter portion appears to waver between these edges.

There is no logical reason why the orbitor should appear to wobble it's way across the sky, whilst the plasma trail remains essentially straight. This author has not seen anywhere, a picture of this or any other space shuttle taken with any device, under any conditions, which exhibits this feature.

It is equally illogical to think that the photographer who took the image could keep the camera perfectly still for the other images he took on the day, and yet managed to make it shake for the entire time the orbiter was in frame. First a wild shake, and then a consistent wobble for the rest of the frame.

It is the contention of this author that the anomaly is in fact an electrical discharge, helical in form, and which likely struck only milliseconds before the shutter was closed. From the poor quality of the available imagery, it is impossible to tell if the anomaly continues to the very end of the plasma trail. That is, the shuttle may not have even been struck until milliseconds after the shutter was closed. Only careful analysis of the original image would provide a definitive answer to this question.

The most common argument from those who agree it is camera shake, is that the shutter was opened after the shuttle had entered the frame. The camera has captured the luminous plasma trail left by the orbiter, and also the highly

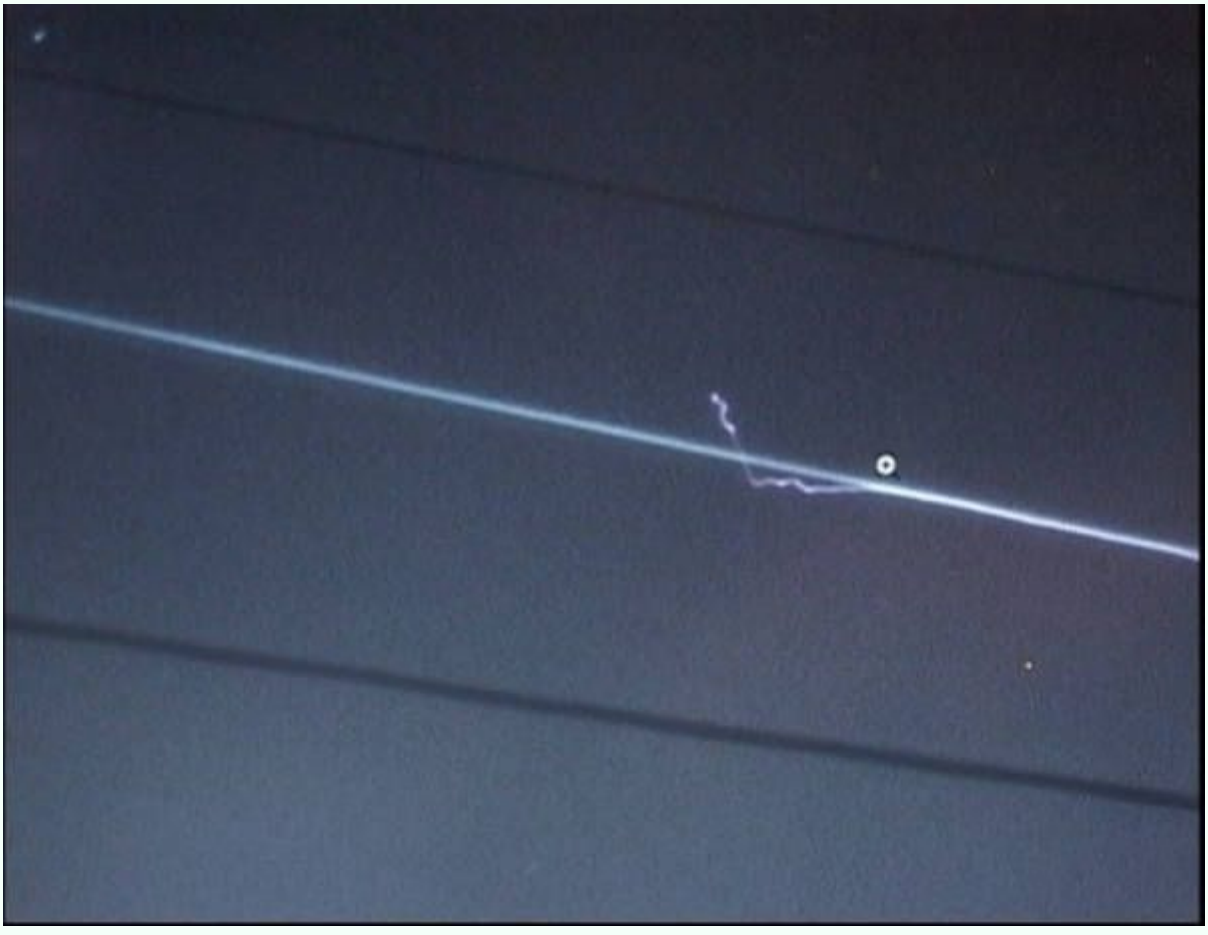
luminous shuttle at first moving with camera shake upon opening of the shutter, then settling down for the remainder of the time the shutter was opened. This explanation fails to explain the phenomenon highlighted above.

Furthermore, the power lines visible in the image are rendered clearly, and one of the initial media reports describes a "crisp background field of stars".

> A precise time may be mapped by matching the photo and the strange electrical signature to the crisp background field of stars.

One can not help but ask why the exact time the image was taken was not calculated. The only answer I can deduce from the CAIB Report is that the image was considered unimportant because of the 'anomaly' being explained away as camera shake. But this explanation again fails to account for the apparent "crispness" of the stars in the image, and in fact the powerlines appear to be rendered the same in all of the images taken by Goldie. Image #3 does not display any blurring of either the powerlines or the stars due to camera shake.

Below is another screen grab from the documentary which does show several stars (and a cursor on screen), though the quality is still low.



Screen grab with stars visible.
[Figure 4.e.10]

It seems that the image was written off summarily because the sky was clear, and no known form of lightning could be expected. When one considers how long it took to identify positive lightning, sprites and other forms of megalightning, and that much is still unknown about the ionosphere, this seems a rather short-sighted approach. For more on this, see the section Space Weather below.

It bears repeating here the words of Walt Lyons from the Megalightning documentary:

> The chances are the sprite *per se* is not going to be a threat to the space shuttle but there are other creatures up there which we maybe shouldn't be so sure about.
>
> [...]
>
> There's just a lot of things happening above the cloudtops that we never knew ten years ago and perhaps have not yet designed properly for.

Also several other experts consulted for the film offered similar opinions.

Israel's leading lightning researcher, Yoav Yair:

> It's a whole menagerie out there, its a zoo. There could be other types of discharges and emissions in the upper atmosphere.

Matt Heavner, who operates an array of ground-based lightning detectors at Los Alamos.

> In terms of the middle atmosphere I think there still are unknowns and new discoveries to be made. it definitely should be studied in terms of safety for both manned and un-manned space flights.

CAIB Reentry Timeline

Section 4.f

Now let's take a look at the timeline of reentry to see how the instrumentation data fits with the possibility of the proposed megalightning strike having occurred.

CAIB Report Vol 1 page 64:

> **3.6 DE-ORBIT/RE-ENTRY**
>
> *For a complete compilation of all re-entry data, see the CAIB/NAIT Working Scenario (Appendix D.7), Qualification and Interpretation of Sensor Data from

STS-107 (Appendix D.19), and the Re-entry Timeline (Appendix D.9)

[*This sentence added as per Errata Vol 2 Appendix D.b page 19.]

As Columbia re-entered Earth's atmosphere, sensors in the Orbiter relayed streams of data both to entry controllers on the ground at Johnson Space Center and to the Modular Auxiliary Data System recorder, which survived the breakup of the Orbiter and was recovered by ground search teams. This data – temperatures, pressures, and stresses – came from sensors located throughout the Orbiter. Entry controllers were unaware of any problems with re-entry until telemetry data indicated errant readings. During the investigation data from these two sources was used to make aerodynamic, aerothermal, and mechanical reconstructions of re-entry that showed how these stresses affected the Orbiter.

[...]

Re-Entry Environment

In the demanding environment of re-entry, the Orbiter must withstand the high temperatures generated by its movement through the increasingly dense atmosphere as it decelerates from orbital speeds to land safely. At these velocities, shock waves form at the nose and along the leading edges of the wing, intersecting near RCC panel 9. The interaction between these two shock waves generates extremely high temperatures, especially around RCC panel 9, which experiences the highest surface temperatures of all the RCC panels. The flow behind these shock waves is at such a high temperature that air molecules are torn apart, or "dissociated." The air immediately around the leading edge surface can reach 10,000 degrees Fahrenheit; however, the boundary layer shields the Orbiter so that the actual temperature is only approximately 3,000 degrees Fahrenheit at the leading edge. The RCC panels and internal insulation protect the aluminum wing leading edge spar. A breach in one of the leading-edge RCC panels would expose the internal wing structure to temperatures well above 3,000 degrees Fahrenheit.

CAIB Report Vol 1 pages 65-67:

Re-Entry Timeline

Times in the following section are noted in seconds elapsed from the time Columbia crossed Entry Interface (EI) over the Pacific Ocean at 8:44:09 a.m. EST. Columbia's destruction occurred in the period from Entry Interface at 400,000 feet (EI+000) to about 200,000 feet (EI+970) over Texas. The Modular Auxiliary Data System recorded the first indications of problems at EI plus 270 seconds (EI+270). Because data from this system is retained onboard, Mission Control did not notice any troubling indications from telemetry data until 8:54:24 a.m. (EI+613), some 10 minutes after Entry Interface.

Left Wing Leading Edge Spar Breach

(EI+270 through EI+515)

At EI+270, the Modular Auxiliary Data System recorded the first unusual condition while the Orbiter was still over the Pacific Ocean. Four sensors, which were all either inside or outside the wing leading edge spar near Reinforced Carbon-Carbon (RCC) panel 9-left, helped tell the story of what happened on the left wing of the Orbiter early in the re-entry.

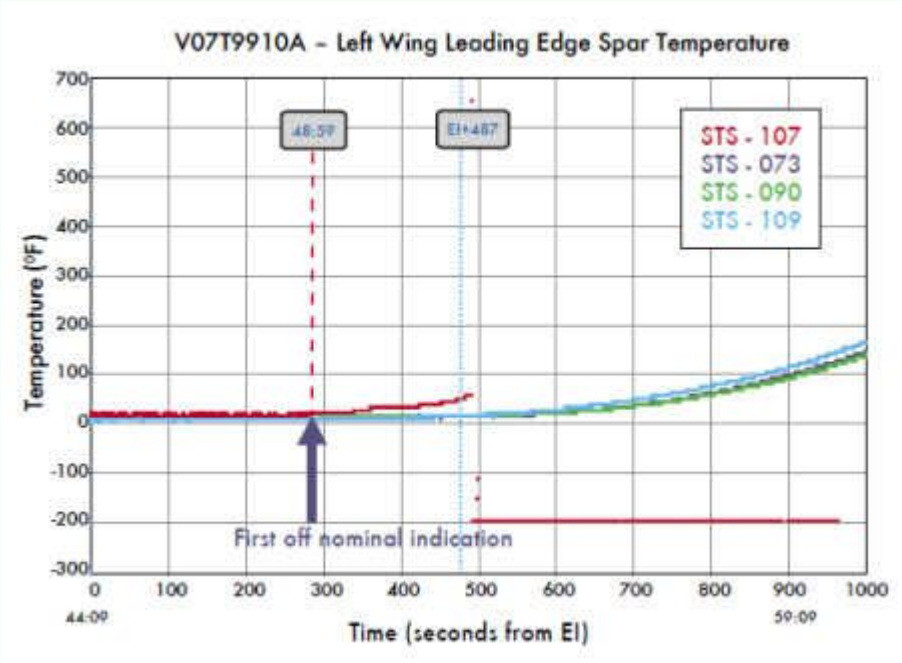
[...]

Sensor 1 provided the first anomalous reading (see Figure 3.6-3). From EI+270 to EI+360, the strain is higher than that on previous Columbia flights. At EI+450, the strain reverses, and then peaks again in a negative direction at EI+475. The strain then drops slightly, and remains constant and negative until EI+495, when the sensor pattern becomes unreliable, probably due to a propagating soft short, or "burn-through" of the insulation between cable conductors caused by heating or combustion. This strain likely indicates significant damage to the aluminum honeycomb spar. In particular, strain reversals, which are unusual, likely mean there was significant high-temperature damage to the spar during this time.

The strain gauge (Sensor 1) on the back of the left wing leading edge spar was the first sensor to show an anomalous reading.
In this chart, and the others that follow, the red line indicates data from STS-107.
Data from other Columbia re-entries, similar to the STS-107 re-entry profile, are shown in the other colors.
[Figure 4.f.1]

At EI+290, 20 seconds after Sensor 1 gave its first anomalous reading, Sensor 2, the only sensor in the front of the left wing leading edge spar, recorded the beginning of a gradual and abnormal rise in temperature from an expected 30 degrees Fahrenheit to 65 degrees at EI+493, when it then dropped to "off-scale low," a reading that drops off the scale at the low end of

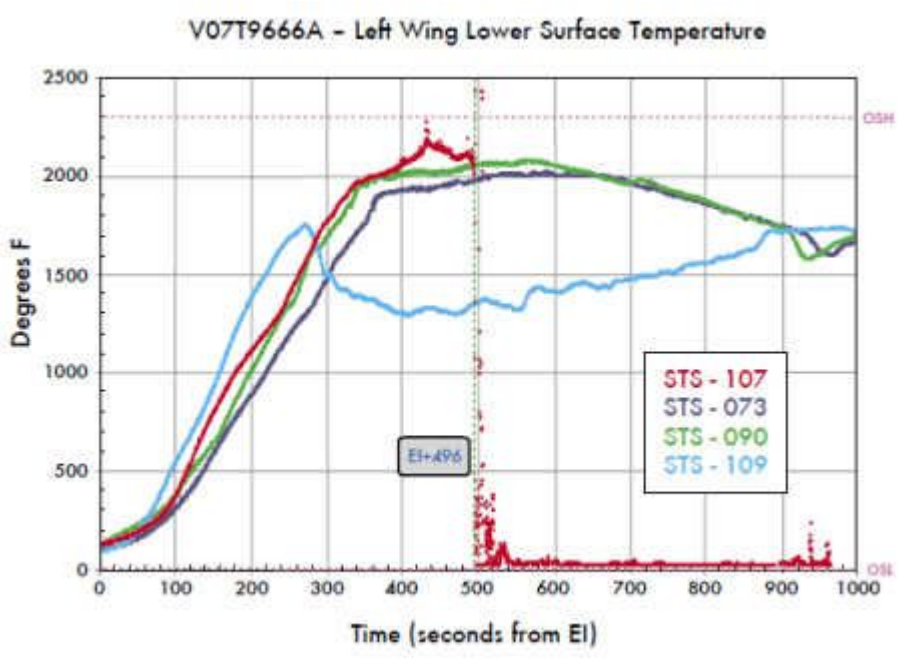
the sensor's range (see Figure 3.6-4). Sensor 2, one of the first to fail, did so abruptly. It had indicated only a mild warming of the RCC attachment clevis before the signal was lost.



This temperature thermocouple (Sensor 2) was mounted on the outside of the wing leading edge spar behind the insulation that protects the spar from radiated heat from the RCC panels. It clearly showed an off-nominal trend early in the re-entry sequence and began to show an increase in temperature much earlier than the temperature sensor behind the spar.
[Figure 4.f.2]

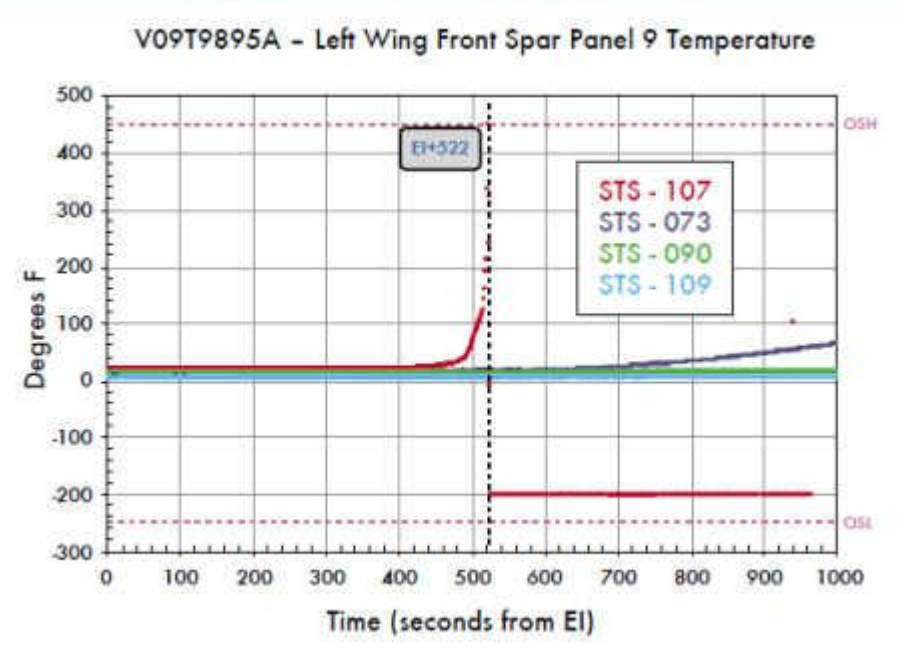
[...]

The readings of Sensor 3, which was in a thermal tile, began rising abnormally high and somewhat erratically as early as EI+370, with several brief spikes to 2,500 degrees Fahrenheit, significantly higher than the 2,000-degree peak temperature on a normal re-entry (Figure 3.6-6). At EI+496, this reading became unreliable, indicating a failure of the wire or the sensor. Because this thermocouple was on the wing lower surface, directly behind the junction of RCC panel 9 and 10, the high temperatures it initially recorded were almost certainly a result of air jetting through the damaged area of RCC panel 8, or of the normal airflow being disturbed by the damage. Note that Sensor 3 provided an external temperature measurement, while Sensors 2 and 4 provided internal temperature measurements.



As early as EI+370, Sensor 3 began reading significantly higher than on previous flights. Since this sensor was located in a thermal tile on the lower surface of the left wing, its temperatures are much higher than those for the other sensors.
[Figure 4.f.3]

Sensor 4 also recorded a rise in temperature that ended in an abrupt fall to off-scale low. Figure 3.6-7 shows that an abnormal temperature rise began at EI+425 and abruptly fell at EI+525. Unlike Sensor 2, this temperature rise was extreme, from an expected 20 degrees Fahrenheit at EI+425 to 40 degrees at EI+485, and then rising much faster to 120 degrees at EI+515, then to an off-scale high (a reading that climbs off the scale at the high end of the range) of 450 degrees at EI+522. The failure pattern of this sensor likely indicates destruction by extreme heat.



Sensor 4 also began reading significantly higher than previous flights

before it fell off-scale low. The relatively late reaction of this sensor compared to Sensor 2, clearly indicated that superheated air started on the outside of the wing leading edge spar and then moved into the mid-wing after the spar was burned through. Note that immediately before the sensor (or the wire) fails, the temperature is at 450 degrees Fahrenheit and climbing rapidly.
It was the only temperature sensor that showed this pattern.
[Figure 4.f.4]

CAIB Report Vol 1 page 70:

> Between EI+530 and EI+562, four sensors on the left inboard elevon failed. These sensor readings were part of the data telemetered to the ground. Noting the system failures, the Maintenance, Mechanical, and Crew Systems officer notified the Flight Director of the failures. (See sidebar in Chapter 2 for a complete version of the Mission Control Center conversation about this data.)
>
> At EI+555, Columbia crossed the California coast. People on the ground now saw the damage developing on the Orbiter in the form of debris being shed, and documented this with video cameras. In the next 15 seconds, temperatures on the fuselage sidewall and the left Orbital Maneuvering System pod began to rise. Hypersonic wind tunnel tests indicated that the increased heating on the Orbital Maneuvering System pod and the roll and yaw changes were caused by substantial leading edge damage around RCC panel 9. Data on Orbiter temperature distribution as well as aerodynamic forces for various damage scenarios were obtained from wind tunnel testing.

Though difficult to give an exact time, it appears that the Goldie image was taken just after the time that Columbia crossed the California coast. This would place it roughly between EI+555 and perhaps EI+615.

Guy Cramer (superforce.com) estimated the picture to have been taken at around EI+562:

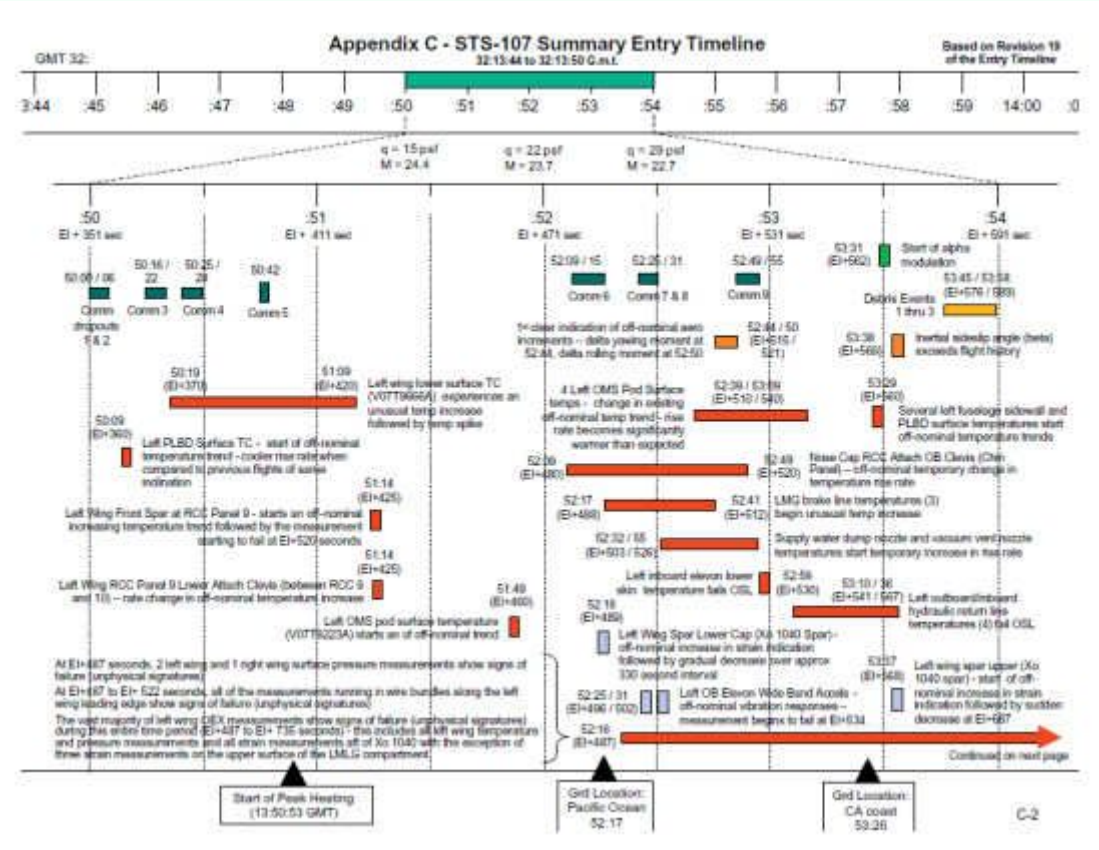
> ... the photograph, was taken from Bernal Heights in San Francisco by an amateur astronomer. Page 8 shows Licks Observatory (slightly east of Bernal Heights) Acquisition Of Signal was at 13:53:29
>
> Unexpected Return link communications drop-out (Communication event 10) 13:53:32 / 34 (3 Seconds) [EI+562/564]
>
> Given that Bernard Heights is west of Licks Observatory, Communication event 10 took place while the photographer would have had acquisition of the shuttle.

The timing of Communication event 10 is confirmed in Appendix D.9 on page 278, and also in Appendix D.7 on page 205:

There were other communication dropouts in this timeframe as well (8:53:32 to 8:53:34 EST, EI +563 to 565 sec.).

Now if we look at the entry timeline data in chart form, things become clearer. Comms event 10 is indicated below by the green vertical block at EI+562.

CAIB Report Vol 2 Appendix D.9 page 286:



Reentry timeline data
[Figure 4.f.5]

The first visual sighting of debris shedding was some 14 seconds after Communications event 10, at 8:53:46 or EI+576

CAIB Report Vol 3 Appendix E.2 page 102:

Detailed map of the Western U.S. re-entry debris event locations.
The blue dots and connecting lines are the observer positions (identified by video number)
and their relative fields-of-view captured by their videos.
[Figure 4.f.6]

The timeline and data above at least help to confirm that Goldie's image #3 was likely taken at or around the time of Communications event 10, EI+562.

It is also quite clear that the shuttle was already experiencing significant damage by the time the anomalous photo was taken. Even if the anomaly was confirmed as megalightning, it was likely not the **sole** cause of the shuttle's demise, however it still may have been a contributing factor.

Space Weather

Section 4.g

CAIB Report Vol 1 page 90:

> Space weather refers to the action of highly energetic particles in the outer layers of Earth's atmosphere. Eruptions of particles from the sun are the primary source of space weather events, which fluctuate daily or even more frequently. The most common space weather concern is a potentially harmful radiation dose to astronauts during a mission. Particles can also cause structural damage to a vehicle, harm electronic components, **and adversely**

affect communication links.
[Emphasis added]

> After the accident, several researchers contacted the Board and NASA with concerns about unusual space weather just before Columbia started its re-entry. A coronal mass ejection, or solar flare, of high-energy particles from the outer layers of the sun's atmosphere occurred on January 31, 2003. The shock wave from the solar flare passed Earth at about the same time that the Orbiter began its de-orbit burn. To examine the possible effects of this solar flare, the Board enlisted the expertise of the Space Environmental Center of the National Oceanic and Atmospheric Administration and the Space Vehicles Directorate of the Air Force Research Laboratory at Hanscom Air Force Base in Massachusetts.
>
> Measurements from multiple space- and ground-based systems indicate that the solar flare occurred near the edge of the sun (as observed from Earth), reducing the impact of the subsequent shock wave to a glancing blow. Most of the effects of the solar flare were not observed on Earth until six or more hours after Columbia broke up. See Appendix D.5 for more on space weather effects.
>
> **Finding:**
>
> F4.2-8 Space weather was not a factor in this accident.

One of the researchers mentioned in the second paragraph above was Guy Cramer. Cramer is an Air Ion expert who had been consultant for NASA on a previous project where ionization expert advice was required.

In his article "Wrong Place, Wrong Time" Cramer expresses a very different view of the possible role of space weather on the day. He states that there was a **Rare** Solar Shockwave which impacted the ionosphere at the same time the shuttle was reentering the Earth's atmosphere.

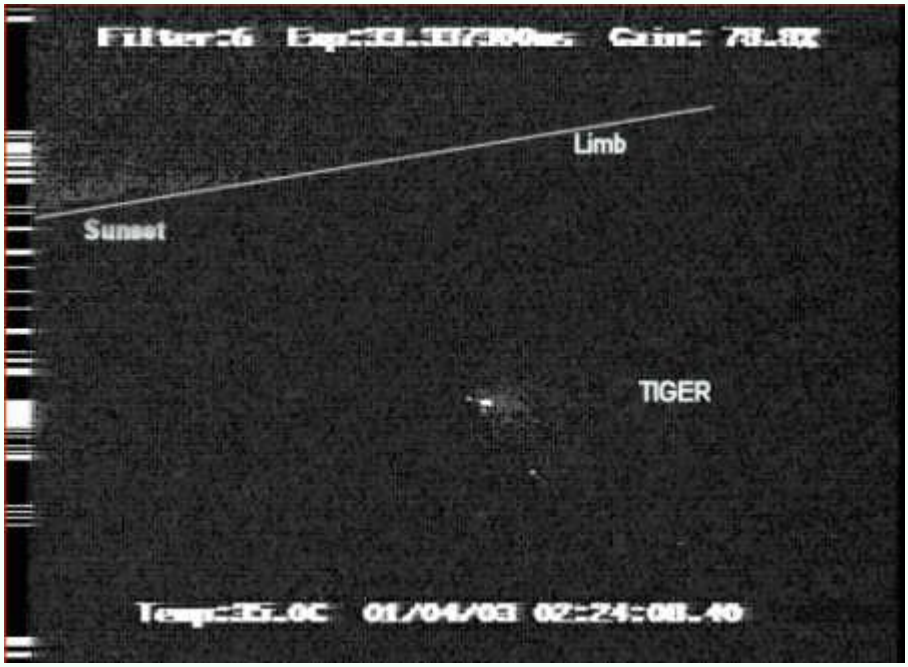
This assertion is backed with data from both the ACE and SOHO satellites and calculations which place the shockwave at the ionosphere at the time of the shuttle's unexpected communications difficulties and the time the Goldie photo was taken. It is worth mentioning here that Mission Control expects a certain degree of communications drop-outs with any reentry, but that they usually begin to occur later in the reentry timeline than on this occasion. A quote from Cramer's article, quoting a SOHO data monitoring site (emphasis added by Cramer):

> The geomagnetic field was quiet to minor storm on February 1. Solar wind speed ranged between 338 and 971 km/sec. **An unusual solar storm arrived at SOHO near 13:10 UTC. This storm is unusual in that solar wind speed was very low at the time of its arrival and had some of the highest peak solar wind speeds recorded during this solar cycle. At**

> **the first solar wind shock the velocity jumped abruptly from 390 to 520 km/sec, then increased slowly to 600 km/sec.** Near 14:30 UTC at SOHO there was another shock, this time speed increased to above 800 km/sec. By 16h UTC solar wind speed had peaked just below 1000 km/sec. The interplanetary magnetic field was mostly northwards for the remainder of the day. Early on February 2 solar wind speed has decreased to below 600 km/sec.

The prevailing belief at the time of the investigation was that lightning, including sprites, could not form without a nearby storm or stormclouds. It was later revealed that this is not the case, ironically from data taken earlier on in the ill-fated mission but not analysed until well after the investigation, in a paper titled "Space shuttle observation of an unusual transient atmospheric emission" Yoav Yair *et al* and published in *Geophysical Research Letters*, Vol. 32, L02801, doi:10.1029/2004GL021551, (2005).

> [1] We report an observation of an unusual transient luminous event (TLE) detected in the near IR, south of Madagascar above the Indian Ocean. The event was imaged from the space shuttle Columbia during the MEIDEX sprite campaign [*Yair et al*., 2004]. It was delayed 0.23 seconds from a preceding visual lightning flash which was horizontally displaced >1000 km from the event. The calculated brightness in the 860 (±50) nm filter was ~310 ± 30 kR, and the morphology of the emitting volume did not resemble any known class of TLE (i.e., sprites, ELVES or halos). This TIGER event (Transient Ionospheric Glow Emission in Red) may constitute a new class of TLE, not necessarily induced by a near-by thunderstorm. We discuss possible generation mechanisms, including the conjugate sprite hypothesis caused by lightning at the magnetic mirror point, lightning-induced electron precipitation and an extraterrestrial source, meteoric or cometary.
>
> [...]
>
> [4] Here we report the detection of an unusual transient emission with a peculiar morphology. Shuttle-related sources for this event had been ruled out based on the mission operations time-line. The shuttle glow phenomenon [*Murad*, 1998] was also ruled out based on the physical detachment of the emission from the surfaces of the orbiter and its very short duration.
>
> [...]
>
> [8] The new observation reported here presents a unique deviation from the prevalent attributes of CG lightning-TLE relations and may possibly be a new type of TLE. We shall refer to it as TIGER (Transient Ionospheric Glow Emission in Red) for it bears little morphological resemblance to the known forms of sprites, haloes or ELVES, and is also very different from the typical luminosity pattern of cloud-diffused lightning light, which often has an elliptical shape and lasts several tens of ms.
>
> [...]



The brief luminosity of the TLE as observed above the Indian Ocean, east of the main storm system.
Based on the assumption that the event occurred at an altitude of ~100 km,
the computed range from the shuttle is ~520 km,
more than 700 km from near-by thunderstorms.
[Emphasis added]
Image credit: MEIDEX/ISA/NASA
[Figure 4.g.1]

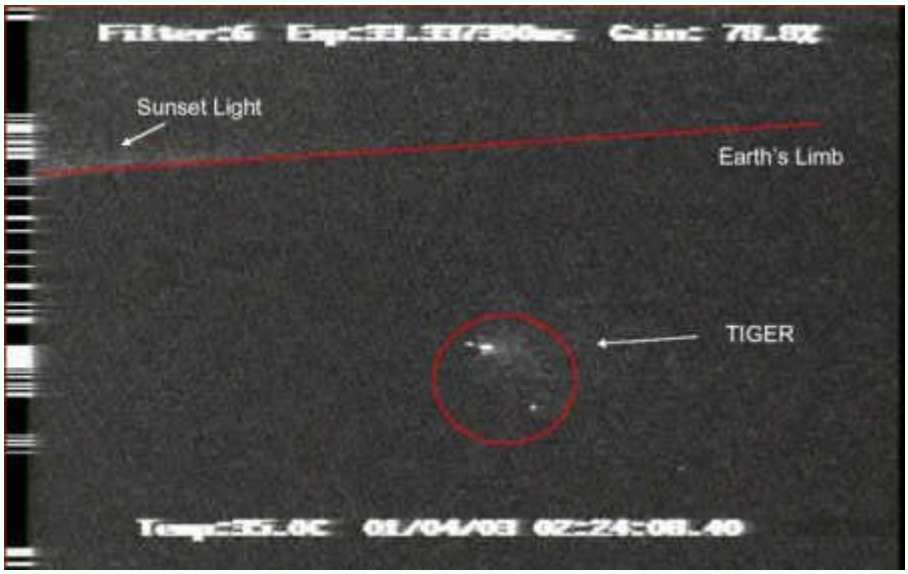
> [...]
>
> [10] An extraterrestrial source for this emission is one possibility that should be considered. Meteor trails were observed by the MEIDEX camera during orbit 87 on January 22nd, 2003 over Africa [*Yair et al*., 2004]. Although most meteors start ablating in the atmosphere at heights around 110–115 km, there are also other reports of unusually high altitude emission from meteors [*Fujiwara et al*., 1998].

Another article by Cramer in 2005 titled "Wild Blue Yonder" also looks at this TIGER event, and notes particularly the "corkscrew" shape apparent in both Goldie's image and albeit very faintly in the TIGER event recorded by the shuttle.

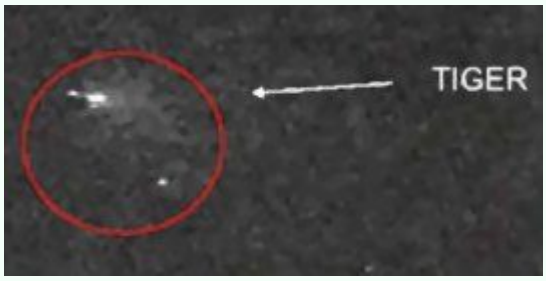
> New information in January 2005 based on the research of STS-107 (astronaut Ilan Ramon's experiments) shows a new form of high altitude lightning with no thundercloud activity called "TIGER" (Transient Ionospheric Glow Emission in Red). The reason the experts and CAIB dismissed the San Francisco (corkscrew Lightning) photo was the lack of thunderclouds in the region and no other objective examples of this new form of lightning. My review of the TIGER event shows a similar pattern to the San Francisco photo - no thunderclouds in the region and a corkscrew bolt. I have included the photos below of both the TIGER and the Hyper Lightning, a name I have given to the San Francisco bolt (Hyper-Lightning would be an artificially induced TIGER event which strikes a hypersonic vehicle without leaving detectable

low-frequency sound waves - infrasound). I initially thought the term Hobbit would do but the term had little to do with the anomaly.

The TIGER event also has a corkscrew behind it, difficult to see but it's there (I did some enhancement on the entire picture to better show the corkscrew) which starts right under the T in the word TIGER and travels left to right. **Air Ions charges do corkscrew with altitude** as per my research in the Southern Hemisphere Study 1990.
[Emphasis added]



Original photo unaltered
[Figure 4.g.2]



Enhanced 1
[Figure 4.g.3]

Enhanced 2
[Figure 4.g.4]

The Terminator

Section 4.h

The "terminator" is a name given to the "line" where night meets day, and day meets night. Obviously it's location on the globe changes as the Earth rotates. There is significant evidence that the terminator would be more likely to attract electrical activity than other areas of the globe at any given time. Space Shuttle Columbia crossed the terminator at around the time the Goldie image was taken.

Using a tool from John Walker's fourmilab site, Cramer generated this "view" of Earth at the time of Columbia's reentry.

Earth as the daylight-darkness would have appeared at 2003/02/01 13:52:00 UTC
Credit: Guy Cramer/fourmilab
[Figure 4.h.1]

The following paragraphs (12 [Scroll down to #25 - Electric Currents from Space]) make reference to large sheets of electric current running through the morning side and evening side of the ionosphere, a region the shuttle was just passing through.

> In 1973 the navy satellite Triad flew through the auroral zone region in a low-altitude orbit, its magnetometer indeed detected the signatures of two large sheets of electric current, one coming down on the morning side of the auroral zone, one going up on the evening side, as expected. Because Kristian Birkeland had proposed long before currents which linked Earth and space in this fashion, they were named **Birkeland currents** (by Schield, Dessler and Freeman, in a 1969 article predicting some of the features observed by Triad). Typically, each sheet carries a million amperes or more.

> But that wasn't all. Equatorward of each current sheet, Triad noted a parallel sheet almost as intense, flowing in the **opposite** direction: those field lines were no longer open, but closed inside the magnetosphere. It thus seemed that most of the electric current coming down from space (about 80%) did **not** choose to close through the ionosphere across the magnetic poles. Rather, it found an alternate way: it flowed in the ionosphere a few hundred miles equatorward and then headed out again to space, where the currents (presumably) found an easier path.
>
> [...]
>
> Further information Steven [Schwartz, former MIT research scientist] collected was on Auroral Activity Estimates from a series of NOAA satellites that orbit Earth between the North and South Poles. These Satellites can only monitor these Aurora when flying past the North or South polar regions so the data is only sporadically given every few minutes. The information shows the Auroral Activity Estimates for Northern Hemispheric power at 1345 UT = 8:45 AM EST was at 55 gigawatts (level 8) just prior to the Shuttle problems, average expected levels are 12 gigawatts (level 5). This information may confirm that the dawn current sheet had indeed extended southward to the Shuttle location, or close enough for a discharge to take place between the million amperes or more current sheet and the shuttle.

Not only is the terminator an ideal place to find electric currents in the ionosphere, when combined with it crossing a coastline the significance of this fact increases with regard to the Columbia disaster.

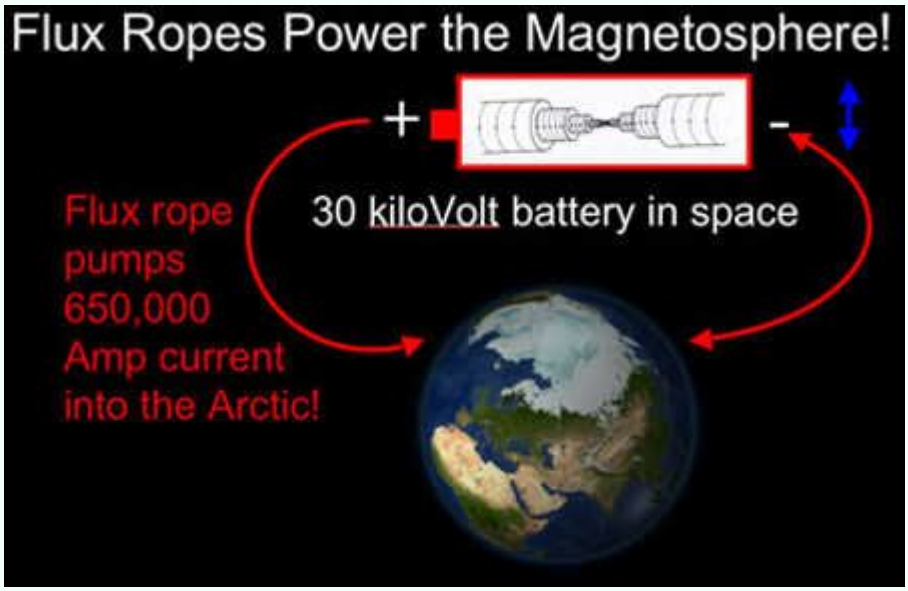
Physicist and electrical theorist Wal Thornhill (holoscience.com) in an article titled "Columbia: Questions of Some Gravity" in 2003 wrote:

> In 1998 it was reported by Professor Louis Frank and colleagues from the University of Iowa that auroras mysteriously show a tendency to hug coastlines. They write, "coastline arcs can be as thin as tens of miles, align along coastlines for several hundred miles, and last several minutes. The phenomenon normally occurs during the early phase of an auroral storm. Though scientists cannot yet explain why this coastline effect occurs, part of the answer seems to lie in the knowledge that ground currents are much greater off shore because sea water is a better conductor of electricity than the land." "It would appear," notes Frank, "that at certain times the ionosphere is primed for the generation of the thin arcs over the coastlines and that the arcs are tickled into brightening by the magnetic or electric fields from the ground currents. This is quite remarkable because these auroral lights are occurring at altitudes of 60 to 200 miles above the shores."
>
> This discovery indicates the possibility that a high altitude discharge could have been triggered near the U.S. coastline by a rare combination of circumstances.

Sun - Earth Electrical Connection

Section 4.i

In 2007 NASA's Goddard Space Flight Center published a press release in which THEMIS had identified a huge electric current flowing to Earth from the Sun.



Flux Ropes Power the Magnetosphere!:
THEMIS discovered a flux rope pumping a **650,000 Amp current** *into the Arctic.*
[Emphasis added]
Credit: David Sibeck/NASA/GSFC
[Figure 4.i.1]

"The satellites have found evidence of magnetic ropes connecting Earth's upper atmosphere directly to the sun," said David Sibeck, project scientist for the mission at NASA's Goddard Space Flight Center, Greenbelt, Md. "We believe that solar wind particles flow in along these ropes, providing energy for geomagnetic storms and auroras."

A magnetic rope is a twisted bundle of magnetic fields organized much like the twisted hemp of a mariner's rope. Spacecraft have detected hints of these ropes before, but a single spacecraft was insufficient to map their 3D structure. THEMIS' five identical micro-satellites were able to perform the feat.

"THEMIS encountered its first magnetic rope on May 20," said Sibeck. "It was very large, about as wide as Earth, and located approximately 40,000 miles (70,000 km) above Earth's surface in a region called the magnetopause." The magnetopause is where the solar wind and Earth's magnetic field meet and push against one another like sumo wrestlers locked in combat. There, the rope formed and unraveled in just a few minutes, providing a brief but significant conduit for solar wind energy.

> THEMIS also has observed a number of small explosions in Earth's magnetic bow shock. “The bow shock is like the bow wave in front of a boat,” explained Sibeck. “It is where the solar wind first feels the effects of Earth's magnetic field. Sometimes a burst of electrical current within the solar wind will hit the bow shock and—Bang! We get an explosion.”

Independent researcher Michael Gmirkin expanded upon the release in a Thunderblog titled Cluster's "Magnetic Reconnection" Data and the Big Picture:

> The "magnetic flux ropes" have been directly characterized as a 650,000 Amp current. We agree wholeheartedly that these features should be referred to in explicitly electrical terms.
>
> As mentioned above, electrical currents in plasma will tend to adopt a filamentary structure, as demonstrated by your garden-variety plasma lamp available at most novelty stores. Those filaments may also be composed of sub-filaments, and so on. Thus the description of the "flux ropes" (a 650,000 Amp current flowing between the sun and the Earth) as being braided like the hemp of a mariner's rope appears to be perfectly apt and, moreover, expected under an electrical interpretation.

Add to this recent observations of lightning interacting with space.

> **Lightning Interacts with Space, Electrons Rain Down**
>
> Energetic byproducts of lightning known as whistler waves streak thousands of miles above Earth's atmosphere into the magnetosphere, where they engage in a near-space dalliance that could be called the electron shuffle.
>
> The whistler waves interact with already gyrating electrons, then fling them off onto new paths. Some of the electrons rain back into the atmosphere a mere second later and a thousand miles away.
>
> [...]
>
> Johnson explained that energy from lightning moves in all directions. A small portion, traveling as whistler waves, heads into the magnetosphere, where invisible lines of radiation run from one of the planet's magnetic poles to the other.
>
> Meanwhile, the sun spews a constant stream of energy our way. These charged particles, including electrons, are known as the solar wind. The electrons become trapped in the magnetosphere's lines of radiation, a nifty feature that helps protect the planet. There, they bounce back and forth between the north and south magnetic poles.
>
> The energy of the whistler waves, Johnson says, is able to interact with these trapped electrons, an effect that may extend 15,000 miles or more above Earth.

Dr. Joseph Dwyer, an expert in lightning research at the Florida Institute of Technology, was one of the first to discover that lightning is not produced nor triggered via the mechanisms thought for so many years.

[At the link above, under "Choose a month and year to view:" choose "November" and "2003" and click "Submit"]

> **November 06, 2003 : Thunderstorm Research Shocks Conventional Theories**
> - If Joseph Dwyer, Florida Tech associate professor of physics, is right, then a lot of what we thought we knew about thunderstorms and lightning is probably wrong.
>
> In the latest issue of Geophysical Research Letters , the National Science Foundation CAREER Award winner caps two years of lightning research with a startling conclusion: **The conditions inside thunderstorms that were long thought necessary to produce lightning actually do not exist in nature**.
> [Emphasis added]
>
> "For generations, we've believed that in order to produce a lightning discharge, the electric fields inside storms must be very big, similar to the fields that cause you to be shocked when you touch a metal doorknob," said Dwyer.
>
> The problem is scientists have searched inside thunderstorms for many years, looking for these large electric fields, only to come up empty handed. Some researchers have suggested that maybe we haven't been looking hard enough; maybe the big electric fields are really there, but they were somehow just missed. Now, Dwyer's new theory shows that these searches were actually in vain; super-sized fields simply don't exist, period.
>
> "What we've discovered is a new limit in nature. Just as a bucket can only hold so much water, the atmosphere can only hold a certain sized electric field. Beyond that, the electric field is stunted by the rapid creation of gamma-rays and a form of anti-matter called positrons," he said.
>
> While Dwyer's research shows that lightning is not produced by large, unseen electric fields inside storms, the triggering mechanism remains a mystery. "Although everyone is familiar with lightning, we still don't know much about how it really works," said Dwyer.

Could it be that due to dogma researchers have been looking in the wrong place for their answers? Perhaps it is time to seriously consider an alternative, such as is offered by Wal Thornhill:

> Meteorologists have a major problem. They acknowledge that the Earth's atmosphere acts like a leaky, self-repairing capacitor (condensor). However,

> they assume that this spherical capacitor is charged from within by thunderstorm activity because they have been told that the Earth is an uncharged body flying through an uncharged solar wind. But it has never been shown precisely how the thunderstorm charging process works. And it cannot explain the recent discoveries of strange discharge phenomena above thunderstorms, stretching up into space.
>
> The electric universe model argues that the solar system is not electrically "dead." The Sun, like all stars, is a focus for a galactic discharge. Earth is a charged body that continually transfers charge from space to maintain equilibrium with the solar electrical environment. Thunderstorms are generated by a breakdown of the insulating layer of atmosphere between the Earth's surface and the ionosphere. Leakage currents CAUSE the vertical winds in a thunderstorm and the charge build-up in the cloud. Occasionally, a bolt of megalightning streaks from the top of a large storm instead of its base. This 10-kilometres-high short-circuit throws the switch for a further powerful discharge to the ionosphere. The result is a towering diffuse discharge at very high altitudes - a "red sprite" or "blue jet."

In the above paragraphs Thornhill links to one of his own earlier articles, from 2002 titled The Balloon goes up over lightning! which has more detail.

> **Bering's results**-some of which he presented at the recent American Geophysical Union meeting in San Francisco-**turns sprite theory on its head**. "The charge that produces sprites is not below in the cloud, it's in the mesosphere itself," suggests Bering. So now there are new puzzles: **where could this charge be coming from**, and if there's no QE [quasi-electrostatic] field, what causes the delay between lightning and sprite? "We have a problem understanding why the sprite takes so long to form," admits **James Benbrook**, a colleague of Bering's in the physics department at the University of Houston.
>
> [...]
>
> **Most sprite investigators agree that Bering should have been able to detect the low-frequency hum, and blame his instruments for failing to do so**. Bering defends the quality of his experiment and insists his instruments were working. "We wouldn't have seen the electric signal of the sprite if they weren't."
>
> Can the QE field theory recover from this blow? "My personal guess is no," **says Bering. "None of the existing models will survive when people finally pay attention to what our data actually says."**
>
> [...]
>
> Birkeland was the good guy in a 50-year dispute involving the idea that electrons streaming along magnetic field lines caused the Earth's auroras. His opponent was the astronomer Sydney Chapman who maintained that the

Earth moved through a vacuum. In 1974 space probes found in Birkeland's favour. Chapman and others then promptly made space plasma superconducting, which relieved them from the complications of dealing with electric fields. Birkeland actually demonstrated his theory long before in an experiment called a "terrella." It consisted of an electromagnet contained within a sphere and placed in a large vacuum chamber. By initiating an electric discharge in the chamber he was able to reproduce a light show with many of the odd features of auroras. **The importance of this simple experiment cannot be overstated because it demonstrates that aurorae and lightning seem to require an electrical power source external to the Earth! That would explain the puzzle raised by Bering: "The charge that produces sprites is not below in the cloud, it's in the mesosphere itself."**

The Electric Universe model suggests that the Earth plays a cathode role in the Sun's discharge and therefore is in the business of supplying negative electrons to space and receiving positive ions from the solar wind. It is interesting therefore that the presence of solar wind ions inside the earth's magnetosphere has puzzled scientists. Thunderstorms are not electricity generators, they are passive elements in an interplanetary circuit, like a self-repairing leaky condenser. The energy stored in the cloud "condenser" is released as lightning when it short-circuits. The short-circuits can occur either within the cloud or across the external resistive paths to Earth or the ionosphere. The charge across the cloud "condenser" gives rise to violent vertical electrical winds within the cloud, not vice versa. By creating a short-circuit to high altitudes in the storm the lightning effectively "throws the switch" connected to the glow discharge "tube" in the upper atmosphere. It then makes perfect sense that the much taller positive cloud-to-ground discharge will be more effective at providing power to the glow discharge than will low-level negative cloud-to-ground lightning because the circuit resistance is lower. Ultimately, lightning on Earth is driven by electric power focused on the Sun but minutely intercepted by the Earth. So lightning on Earth is a pale imitation of what is happening on the Sun.

Plasma "Lightning Rod"

Section 4.j

On 14th November 1999 Space.com re-told the story of Apollo 12's close brush with lightning 30 years previous:

Apollo 12's Stormy Beginning

[...]

Thirty seconds after liftoff, Conrad saw a bright flash through his window. Seconds later, he and his crewmates heard the wail of the master alarm in

> their headphones. When he glanced at the instrument panel, Conrad saw more warning lights than he'd ever encountered in any simulation on Earth. Something was very wrong with the spacecraft's electrical system.
>
> What no one had yet realized was that Apollo 12 had been struck by lightning. As the Saturn booster sped through rain clouds, it had become the world's longest lightning rod. **A bolt of electricity had struck the spacecraft and traveled all the way to the ground, 6,000 feet below, along the column of hot, charged gases of the Saturn's exhaust plume**. The bolt had knocked Yankee Clipper's power-producing fuel cells off line, and had even jolted the command module's navigation system. No Apollo mission had ever been aborted -- was Apollo 12 about to become the first?
> [Emphasis added]

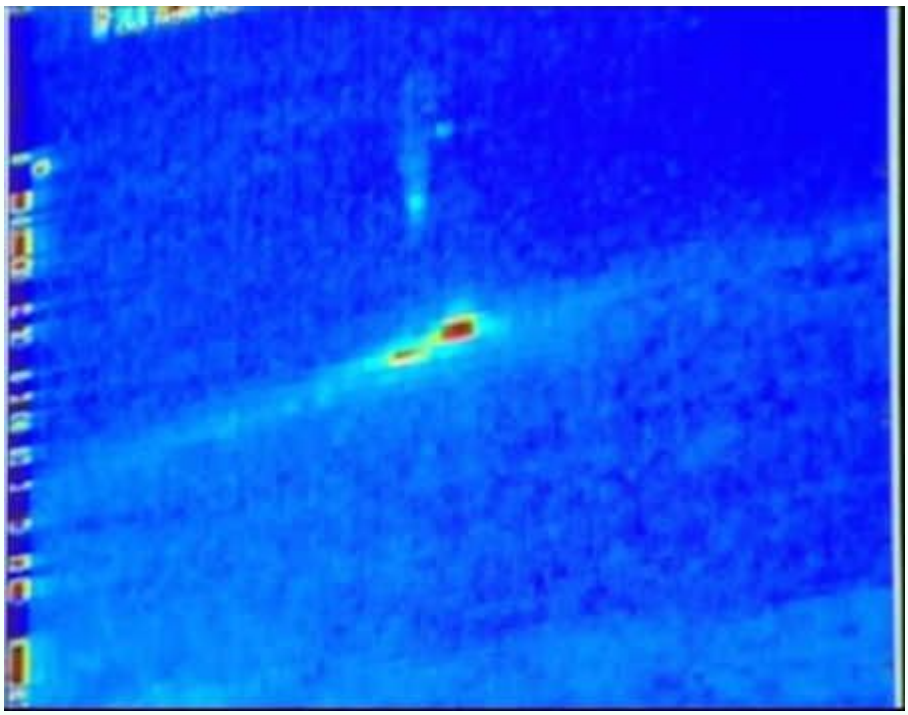
This is just one example of terrestrial lightning following a contrail, but meteors have also been known to trigger sprites high in the atmosphere, at the edge of space, as noted by Thornhill in 2005:

> It has been discovered that meteors can trigger sprites. Meteors leave an electrically conducting trail, like a lightning rod, from the ionosphere into the lower atmosphere. A spacecraft re-entering the atmosphere creates a similar ionized trail.

The possibility that Columbia acted as a lightning rod was raised **BEFORE** publication of Goldie's image, by weather expert Walt Lyons as noted above in the Initial Media Reports section:

> As the space shuttle streaks through the upper atmosphere, it leaves a wake in the air just as a boat leaves a wake behind it in the water. The shuttle's wake becomes electrified. **Lyons says some scientists are speculating that its electrified wake acted as an antenna and drew a blue jet to the Columbia.**
> [Emphasis added]
>
> NASA and the Air Force have been losing interest in studying the uppermost atmosphere. Meanwhile, Lyons says scientists are still discovering unexplained phenomenon. "We're nickel-and-diming to do our research," he says. **"And there is all sorts of electrical foolishness going on up there that we still don't know anything about."**
> [Emphasis added]

More from the documentary Megalightning:



Sprite apparently triggered by a meteor
Credit: dmptv/NASA/Yoav Yair
[Figure 4.j.1]

(Yoav Yair) On the night of January 22nd, note this first meteor coming, a second one come from ... we see lightning below the horizon, and this is the sprite.

Discussion

Summary

Section 5.a

The foam strike discussed in the first section of this paper clearly did happen, and when viewed in conjunction with the reentry data it is obvious that the damage caused by the foam strike was having a significant effect on the shuttle as it reentered the Earth's atmosphere and began heating due to the drag friction involved. The numerous "out of family" readings from the left-wing sensors are testament to this.

It is equally obvious that the anomalous photograph taken by Peter Goldie was taken at about the time of Communications event 10. What cannot be stated for certain is that the anomaly is an electrical discharge, though this author is of the opinion that it was not caused by camera shake, which leaves few explanations other than an electrical discharge event.

It appears that the main reason for discounting megalightning is that there was

no storm in the vicinity, which on the surface sounds reasonable. But as Walt Lyons and other commentators note, not everything which could be known about the ionosphere is yet known. This was further borne out by the 2005 Yair paper mentioned in the Space Weather section.

As more research is conducted into Earth's electrical circuitry, more phenomena are discovered which were not even conceived of before. Recently we have even seen that the Earth is "connected" electrically to the Sun, so to discount an as yet unknown form of electrical atmospheric discharge is somewhat short-sighted.

We also must keep in mind that the plasma trail left by the shuttle is an ionised path, a good conductor of electrical energy. If as the reentry data suggests, there was any melting or sublimation of metal components, this would add to the ionization and the conductivity of the plasma trail, and would attract any discharge to the part which was already damaged, and likely increase the damage significantly.

There are many descriptions one can find of a rocket being likened to a giant lightning rod, especially the ionized contrail thereof. With the discovery of a meteor triggering a sprite, and with scientists and weather specialists willing to consider the possibility of the Shuttle acting as a huge lightning rod, we have no reason to dismiss the possibility out of hand.

As Columbia crossed the coast of California, it also crossed the "terminator" and at the same time a rare solar shockwave had reached the same area of the ionosphere. All of these coincidental events can have an effect on the possibility of an electrical discharge to the contrail occurring.

The Columbia Accident Investigation Board seemed to not have the expertise to evaluate the space weather conditions carefully enough to rule out space weather as a contributing factor to the accident.

Conclusions

Section 5.b

These conclusions are those of this author alone, and do not constitute the views of any organization or body.

- *The foam strike on launch as found by the CAIB happened as stated, and caused enough damage to significantly affect Columbia on reentry.*

- *Columbia reentered Earth's atmosphere under an unusual set of*

circumstances which together could have contributed to a high-energy electrical discharge (or a number of discharges) to the orbiter as it crossed the California coast.

- *The CAIB did not sufficiently investigate the anomalous photo (by Goldie) or the space weather conditions to draw the conclusion that the anomaly in the image was caused by camera shake.*

- *It is highly likely that the Goldie image did capture an as yet unknown type of electrical discharge to the orbiter, possibly a TIGER or similar discharge.*

- *It is likely this discharge caused more damage to the orbiter than the foam strike and friction of reentry alone would have inflicted, and may well have contributed to the Shuttle's demise.*

- *The images Goldie took of the Shuttle reentry should be made available for public scrutiny or at least for independent analysis.*

- *The CAIB should re-convene a group to further investigate these assertions in the interests of future mission and public safety.*

Should any other researchers find this study or these conclusions of interest and be able to offer further comment either in support or in contradiction of my findings I am open to further discussion in this regard.

Initial contact should be made via email by clicking this link.

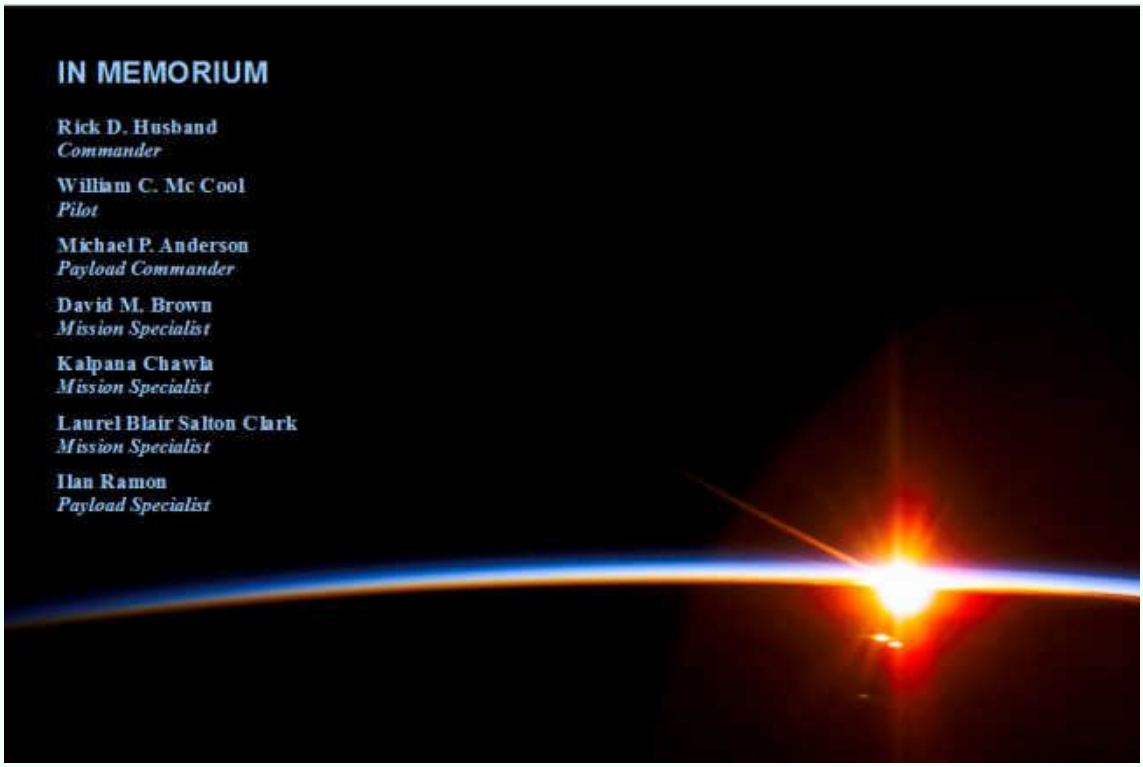
Epilogue

Section 5.c

CAIB Report Vol 1 page 73:

> Even with all thrusters firing, combined with a maximum rate of change of aileron trim, the flight control system was unable to control the left yaw, and control of the Orbiter was lost at EI+970 seconds. Mission Control lost all telemetry data from the Orbiter at EI+923 (8:59:32 a.m.). Civilian and military video cameras on the ground documented the final breakup. The Modular Auxiliary Data System stopped recording at EI+970 seconds.

With deepest respect



Sunrise from STS-107 on Flight Day 3
[Figure 5.c.1]

Disclosure

As a matter of public record I would like it known that the entire study above is my own work, and does not constitute the opinion of nor represent any affiliation I have with any groups either mentioned therein or not.

I am involved in a voluntary capacity for the Thunderbolts Project, as Managing Editor of their Thunderblogs and administration of some other facets of their web presence. This study however is completely independent of any association I have with the Thunderbolts Project or anyone else associated with same.

Dedication

This study is dedicated to the memory of my brother Carl Smith, who passed away on 24th June 2009, after an arduous battle with cancer.

It was Carl who, less than two and a half years ago inspired me to take a closer look into astrophysics and climate than I had previously. It was a conversation

about the Columbia disaster and the anomalous image which dominated that exchange of thoughts, and which ultimately led me to conduct my own study into this tragedy.

May he rest in peace. No more pain.

Copies of this study in pdf format can be downloaded here (1.05MB).

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