Back to some photos. The reviews of Tim Furniss' Challenger Chapter on this thread and elsewhere were cruel. Tim writes of fire at lift-off, continued leak from the stricken booster, debris falling in flight, the censored "New Smyrna Beach" tape and the Crew Cabin. Here are some photos that explain the "other sequence of events" that I developed in 1986.

First, you saw the fire through the Challenger right wing at lift-off in a previous Post. There are other compelling photos of the fire. If raging fire escaped the joint area at lift-off, no demon could reseal the stricken area. Also, had the failure occurred through the O-rings, then the smoke, fire or other exhaust would have surged straight up the side of the booster and beyond the tip of the External Tank. This is self-evident from the geometry of the SRBs' field joints, though no one noticed it before. And so on.

Furniss writes about the New Smyrna Beach film with fervor. I will give some photo evidence in this Post and some description.

- In December 1986, I received the original VHS tape of the Challenger flight taken from the New Smyrna Beach area by Mr. Harold Sehnert, of Lima, Ohio. The car radio was on loud, and I established accurate timeline for the tape from Steve Nesbitt's voice in the background.

- NASA had shown the Commission a "New Smyrna Beach" view, received from a "citizen." The Commission was shown the NSB tape from T+71s, i.e., only from two seconds before the explosion, hardly enough time to grasp what's going on.

- Why didn't NASA show the Commission the full NSB tape? One might think that there was not enough time to show the full tape in a public hearing. This is not so because the Commission was shown a TV-like feed from lift-off to T+71s, at which time the view was suddenly switched to the NSB view.

- It is possible that the NSB tape that NASA had was a close-up of Challenger and, hence, did not capture the astonishing events that I was able to develop from Sehnert's tape – a great bird's eye view.

- Another possibility was that the broadcast quality tape that NASA had was corrupted in some segments from lift-off to T+71s.

- The experts could have disagreed on the interpretation of the tape, and the Commission had a deadline to meet.

- I could not find the full "1-inch" quality tape in the National Archives, though I obtained and examined the recordings of "almost all," "but not all," photo record.

- In December 86, I wrote to NASA and offered to arrange for the immediate delivery of Sehnert's original tape to the agency. NASA declined my offer. I knew that cameras were impounded after the accident, and wondered whether there were legitimate reasons, e.g., national security, why the full NSB views should not be aired publicly. Neither NASA nor anyone else contacted me to say so.

Was it a cover-up? I don't think so. If NASA wanted to cover up the NSB tape(s), they would have simply not mentioned it at all. Here are some photos and comments:

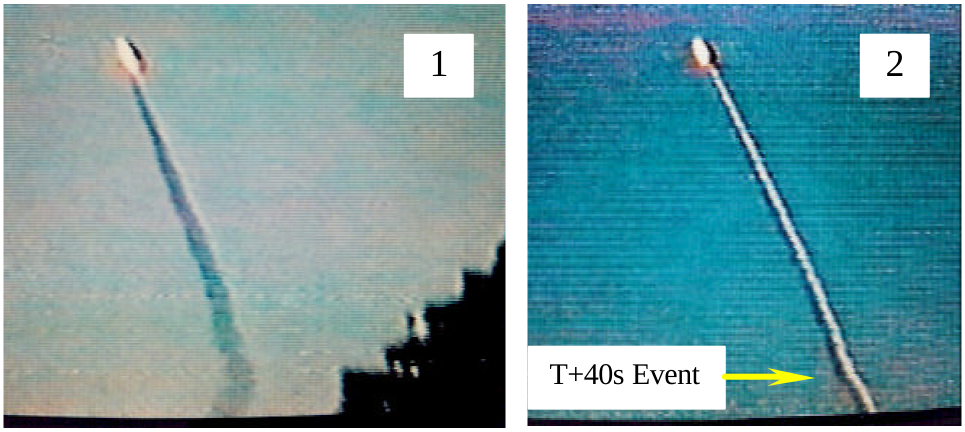
1. Here, you see the "roll maneuver" at the lower part. Notice that the two plumes blended into one plume, which I call the main plume.

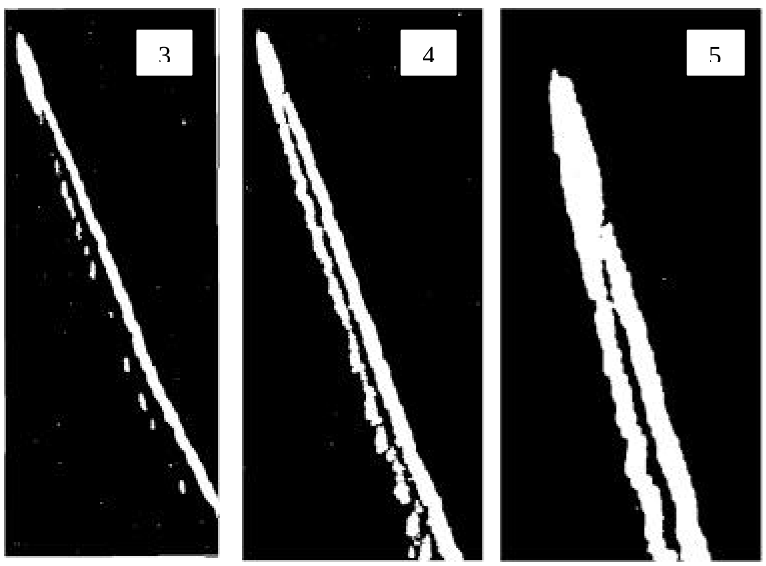
2. At T+40 seconds, Challenger executed a sudden upward turn – to counter excessive speed. At this time, puffs of smoke become visible to the left of the main plume (or, the combined left and right plumes).

3. The puffs of smoke are clearly visible to the left of the main plume (T+50s^{+}).

4. The puffs increase in intensity and coalesce into a semi-continuous trail (T+57s^{+}).

5. After T+71 seconds, the leaking trail (on the left) takes on the form of a distinct plume. The two plumes in Photo #5 are NOT the two plumes of the right and left SRBs; rather the main plume on the right side is the two plumes of the right and left boosters and the plume on the left side is the leak footprint.





From the sequence you see above, it is evident that the stricken right booster on Challenger was leaking hot gases throughout flight. If you only saw the New Smyrna Beach tape from T+71s (Photo #5), you could easily conclude that all was well. For example, you might think there were two boosters and you see two plumes, i.e., the plume on the right belongs to the left booster and the left plume belongs to the stricken right SRB. Not so. After T+71 seconds (Photo #5), the plume on the right belongs to both the left and right SRBs (the main plume) and the plume on the left is a third plume – the leak trail.

> Originally posted by fragmeister:
> He (Ali AbuTaha) seems very confident of his ability to make calculations based on even the best quality video tapes …

Wherever possible, I had made measurements and calculations from my, and others', photos. Let me pick up one item for discussion. What happened at T+40 seconds? If you print my Photo #2 and look right into the end of the plume, you will see that Challenger made a sudden turn upward – just like a runaway truck going downhill tums into a "gravity-ramp" on the side of a road to come to a safe stop. Well, how many degrees was the sudden turn at T+40s?

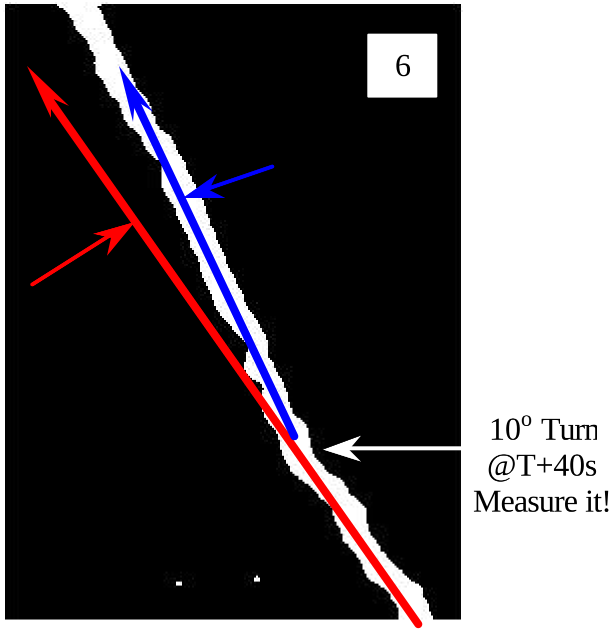
The question was subject of discussion by the Commission. Some NASA experts said Challenger turned 2-degrees and some said it turned at "a rate of 2-

degrees per second." Some said the SRB nozzles could turn 3-, 8- or 13.5-degrees. If Challenger turned 10-degrees at a rate of 2-deg/sec, then it would take 5 full seconds to make the turn. Well, what happened at T+40s, how many degrees did Challenger turn, and was the turn sudden or gradual? Here is a sample Q/A from the Commission records (pages refer to Vols. 4 and 5):

> NASA: … and then there was an unusual event, a forced event that occurred around, what, 40 seconds or so is what the time line chart indicated. (p.216)
>
> DR. RIDE: … I think there may be something at around 40 seconds. (Ibid)
>
> VICE CHAIRMAN ARMSTRONG: Is it determined yet that the two degree nozzle switch would be consistent with – would the direction of the two degree nozzle change be consistent with the moment direction that would be expected …(p.225)
>
> VICE CHAIRMAN ARMSTRONG: …have you ever seen nozzle excursions of this magnitude as a result of a breach? (Ibid)
>
> NASA: They have what, a three degree limit of the motion of the nozzles? (Ibid)
>
> MR. WALKER: I thought I saw eight degrees. (Ibid)
>
> NASA: At around 40 seconds – during ascent we get our normal actuator movement responding to wind. (p.434)
>
> NASA: At 40 seconds we see a 2-degree gimbal angle on the – on both the solid rocket boosters. This is well within our experience base; and we explain that because of winds; it is directly related to some winds. We don't see anything unusual; so we don't worry about that. (p. 498)

Communications dropouts, corrupted data, sensor failures and other factors could explain the above ambiguities. There are two important numbers to consider for the T+40 seconds event: The nozzles can turn 13.5-degrees, but what was the angle that Challenger turned!

A picture is worth a thousand words, and here is such a picture. I had taken a close-up of the 40-second event (Photo #6); and the average of measurements made by the engineers attending my Challenger course at the George Washington University was 10-degrees. You can measure the angle that Challenger made at T+40s directly from my photo with a simple protractor. Is it that simple? Yes. The Shuttle is driven through its center of gravity. When the nozzles turn, the stack turns on a dime, more like a London Cab than a New York Taxi.



A sudden 10-degree turn is a Major Event, but it is not listed in the "**STS 51-L Sequence of Major Events**" Table in the Commission, Vol. I, page 37! Before T+40s, the SSMEs had throttled down to 65% in the bucket, but the assembly was moving alarmingly fast, and the onboard computers, to counter the unexpected speed, executed the major 10^{o} turn. The faster than normal speed would have resulted from the uneven burning of propellant in the stricken right booster aft segments, which I mentioned before.

Let me add that my reconstructed trajectory, based on the (very reliable) data called out by Dick Scobee and Mike Smith, showed that Challenger was moving faster than the projected trajectory.

Here is another photographic measurement that can be easily made. From my Course notes, I mark two exact times on a photo similar to Photo #3. Dr. Hansen will appreciate this; all one needs do is count the number of puffs, divide by the time in seconds to obtain the fundamental, or natural, frequency of oscillation (in puff/sec, or cycle/sec, or Hz) of the in-flight twang. For those who don't know it, hold a ruler firmly at the edge of a table and tap the free end. The up and down oscillation is the twang. If you hold the ruler vertically, the oscillation (or twang) will be sideways – just like the SRBs exhibit in flight – the in-flight twang. This oscillation was responsible for the 3-hertz frequency of the puffs of smoke detected and reported in the official reports soon after lift-off during the time referenced by Hansen as, "*the SRB joint leaked from 0.638 to 2.5 seconds during liftoff …*" Some of us wondered in the 1970's how long the in-flight twang lasts. As Dr. McDonald can see from Photo #3, the oscillation continues well into flight. Also, a careful and knowledgeable observer can calculate important things from photos and video tapes.

This brings up another matter of great interest (an important Challenger lesson). I mentioned the change of liftoff timing in my first Post here. One can see why NASA and the Contractors were between the rock and a hard place when the liftoff timing change was made. If the lift-off timing were not changed, the in-flight twang would have been far more prominent and destructive of the Shuttle and its payloads. Satellites, especially antennas and solar arrays, are very fragile and very vulnerable to lateral loading, which the in-flight twang produces. I had analyzed this mode in the 1970's before I left the space program. Since then, I haven't seen studies by Thiokol engineers that evaluate the possible role that the in-flight twang might have played in the unseating of the famous O-rings in the field joints to cause erosion and blow-by in pre-Challenger flights.

> Originally posted by Dr. James R. Hansen:
> There is no way the SRM could be leaking near 6000^o gas from a broken case for the previous 59 seconds (as AbuTaha claims) without any drop in pressure, without developing any observable plume, or not causing a major structural failure to the SRM or burning through the ET during that time frame.

My NSB Photos 2, 3 and 4 clearly show "observable plume" before 59 seconds. My close-up photos, and video, give further convincing evidence, but I have to manage the file size for now.

Ali