“MY” GMC STORY

BY CHUCK AULGUR

“My” GMC story is about some of the things that I have learned during the 19 years that I have owned GMCs, and my purpose is to help other people learn about my thoughts relative to what some of the things that can be done to improve the great GMC motorhome we all love and drive. They are my thoughts only and in most cases are not based on any factual information from GM or any other source. What you do to your coach is your business and I am not recommending anyone to do the modification that I will be talking about to their GMCs.

First, a little history about myself that might help you to decide if what I will be discussing has any validity. After I graduated from the University of Missouri with a masters degree in mechanical engineering, I spent my entire working career designing various mechanical components used to control propellants, fluids and gases on many rockets produced by General Dynamics Corp. for a variety of space missions. There are several pieces of hardware still being used today that I had helped design. So, if I want to impress someone as to what I did in life; I tell them I was a “Rocket Scientist”. I’m sure all of you have heard the phrase “you don’t have to be a rocket scientist or brain surgeon to know how to do a particular thing”. It is usually used as semi-nice way of telling someone they don’t know squat. As far as I know, there is no such person with the title of “Rocket Scientist”. In my 27 years in the rocket business, I never saw or meet a Rocket Scientist. It is usually used in a joking way and that is the way I just used it. It is my attempt at making a joke so you will laugh and wake the folks that are taking a nap. I will be using it several times in my presentation for the same purpose, so listen carefully and laugh when you hear it.

The GMC was sold from 1973 thru 1978 and its life ended early probably for the same thing we all experienced driving to this rally; high gas prices. Prior to GMC production, the US government had built new freeways all across our country and the people who bought GMCs had lots of nice smooth major roads to drive on to enjoy their good looking and smooth ridings RV. During that time period, GM was a big manufacture of large busses and trucks. Some of you will remember all the advertising that GM and Greyhound did about their new tall scenic cruiser that was the forerunner of the busses and large RVs we see on the roads today. The advertisement pitch was to create a more scenic view for the passengers but the real reason was to create more storage space. At that time period Greyhound was also carrying freight. One story told was that GM developed the GMC moterhome first as a small intercity bus but found they had very poor traction on wet and snowy roads, so the management was about to cancel its production until someone suggested they make it into a motorhome. Another story told was GM started out from scratch to build the best motorhome on the road. They searched the world over for the best riding and driving vehicle with the intent of copying their best engineering features That vehicle was said to be the French automobile called Citron, which had front wheel drive and air over hydraulics suspension system, and the front wheel track was much less then the rear wheel track. The story went on to say that GM found the air over hydraulics suspension was costly and they were searching for another option when a Firestone man just happened by and saved them. He had an air bag that was already in production and was very inexpensive and would provide them with a nice smooth ride. It sounded so good GM jumped on the design and that is what we have today. Wouldn’t it be nice if we knew the real story.

This is where I start “my” story. I believe all the big wheels were setting around a large table discussing how they could cut some production cost. Someone was looking at the rear suspension and saw the two trailing arm suspension members with a large piece of structure in front of each swing arm that supported the air bag loads. A big red light came on in some bean counter’s head and he suggested if you would turn that forward swing arm around they could eliminate all that air bag support structure and you would only need one air bag. The suspension system engineers that where at the table fainted, because no engineer in his right mind would have purposely designed a suspension with a forward swing arm configuration. While the suspension engineers were out cold, management and the production people ran with the design we have today. That major mistake of using the forward facing swing arm is the cause for most of the modifications that have been developed over the last two decades to improve braking and the driving capability of our lovely coaches that we all drive today.

The first problem we heard about on the GMCs was with tire failures that I will discuss later. Then, as the suspension and steering systems started showing some wear, we started hearing about "wiggle-waggle". GM had a big study done and it was determined the original bias-ply tires were not capable of carrying the GMC loads. Along came the famous steel belted radial tires that were going to solve all the tire problems. Well it did help the tire problem somewhat, but the more flexible side walls of the radial tires caused more steering problems. A gentleman from Texas came up with what some people call "true track" and we all started spending our money on one of the many modifications to come along that would help the GMC steering. If you asked anyone that put them on, including myself, they would tell you what a great improvement they made because we all wanted them to foolishly spend their money like we did. People started selling gigantic anti-sway bars that would cure all our problems. They did have one good aspect, if you had installed two of the largest that were available, you could jack both sides of the coach rear wheels by just using a jack under just one side. You spent the money so sure it helped with the steering. Just don't try to level your coach from side to side with the air bags. Never mind how they affected the ride. If you hit a small depression on one side of the vehicle you were sure to fell it throughout the entire coach via the rolling action they caused. We also had people that installed long pinned rods from one side of the rear frame over to the opposite wheel.

Along came another GMC scientist (now remember to laugh) that said if we moved the front wheels out to be in line with the rear wheels that would solve all the steering problems, so the famous front wheel spacer arrived to save the day. Moving the front wheels out did improve the steering slightly. I dough if the person that invented them knew the reason why they did help the steering on some vehicles. The front suspension on the GMC, and most other vehicles, were designed so if you drew a straight line down through the center of the upper and lower ball joints, that line would intersect the ground at the center of the spot where the tire contacts the road surface. That is what causes your vehicle (I didn't say GMC) to go straight down the road when there is no force being applied by the steering box. By moving the center of the road/wheel contact point out two inches from where the line through the ball joints intersects the road surface, he created a load on each front tire that wants to turn the tires outward. What this does is put an inward compression load on all the tie rod joints and that takes some looseness out of worn tie rods and ball joints, which helps the steering if you have a worn front suspension.

What I'm finally getting around to telling you is what I think is the cause of all our GMC steering problems. It is caused by the forward facing swing arm suspension on the rear mid axle that got implemented when the suspension system engineer fainted at the GMC final design review that I talked about previously. I know all of you have pushed a grocery cart some time in your life. Remember that the cart has fixed casters on the rear wheels and swivel casters on the front. When you push the cart around the store, the front swivel casters go in whatever direction you point the cart, same as the two swing arm supported rear wheels on a GMC. If you stop and move the card straight backwards, the front swivel casters immediately turn around 180 degrees to the direction the cart is moving. As hard as you try, you cannot keep the front casters from turning around if you change the fore and aft directions of the cart. There are always forces acting on the caster that want to change the caster detection so that the offset in the caster support is in the opposite direction of travel. These are the same type of forces that are acting on the GMC forward facing swing arm suspension on the mid axle. The uneven surfaces of the roads are always wanting to turn the mid axle wheels in different directions and this causes the rear mid axle to try to steer in all different directions. The result is the famous GMC wiggle- waggle that all of us are constantly trying to correct. If you think about the small offset there is in the grocery cart front swivel caster, compared to the approximately 2 feet offset we have on the GMC mid axle tire, it is easy to see why we have such a problem with wiggle-waggle. If you were to change the mid axle horizontal support pin to a vertical pin the mid axle would want to immediately turn around 180 degrees. The rear wheels on a GMC are not rigidly supported like they are on a vehicle with fixed axles. They are suspended out on the end of the long suspension arms and can flex in all directions. Did you ever stop your GMC while making a sharp turn in a parking lot and look at the rear set of wheels? They are all bent out of shape to the point they look like they are about to break off. If those suspension engineers had not fainted in the final rear suspension design review, we would have the best driving motorhome on the road. Maybe Jim Bounds will make this change on his new heavy duty chaises he is building for his new diesel engine

GMC, and make a mod kit we can all put on our GMCs.

Since we are all stuck with the rear swing arm suspension for now, I will try to explain why I designed a modification to eliminate the negative effect these wing arm suspension have on our rear wheel brakes. I doubt that many GMC drivers with good brakes know that when they do a hard stop, the rear two wheels are lifted off the ground, and you have a six ton vehicle that is being stopped with only four wheels. Remember when I talked about the tire failures that were occurring on the OEM tires? I'm sure most of you know what happens to a tire when it's overloaded. Each time you slow your GMC, you take weight off the rear two tires and add it on the mid axle tires. You don't have to brake very hard to overload the mid axle tires beyond their rated capacity. When the tires are overloaded, they are damaged to some degree and over the long run the damage increases until the point of tire failure. Remember when we were told that we needed to install higher load range steel belted radials tires with steel braid in the side walls. We reduced the tire failure over the previous bias-belted tires, but we increased the wiggle-waggle. Even if we put on load range E radial tires, they are still damaged when the two mid axle tires have to carry around 8,000 pounds while also having to handle the forces caused by the tire friction with the road surface during stopping. It's a good thing there is a large margin of safety built into the tires when they are manufactured. That is also why you should keep the mid axle tires pressurized to the maximum recommended pressure. I know there will be some GMC scientist (did you remember to laugh?) that will disagree with what I'm telling you, but that's a problem of their on making and this seminar won't help them. The main subject of this seminar it to show you how I stopped the mid axle tire overloading and greatly increased the braking capability. I have six wheel brakes on my GMC all the time and no overloaded tires.

Explaining how all this works is hard to understand my most people. I apparently did a very poor job of explaining it at the last GMCWS rally. Even though I used an actual rear suspension model for my demonstration, and my presentation hand out, photos and testing video were put on the GMCWS web site, I never received a single phone call or e-mail asking any questions about the modification. A little mouse told me there was some effort by someone to keep all this "false" information from contaminating the GMCWS web site. Maybe that same little mouse traveled all around the country and told all the GMC owners and that is why I never received any questions. I hope to do a better job at this rally.

The best way I have come up with to explain what is happening in the rear suspension is by using a torque wrench and a ratchet with the two square drive connected via a 12-point socket. Try and visualize a torque wrench standing up at an angle on a scale with the ratchet extended on upward at a 90 degree angle to the torque wrench, where the outer ends of the ratchet and the torque wrench handles are positioned so they both are located in the same vertical plan. Now, if we place a weight balanced on the top of the ratchet handle, the scale would read the total weight of the torque wrench and ratchet, plus the added weight, and the line of force from the weight would point directly downward in a straight line to the scale. The ratchet acts like a brake and transfers the load on the ratchet through the 90 degree turn to the torque wrench and down to the scale.

Now, let's replace the mid axle swing arm and wheel with the ratchet handle placed on the ground where the tire contacted the ground. If we move the motorhome forward , the ratchet handle would slide along the ground and the force on the ratchet handle caused by the friction with the ground would cause a line of force directly from the point where the ratchet handle touched the ground to the other end of the torque wrench handle where it is supported by the swing arm support pin (remember the previous discussion using the ratchet and scale). This line of force (called a force vector) is pointing upward at the swing arm support pin. The angle between this force vector and the ground is approximately 40 degrees. For talking purposes, let us assume the angle is 45 degrees. This angled force vector can be transposed to a horizontal force and a vertical force acting on the suspension arm support pin. This means that half of the force from the force vector is pushing horizontal aft on the suspension support pin, and is the force that is helping to slow the forward motion of the GMC. The other half of the force vector is pushing vertically on the suspension pin and is causing the rear of the coach to be lifted. As the rear of the coach is being lifted, the angle the force vector makes with the ground is increasing which reduces the braking load and applies more load to lifting the coach. As the brake pressure builds up, the friction force at the ground contact point increases proportionally and the rear of the coach keeps lifting until the mid axle shock is full compresses and the rear *wheel is off the ground. During this transition period is when you hear the rear tire screeching and flat spots are caused on the rear tire. This sound may make you think you have good brakes but you are only braking with four wheels and over half of the braking energy is being dissipated by lifting your coach. Also during this transition period, there is more weight being shifted to the front wheels because the rear of the coach is being raised. With all of the coach weight being supported on four tires, I doubt that anyone has enough braking capability to slide either the front wheels or mid axle wheels during a full pressure stop on dry rough pavement. If you still need convincing that our GMCs only have four wheel braking during panic stops, find yourself a nice section of rough dry pavement and have someone make a hard stop while you observe from the side of the road. Or you can do the same as I did during my brake testing. I cut a 2-inch diameter hole near the top front of my right side rear wheel well so I could mount a video camera looking down perpendicularly on the mid axle shock. I placed a scale with large numbers along the top side of the shock and taped it to the fixed end. I put a piece of white tape around the moving end of the shock (plastic cover). The shock absorber stroke is what controls the limits of of the suspension arm travel so monitoring the shock travel directly equates to the suspension system travel. My video camera also recorded sound so by monitoring the video frame by frame, I could determine at what point of mid axle suspension travel the rear tire started screeching. It also gave a good feel as to how much brake pressure was needed to cause the rear suspension to lift the coach to the upper limit (shock fully compressed).*

I first learned about the rear end lifting problem on the GMCs about 15 years ago. When I first started going to GMCMHI rallies in the late 80s. There was a group of owners from Texas that came to all the rallies that seemed to have more knowledge about the GMCs than anyone else. The person that seemed to know more about GMCs then anyone was Ken Rose. He was a very nice gentleman and he never attended many seminars. If you stopped at his motorhome (first stretched GMC I ever saw) he would talk all day about GMCs. He was the first person that I know of that that designed the four bag rear suspension that Jim K. sells today. He created them primarily because of his much heavier stretched coach but he also knew about the rear lifting problem. He had installed a solenoid valve in the pressure supply line between the two air bags that was actuated closed by the brake light switch. Apparently, it didn't help the rear lifting problem as he expected because he later removed the valve from his system.

A local GMC scientist (you were supposed to laugh again) also knew about the rear lifting problem. He would set for hours talking to Ken Rose at rallies and they had lots of phone conversation over the years. He has been playing around with his rear brakes for years trying to solve the lifting problem. He has experimented with decreasing the brake pressure to the rear set of wheels and has tried numerous different size brake cylinders with no success in eliminating sliding of the rear set of tires during hard braking. I tried to show him many times how I solved the lifting problem but he expressed little interest, primarily because he doesn't like disc brakes and he doesn't like to take advice from some dumb ass engineers. Even after statements like that we are still good friends and any major work I do on my GMC is at his house because he has tools for every kind of task. He probably has more tools then Manny.

If I have been successful is describing what causes the lifting action on the rear brakes, it's time to show you how I corrected the problem they cause during braking. When the brakes are applied on the rear wheels, there is a high torque moment created around the wheel axle by the brakes trying to stop the wheel from turning. The disc brake calipers, or drum brake backing plates, transfer this braking torque onto the suspension arm that is supporting the wheel spindle. This braking moment is trying to rotate the suspension arm in the direction the wheel is turning. There is a downward force created at the wheel spindle which is adding weight to the tire and there is an equal and opposite force pushing upward on the suspension arm support pin. The tire and wheel are supporting the wheel spindle at a somewhat fixed distance from the ground. As the braking torque increases, more load is put on the tire and more load is pushing upward on the suspension arm pin. These opposite forces are trying to rotate the suspension arm around the wheel spindle and the vehicle weight is what is resisting the suspension arm rotation. With increasing brake pressure more load is being put on the mid axle tire and more force is trying to lift the rear of the coach. As the tire gets more compressed, the height of the vehicle rear end keeps rising until the suspension shock absorber is fully compressed and stops the suspension arm rotation. At this point the rear of the vehicle has risen to a sufficient height to lift the rear wheels off the ground. Both the mid axle and aft axle *suspension have identical travel, so with the front of the vehicle being lowered by the braking action and the mid axle setting at its maximum height. The rear wheel cannot be touching the ground unless you have very low pressure in the mid axle tire. You can easily verify this yourself by jacking the rear of your coach to the point the mid axle shocks are fully compresses*

My solution for this problem was to prevent the braking load torque from causing suspension arm rotation. To accomplish this, I unbolted the disc caliper support (or backing plate) from the spindle support flange by using countersunk bolts to hold the spindle flange to the suspension arm. I installed a brass bearing so the caliper bracket can freely rotate on the wheel spindle. To react the braking torque, I design what I call a torque box that is bolted to the caliper support bracket and extends over and under the suspension arm and has an enclosed end on the inboard side of the suspension arm. I designed a brass bearing that is supported from the four bolts that hold the spindle flange to the suspension arm. This brass bearing supports the inboard enclosed end of the torque box so the caliper bracket and torque box become one assembly that is free to rotate around the axle spindle and is supported by an outboard brass bearing and an inboard brass bearing. The clearance of the torque box around the suspension arm is sufficient to allow the torque box to rotate freely approximately 20 degrees in each direction around the suspension arm axle. There is a reaction arm welded to the inboard side of the torque box that protrudes downward and transfers the braking torque through a pinned linkage back to the vehicle frame. On my mid axle I used my anti-sway bar to do double duty by transferring the brake torque back to the vehicle frame and its normal anti-sway function. I used a pinned linkage bar on the rear wheels to transfer the braking torque forward to the vehicle frame. The braking torque causes tension on the rear suspension reaction bar and compression on the mid axle suspension anti-sway bar.

What I ended up with is a four bar linkage that is free to rotate at each corner and cannot transfer any rotational torque through the suspension arm. The suspension arm is the upper horizontal linkage from the wheel spindle to the suspension arm support pin. The lower horizontal linkage is the anti- sway bar on the forward suspension and a separate linkage bar on the aft suspension. At the wheel end of the suspension arm, the vertical linkage is from the wheel spindle down to the reaction bar connection (or sway bar connection). The other vertical linkage is within the vehicle frame from the suspension arm pinned connection down to the lower horizontal reaction bar pinned connection (or sway bar rotational support connection).

Some may wonder why I made the modification on my rear wheels because the aft facing swing arm would play no part in lifting the rear of the coach. My initial intention was to only modify the mid axle suspension and that is what I did first. After I installed the TSM disc brakes on the mid axle and performed sufficient testing to assure myself the modification eliminated lifting the rear of the coach, I was somewhat surprised to find that I could still slide the rear tires if I applied maximum brake pressure. When the rear wheel brakes are engaged you get the opposite effect as you get from the mid axle. Remember my discussion about how there is a force vector going from the center of the tire/road contact area to the suspension arm pin. As the braking energy increases on the rear tire a force vector starts pulling down on the aft suspension arm pin at an angle similar to the mid axle. Thus, about half of the braking energy torque is dissipated pulling aft horizontally on rear suspension arm support pin and is helping slow the vehicle. The other half of the braking torque is dissipated by pulling vertically down on the aft suspension arm support pin and is not helping slow the vehicle. The tire friction on the road is creating a movement around the wheel spindle that is equal to and is acting in the opposite direction of the torqueing moment being generated by the brake friction. The increasing downward vertical force on the suspension pin is decreasing the weight on the tire. As the braking energy increases, it keeps trying to rotate the suspension arm taking weight off the tire which decreases the friction at the tire/road interface, and when the friction at the tire/road interface decreases to where it can no longer balance the brake torque the tire start sliding. So by making the same modification on the rear wheel suspension you remove the rotational forces on the suspension arm and the energy that was previously being dissipated by the vertical downward forces on the suspension pin will be dissipated by helping slow the vehicle. This gives approximately a 50% increase on both the mid axle wheels and the rear set of wheels and both wheels should have nearly similar braking capability if both wheels have the same type of brakes. I currently have more braking capability on the mid axle wheels because I have 80 mm calipers on the mid axle and 60 mm calipers on the aft axle.

I in no way am I saying that my modification will prevent sliding the rear set of tires. I have just put on two new tires to replace my rear set that had lots of flat spots and I do not plan on doing any more brake testing. The first opportunity to determine if I can slide any of my rear tires will be the next time I have to make a panic stop and I hope I never have to. I can assure you that I have by far the best brakes I have ever had on my GMC and I don't have to apply nearly the pressure as I previously had to during normal driving. For years I have been checking the temperature of my tires and brakes when I stop at rest stops or to refuel. Previously, if had just been doing a lot of braking, my front hubs ran on average about 100 degrees higher than the rear hubs. Now under similar conditions, my front hubs run cooler then my rear hubs because I do not apply as much brake pressure during normal driving and the rear brakes are now utilizing the previously wasted energy to help slow the coach. Now for the next to last laugh. Why did it take a rocket scientist to figure all this out? I'm still waiting for some other GMC scientist to solve the steering problems.

Wouldn't it have been great if GM had used the popular vertical strut suspension that is used on a lot of cars today? I doubt if they would have occupied much more space than our current rear suspension. On second thought, what would all of us GMC scientists have had to talk about in seminars for the last three decades?

Now Jim K., don't get upset with me for poking fun at all the great modifications you have for sale to improve the GMC steering problems. Not many people are going to believe what I have told them today and the ones that do will buy one of your mod kits derived from my invention and you will make even more $$$$$! Let's all give a big "ha ha ha!" to end the day.