

Case studies from classes led by Dr. Ron Fulbright, University of South Carolina Upstate.

INNOVATIVE ANALYSIS

EASIER FLAT TIRE

1. BRIEF DESCRIPTION OF THE SITUATION

Dealing with a flat tire on the highway is an ordeal. To change the tire, one must first get out the jack, which is usually stowed away behind a panel or under the floor, requiring the loosening of several types of fasteners. Then one must locate the jack under the vehicle and place it in the correct position. Jacking in the wrong position can damage the car. Next, one must jack up the car to raise the flat tire off the ground. This usually requires either turning a crank or pumping a handle. The spare tire must be located and freed from its stowage location. Often, this is under the car and requires loosening a fastener. Some models of cars require that a special wrench be inserted into a hole on or near the bumper, and then turned to release the spare. Then one must locate the lug wrench (sometimes the wrench is the handle of the jack) and loosen the lug nuts on the tire. One can optionally do this prior to lifting the car with the jack. After removing the nuts (5), one must remove the flat tire and mount the spare tire. After tightening the lug nuts, one must lower the car using the jack and then stow the jack and the flat tire.

For most people, the above process takes 15-30 minutes. During this time, the car, any passengers, and especially the person changing the tire is in danger of being struck by oncoming motorists. Obviously, minimizing the time to change a tire will lessen the risk of being injured. The process is a very dirty one. Tires accumulate dust, dirt, and grime that get all over the person's hands, arms, and clothes. An expensive set of clothes could very well be ruined. Another issue is that handling the tires, jacking the car, etc. requires a certain amount of physical strength. This could present a problem for lighter-framed individuals, the sick, or elderly.

The challenge is to suggest ways to make dealing with a flat tire easier, both in time and effort.



2. DETAILED DESCRIPTION OF THE SITUATION

2.1 SUPERSYSTEM/SUBSYSTEM ANALYSIS

1) Tire

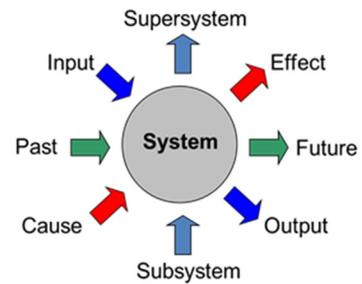
- a) Lug nuts
- b) Lug bolts

2) Jack

- a) Top bracket (saddle)
 - b) Upper arms
 - c) Central screw mechanism
 - i) Self-locking jack screw
 - (1) Threads
 - ii) Tool used to turn screw mechanism
 - (1) Flat end of tire removal tool
 - (2) Specialized handle
 - d) Lower arms
 - e) Foot (wide base)

3) Storage

- a) Spare tire well inside trunk
 - i) Bolt and wing nut fastener
 - ii) Stiff sheet of cardboard
 - iii) Trunk carpet
- b) Underneath rear of vehicle
 - i) Cradle
- c) Externally mounted on rear door
 - i) Spare tire mount
 - ii) Bolts



2.3 INPUT/EFFECT/OUTPUT ANALYSIS

Input	Effect	Output
Find a flat, stable and safe place to change tire	<ul style="list-style-type: none"> •Jack is on a level surface •Person is not injured by traffic 	Tire can be changed safely and correctly
<ul style="list-style-type: none"> •Put car in 'park' position •Apply the park brake 	Restricts car from rolling or moving	Car remains motionless while the tire is being changed
Human strength	Removes spare tire, jack, and tools from the storage area	Spare tire, jack, and tools are out of storage and available for use
Place jack in the correct and safe position	Jack is securely placed under the frame of the car	Jack can be used correctly without damaging the car
<ul style="list-style-type: none"> •Human strength •The side of the tool that fits the lug nuts on the tire 	Loosens lug nuts on the flat tire	Lug nuts are loose enough to remove by hand after jacking up the vehicle
Insert handle or tool into jack and turn counter-clockwise	Jack begins to extend	Car begins to lift off of the ground
Jack is completely extended	Jack reaches its stop point	Prevents overextending the jack beyond its capability
Human strength	<ul style="list-style-type: none"> •Remove the lug nuts by hand from the flat tire •Pull flat tire until it clears the ends of the lug bolts 	Flat tire is removed off of the car
Human strength	Place flat tire in the spare tire storage area	Flat tire is out of the way and placed in storage
Human strength	<ul style="list-style-type: none"> •Lift the spare tire onto the lug bolts •Replace lug nuts and tighten by hand 	<ul style="list-style-type: none"> •Spare tire is placed on the car •Lug nuts hold tire on lug bolts
Insert tool or handle into jack and turn clockwise	Jack contracts and lowers	Car is lowered onto the ground and its weight is off of the jack
Human strength	Remove jack from under the car and replace in storage area	Jack is out of the way and placed in storage
<ul style="list-style-type: none"> •Human strength •The side of the tool that fits the lug nuts on the tire 	Tighten lug nuts completely	Spare tire is secure on the car and ready for use

2.4 PAST/FUTURE ANALYSIS

The early days of motor travel took place on primitive roads that were littered with stray horseshoe nails, which resulted in punctured tires. In 1904, the first spare tire was invented by Thomas Morris Davies. The “Stepney Spare Wheel” was a spoke-less wheel rim fitted with an inflatable tire that was mounted on by adjustable clamps. Thomas B. Jeffrey Company was the first car manufacturer to equip cars with an inflated spare wheel-and-tire assembly in 1909. The interchangeable wheel with a mounted and inflated spare tire allowed motorists to exchange it for the damaged tire that could be repaired at a more convenient place and time. In 1939, the “Continental Tire,” which was an upright, externally mounted spare tire located behind a car’s trunk compartment, was invented. Later in the 1950s, spare tires began being stored in a recess in the floor of the trunk, which is where they are most commonly stored today. The spare tire well is the recessed area, usually in the center, of the trunk. In most cars, the spare tire is secured with a bolt and wing-nut style fastener. Usually, a stiff sheet of cardboard lays on top of the spare tire well, with the trunk carpet on top to hide the spare tire and provide a flat surface, and aesthetically pleasing appearance for the trunk space. Other storage solutions include a cradle underneath the rear of the vehicle and external mounting on the rear door of SUVs and off-road vehicles.



Contemporary vehicles now come equipped with spare tires, depending on the type of vehicle. Cars usually come equipped with “limited use” spare tires, also known as “donuts.” Donuts are typically smaller than the normal tires on the vehicle, in an attempt to reduce cost, save space, and lower the vehicle’s weight. Donuts can only be used for limited distances because of the short life expectancy and low speed rating. Donuts can also severely compromise the braking and handling of the car. SUVs and some trucks are equipped with full-size spares since a donut would adversely affect vehicles with higher centers of gravity. In some cases, automobiles may be equipped with run-flat tires, therefore not requiring a separate spare tire. A run-flat tire is a pneumatic tire that is designed to resist the effects of deflation when punctured and to enable the vehicle to continue to be driven at speeds up to 55 mph, and for limited distances of 100 to 200 miles, depending on the type of tire. However, only 3% of drivers worldwide want run-flat tires and only a handful of volume manufacturers offer them as standard fittings.

Although there are several different types of car jacks, the primary type of car jack issued by automotive manufacturers is the scissor jack. Scissor automotive jacks are hand-operated, using long, self-locking jack screws to raise the vehicle. The jack uses the central screw mechanism to raise and lower the jack. The screw mechanism is turned by either the tire removal tool or a specialized handle supplied with the jack. All jacks have safety features to protect the user from accidental injury. Wide bases help to stabilize a jack and prevent tilting. When in the extended position, jacks will have a stop point that prevents the user from overextending the jack beyond its rated capabilities. When in the contracted position, jacks that are provided by the manufacturer will have a storage area specially formed or designed for the jack to rest in when not in use.

3. RESOURCES, CONSTRAINTS, AND LIMITATIONS

3.1 AVAILABLE RESOURCES

- 1) Vehicle
 - a) Tire
 - i) Rubber
 - ii) Aluminum/alloy rim
 - b) Lug bolts
 - i) Steel
 - c) Lug nuts
 - i) Steel
 - d) Spare tire storage
 - i) Trunk
 - (1) Spare tire well
 - ii) Underneath rear of vehicle
 - (1) Cradle
 - (a) Metal
 - (2) Bolts
 - (a) Steel
 - iii) Externally mounted on rear door
 - (1) Mount
 - (a) Metal
 - (2) Bolts
 - (a) Steel
- 2) Jack
 - a) Screw mechanism
 - i) Metal
- 3) Tool or Handle
 - a) Metal
- 4) Human
 - a) Energy
 - b) Physical strength
 - c) Knowledge
 - d) Time
 - i) Typically about 15 – 30 minutes

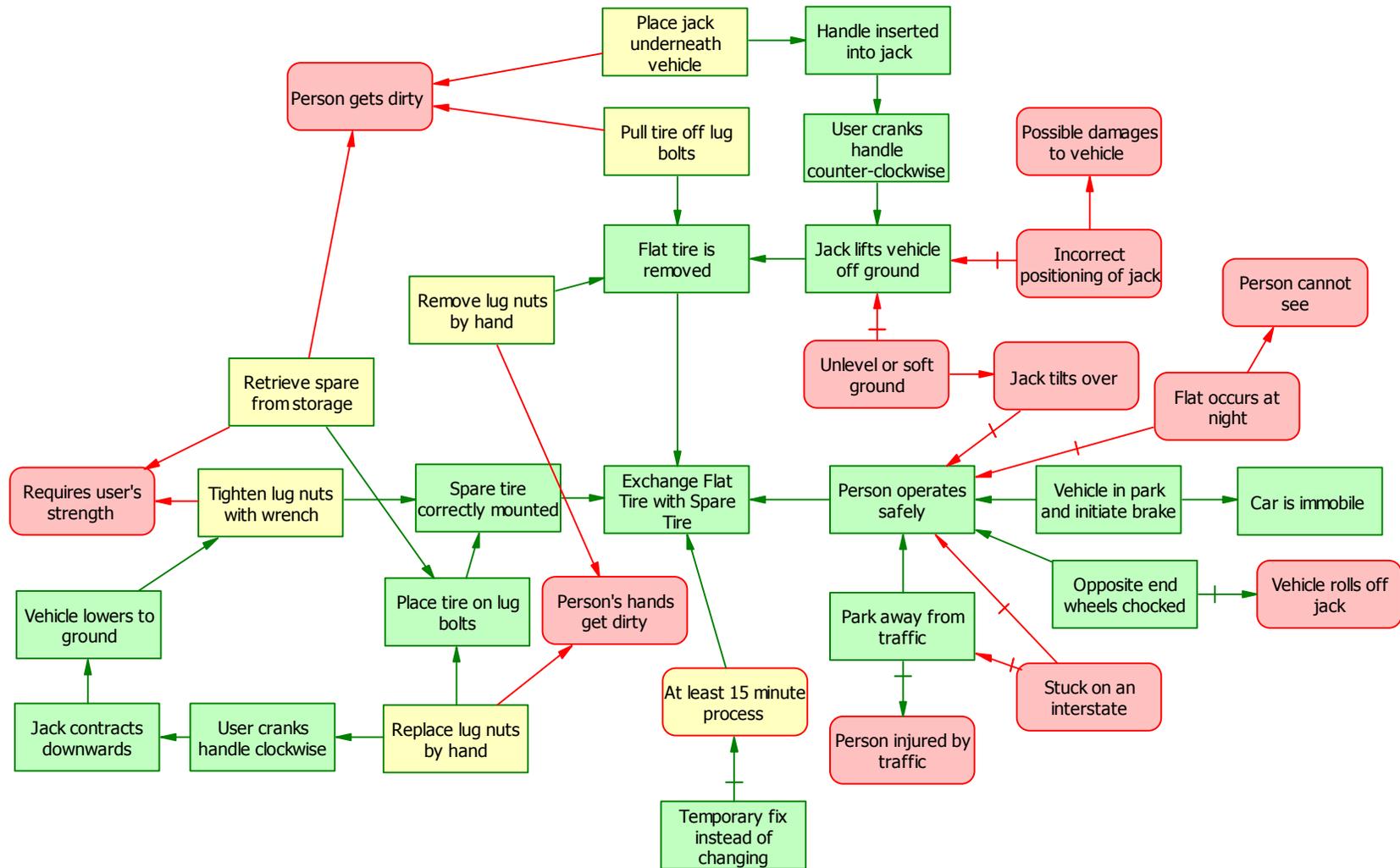
3.2 ALLOWABLE CHANGES TO THE SYSTEM

The shape, size, materials, and characteristics of any component of a flat tire can be altered within the constraints given below. Changes can be made to the jack to incorporate an automatic lift. A press of a button can jack the vehicle up in less than a minute, rather than using human strength, which could potentially cause back problems, uncomfortable stances, and risk damaging the vehicle itself. The spare tire can be made lighter for easy moving, lifting, and lining up with the lug bolts on the vehicle. Unscrewing the lug nuts can be difficult, if not impossible, for people such as the elderly or ill. The spare tire kit provided with the vehicle can come with an automatic handheld tool that adjusts the lug nuts on and off the bolts. The jack can have an attached L.E.D system which can produce light to enable seeing in the dark.

3.3 CONSTRAINTS AND LIMITATIONS

- The user should not consider changing the tire if he or she is unsure of how to correctly do so.
- The owner of the vehicle must have a general understanding of how to change the tire if he or she wishes to attempt.
- There should be a new, unused spare tire in the vehicle.
- The tire should be easily accessible, either in the trunk or beneath the vehicle.
- The vehicle should be equipped with user-friendly tools necessary to replace the tire.
- The user should not attempt to pick up the tire if it is too heavy.
- Replacing the tire should not take the user no longer than 15 minutes.

4. PROBLEM FORMULATION



5. IDEAS

Find a way to eliminate, reduce, or prevent *Incorrect positioning of jack* in order to avoid *Possible damages to vehicle*.

1. Transform an object's shape – Create a notch on the chastity of the vehicle specifically made for the jack to fit into to ensure correct positioning. This will avoid incorrect positioning of the jack underneath the vehicle which may cause damages.

Find a way to eliminate, reduce, or prevent *At least 15 minute process*.

2. Exclude elements/duplicates – Exclude duplicate lug nuts. Instead of five lug nuts, only have three or four, depending on the type of vehicle. This will reduce the amount of time it takes to change the tire, as well as the amount of human strength required to remove and replace tire.

3. Reduce weight of individual parts – Make the tools out of carbon fiber instead of metal. Therefore, the tools are lighter and easier to use.

Find an alternative way to obtain *Pull tire off lug bolts* that offers the following: provides or enhances *Flat tire is removed* does not cause *Person gets dirty*.

4. Use a disposable object - Use a cheap piece of plastic in the shape of a tire with elastic that goes around the surface of the tire, preventing the person from getting dirty while handling the tire.

5. Add a carrier - Incorporate a grasping tool that grasps the tire, pulls it off the lug bolts, and holds the tire while user places it in storage. This grasping tool can also be used to remove spare tire from storage and placing it onto the lug bolts. Using this tool eliminates having to touch or carry the tire, resulting soiled hands and/or clothes.

Find an alternative way to obtain *User cranks handle counter-clockwise* that offers the following: provides or enhances *Jack lifts vehicle off ground* does not require *Handle inserted into jack*.

6. Self-Service – Use an electronic jack that lifts and lowers the vehicle. It operates by being plugged into the vehicle's cigarette lighter receptacle. This reduces the time to complete this process drastically, as well as eliminates the need for human strength to raise and lower the jack.

Resolve the contradiction: *Remove lug nuts by hand should be provided to produce Flat tire is removed* and shouldn't be provided to avoid *Person's hands get dirty*.

7. Shelter for a period of time – Person can wear gloves to protect their hands from dirt and minor injury while handling the tire and lug nuts.

Find an alternative way to obtain *Exchange Flat Tire with Spare Tire* that does not require *Flat tire is removed, Person operates safely, Spare tire correctly mounted and At least 15 minute process.*

8. Apply contact phenomenon – A drop in the tire’s air pressure triggers a dense foam inside the tire to react and fill the punctured area. This results in a temporary fix of the flat tire which enables the person to reach a safe and convenient location to replace or repair the damaged tire.

Find a way to eliminate, reduce, or prevent *Person cannot see* under the conditions of *Flat occurs at night.*

9. Add object with required properties – Attach a battery powered LED light to the jack which enables the person to see in the event that a tire must be replaced during the night.

10. Add object with required properties – A LED headlamp worn by the person will enable him or her to see without having to hold or adjust a flashlight in the event that a tire must be replaced during the night.

Find an alternative way to obtain *Jack lifts vehicle off ground* that offers the following: provides or enhances *Flat tire is removed* does not require *User cranks handle counter-clockwise* is not influenced by *Incorrect positioning of jack and Unevel or soft ground.*

11. Use a mediator – Use a foot pump connected to the jack, which will substitute cranking the handle, to extend or contract the jack. Utilizing a foot pump, rather than having to turn a handle, will be easier and require less strength. This would reduce the time it takes to complete the tire changing process as well.

12. Use dynamic Elements – Incorporate a hydraulic jack already built onto the vehicle. The person just has to simply push a button and a hydraulic jack lowers from underneath the car and jacks the specified area of the car up high enough to remove and replace the tire, then lowers the vehicle to the ground.

13. Modifying the characteristics of an object or substance – Add X-shaped retractable planes on the bottom of the jack that will add stability to the jack and prevent it from tilting over. This will reduce the likelihood of injuries occurring as well.

Find an alternative way to obtain *Retrieve spare from storage* that offers the following: provides or enhances *Place tire on lug bolts* does not cause *Person gets dirty* and *Requires user's strength* .

14. Add a mobile object – Add a U-shaped platform that has wheels on the bottom of it that can be rolled underneath the tire so the tire can be placed on and transported to the storage area easily. This prevents the person from having to carry the tire to and from storage, as well as getting their clothes dirty.

Find a way to eliminate, reduce, or prevent *Person's hands get dirty under the conditions of Remove lug nuts by hand and Replace lug nuts by hand.*

15. Add object with required properties – Use a battery powered handheld automatic tool to remove and replace the lug nuts. This would greatly reduce the time it takes to complete the tire changing process.

Find an alternative way to obtain *User cranks handle counter-clockwise that offers the following: provides or enhances Jack lifts vehicle off ground does not require Handle inserted into jack.*

16. Add object with required properties – Use a handheld battery powered power tool to operate the jack. This eliminates the need of human strength to crank the handle to raise and lower the jack.

Find a way to eliminate, reduce, or prevent *Person injured by traffic.*

17. Use flexible materials – Use reflective hazard markers (like tractor trailers use) to set up on the side of the road around the vehicle to alert other drivers that someone is on the side of the road. This will prevent or reduce the likelihood that the person is injured by traffic.

Find an alternative way to obtain *User cranks handle counter-clockwise that offers the following: provides or enhances Jack lifts vehicle off ground.*

18. Use curvilinear forms – Modify the tool used to crank the jack so that it is curved, not straight, so the person has more leverage and will be able to loosen and tighten the lug nuts easier.

Find a way to eliminate, reduce, or prevent *Stuck on an interstate.*

19. Use other systems – Use “Fix a Flat” or some type of other temporary fix for a flat tire to enable the vehicle to travel a few miles so the person can get off the interstate and not be at high risk for injury.

20. Use a counterweight – Using sensors, when a tire’s air pressure is drastically low, weights located in the center of the car will shift to the opposite side of the damaged tire. This will reduce the weight carried by the low tire. The sensors will alert the driver of the tire’s low pressure and allow the person to repair or replace the low tire as soon as possible. This will prevent the person from being stuck on the side of a dangerous road with a flat tire.