



DEERE IN THE HEADLIGHTS

How Software That Farmers Cannot Access Has Become Necessary To Tractor Repair

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The author bears any responsibility for factual errors.

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| EXECUTIVE SUMMARY

On the farm, the fields must be plowed, planted or harvested whether or not your tractor or combine harvester is running. When their equipment does break down, generations of farmers have found a way to fix their equipment and get the job done. But now, equipment manufacturers refuse to give farmers all of the tools that they need to fix their stuff—especially the software tools to install replacement electronics—leading to delays of hours to weeks while the farmer waits for the dealership to make the repair.

Farm equipment, much like all of the devices and gadgets in our lives, is increasingly driven by software. While this software has increased the efficiency of some tasks, it has also allowed manufacturers to take increasing control of the repair process.¹

The sensors and control systems that feed this software with data have been integrated into most of the functions of modern combine harvesters, tractors and other farm equipment.² In cases where a mechanical issue engages safety or emissions control systems, or some part of those systems fail, the immobilizer is activated.³ This sends the machine into “limp mode,” which disables most of the equipment’s functionality and only allows the machine to “limp” out of the way of other work until it is repaired and the error codes are cleared.⁴

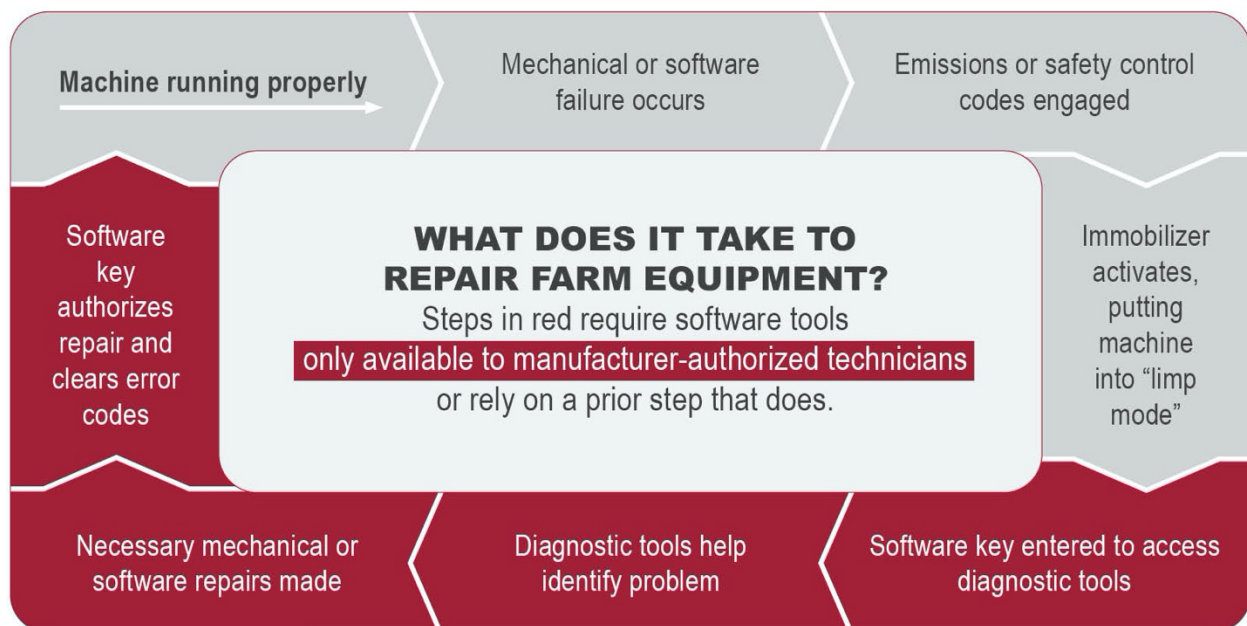


Figure 1: Farm equipment repair procedure. Steps in red require software tools only available to manufacturer-authorized technicians or rely on a prior step that does.

Without the software tools needed to diagnose problems, install replacement parts and authorize repairs, the engagement or failure of any sensor or control system forces a farmer to either haul their machine into the nearest dealership or wait for a field technician to arrive to complete the repair.⁵

Farmers’ inability to repair software-connected systems without proprietary software is a glaring example of how farm equipment is engineered to be dependent on dealership support. Our research shows how prevalent this practice has become: U.S. PIRG Education Fund found as many as 125 sensors in a single combine. Each sensor is connected to a controller network. A problem with any one of those controller networks will require diagnostic tools not available to farmers, sending them back to the dealer for a repair. According to agricultural equipment experts, these sensors and their associated controller networks are now the highest point of failure on the product.⁶

When repair options are limited by software or other restrictions, it can create a de-facto repair service monopoly. Manufacturers’ monopoly on repair has a real impact on farmers’ livelihoods. Without independent repair shops or the ability to fix their own stuff, they are exposed to high repair costs and long wait times. This report describes some of these delays and the associated difficulties and expenses.

Manufacturers defend these behaviors by claiming that providing farmers with the repair resources available to dealerships would lead to illegal modifications that could override safety and environmental controls,⁷ claims that this report shows are false. There is, however, a strong financial incentive to capture repair business. John Deere company filings pointed to trends that services and repair have been as much as three to six times as profitable as new equipment sales for John Deere and its dealerships.⁸

COMBINE HARVESTER MODEL	SOFTWARE-CONNECTED SENSORS
John Deere S760	125 sensors
Rostselmash Torum	64 sensors
Claas Lexion 780	60 sensors
New Holland CR 9.90	56 sensors

! DIAGNOSTIC TOOLS REQUIRED

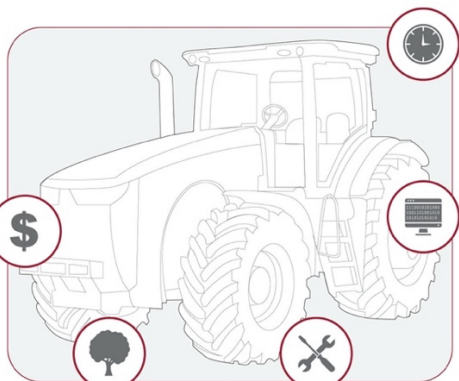
Each sensor is connected to a controller network that requires diagnostic tools not made available to farmers.

There are many examples that demonstrate how farmers are frustrated by the challenges in maintaining equipment. Some are paying unprecedented prices for older

tractors—like the 1980 John Deere 4440 that sold for \$43,500 in Lake City, MN in April 2019⁹—because they are actually fixable. Others, like Nebraska farmer Kyle Schwarting,¹⁰ are hacking their tractors with versions of John Deere Service Advisor cracked and made available on torrent websites based in Eastern Europe.¹¹

Farmer organizations are increasingly supporting policy solutions to eliminate repair hurdles. The American Farm Bureau Federation, the National Corn Growers Association and the National Farmers Union submitted a public comment to the U.S. Copyright Office requesting, “exemption for agricultural vehicle owners to diagnose, repair, and lawfully modify the computer programs contained in and controlling the functioning of their mechanized agricultural vehicles,”¹² in 2018 as a part of the triennial rulemaking process laid out by section 1201 of the Digital Millennium Copyright Act. Right to Repair legislation—which would provide farmers with access to the parts as well as the physical and software tools used to diagnose, calibrate and otherwise authorize repairs—is also gaining popularity amongst farmers. Over 30 states have considered these reforms,¹³ the American Farm Bureau Federation adopted a pro-Right to Repair policy in 2020,¹⁴ and the Montana Farmers Union indicated a 2021 bill in its state is a top priority.¹⁵

This report outlines why farmers need the right to repair their equipment. Absent these reforms, farmers are reliant on dealerships for many fixes and are exposed to high costs and long wait times that cut into already thin profit margins.¹⁶ Despite industry claims, Right to Repair legislation would not provide farmers with the ability to bypass safety or environmental controls, nor would it expose manufacturers to potential loss of intellectual property. It would, however, provide farmers with what they need to get back to work when their equipment goes down.



Deere in the Headlights

Modern farm equipment is full of software. But when manufacturers such as John Deere refuse to sell the associated software tools needed to repair equipment, farmers are forced to rely on the dealer to fix their tractors.

THE REPAIR REVENUE STREAM
Simple acts, such as clearing diagnostic error codes, can cost farmers thousands of dollars. This is bad for farmers, but good for the manufacturers; parts and services are three to six times as profitable as new equipment sales for John Deere

REPAIR ALIGNS WITH ENVIRONMENTAL CONTROLS
If a mechanical malfunction prevents a tractor from meeting emission standards, the immobilizer will prevent the machine from operating at full bore. The tractor can only be put back into use once the resulting repair enables it to meet environmental benchmarks.

SIMPLE FIXES TURN TO LONG DELAYS
Farmers often wait hours, days, or even a month for a dealership to repair problems they could have fixed themselves. With tight planting and harvesting windows, many farmers can't afford to wait that long.

SOFTWARE TOOLS AREN'T SOURCE CODE
The digital repair tools farmers need is embedded code — a series of computer-legible 1's and 0's — not human-legible source code. Providing access to software tools would allow farmers to repair their own equipment but would not enable source code theft.

FARMERS JUST WANT TO FIX THEIR STUFF
More and more farmers are calling for Right to Repair. Agricultural equipment-focused bills have been introduced in Florida, Montana, Nebraska, South Carolina and Vermont in 2021, drawing support from state Farm Bureau and Farmers Union chapters.

| INTRODUCTION

WAITING FOR A FIX

Extreme rains early in the 2018 season forced Jared Wilson, a Missouri-based farmer, to push his operation back two months. Luckily for Wilson, he has a John Deere 4930 fertilizer spreader, which can cover as much as 700-800 acres per day. He said that capacity should have allowed him to catch up despite the difficult conditions.¹⁷

During a routine hydraulic system check before starting the work, the hydraulic filter housing blew. Initial troubleshooting made it apparent that a lack of hydraulic pressure was preventing the rear spinners from operating properly—a problem that needed to be fixed.¹⁸

To fix it, Wilson said he needed to test hydraulic pressures—a process that requires a diagram illustrating how the hydraulic system works as well as access to the diagnostic software that might help identify the issue.

According to Repair.org Executive Director Gay Gordon-Byrne, John Deere has a track record of refusing to provide this information to farmers or independent repair shops,¹⁹ and Wilson said he could not access it. Therefore, Wilson didn't see any other choice besides to take it to the dealership or a John Deere authorized technician. When he did, he says the machine sat there, full of fertilizer, for 32 days.

During that period, Wilson did what he could to speed up the process—he says he called daily for progress updates and visited with the dealership manager in-person twice. He also considered other options. The next closest dealership was an estimated 80 miles away, so Wilson could have loaded the 4930 onto a truck and hauled it that distance. But that would incur expensive hauling fees and the need to physically shovel out the fertilizer loaded in the machine to make sure it was light enough to load on the truck.²⁰ Left without a good alternative, Wilson decided to wait it out.

Eventually, the problem was identified and fixed. The culprit was a blown mechanical valve that Wilson believes he could have repaired himself if armed with schematics and diagnostic information. Instead, he was left feeling helpless and frustrated.²¹

Frustration aside, the time that Wilson lost had a real impact on his crop. Because his margin structure was already so tight, he could not afford to put out much fertilizer in

the first place. Nonetheless, he said he lost two to three days of planting, an estimated loss of \$30,000-\$60,000 by his count.²² “My margins looked negative to start the year,” Wilson said.

“People bend down to pick up pennies where I’m from... I just don’t understand why I can’t have access to the same things the field technicians have.”²³

BELLS AND WHISTLES DON’T MATTER WHEN THE MACHINE WON’T WORK

Even though modern farming technology provides new conveniences and functionalities, farmers still pride themselves in being able to come up with ingenious and creative solutions to the problems that come along with their profession. Farmers’ inability to get hold of the diagnostic tools they require to fix their tractors has caused some to opt for machines without the new technology.

Andrew McHargue of Chapman, Nebraska has seen firsthand how modern software can get in the way of daily operations. When error codes from a balky emissions system sent McHargue’s 2014 tractor—which cost him \$300,000 when he bought it new—into limp mode in the middle of planting season, his machine was down for an entire week. Over the years he used the machine, McHargue spent \$8,000 to have the dealership periodically “clear” these error codes before eventually buying an older tractor without these issues, costing an additional \$160,000. As of March 2020, McHargue had been unable to sell the 2014 tractor.²⁴

Andrew’s frustration doesn’t stem from the emissions controls themselves—he was frustrated by his inability to fix the problems associated with them. “The whole disconnect is about who really owns [the tractor],” he said. “If it’s mine, I should be able to modify and fix it myself. There’s no reason we shouldn’t have a repair system exactly like the auto industry’s.”²⁵

The comparison to the auto industry is particularly apt. Much like tractors, car emissions are regulated by the EPA.^{26 27} Federal regulations require auto manufacturers to hit certain greenhouse gas emissions standards, depending on the model year.^{28 29} Once the car is sold or leased, many states require drivers to maintain their vehicles such that they continue to hit target emission levels.³⁰ Failure to meet standards in these states can prevent the driver from legally operating their car.³¹ Beyond the point of sale,

the responsibility to ensure that an auto meets federal regulations falls on the driver—not Ford, GMC, Toyota, Hyundai or whomever manufactured it.

It only makes sense that the person who bears the responsibility of ongoing compliance should be able to fix their machine as necessary to meet the standards. American car owners can therefore repair their own machines, hire one of the 180,000 independent auto repair businesses in the country³² or turn to the dealer to do so on their behalf. Which they choose is up to them.

In the world of farm equipment, however, manufacturers like John Deere restrict consumer choice.³³ When the software emissions controls built into the tractor or combine detect noncompliance, the immobilizer is activated, throwing the machine into limp mode and rendering it essentially unusable until the problem is resolved and the machine reset.³⁴ But the average, law-abiding farmer who wants to simultaneously protect the environment, grow food to stock grocery store shelves and provide a livelihood for her family does not have access to the diagnostic codes to identify the problem⁴⁴ nor the software needed⁴⁵ to clear the error and return the machine to use once the problem is resolved. She, like McHargue, is reliant on the dealer to do these things and subject to whatever fees they may charge.

THE ROAD TO RIGHT TO REPAIR STARTED IN YOUR CAR

Cars first saw an influx of software following the passage of the 1990 Clean Air Act.³⁵ This policy required automobile manufacturers to install On-Board Diagnostic (OBD) systems in all cars to identify engine or other problems that led to higher emissions of greenhouse gasses.³⁶ The effort was extremely successful—the Auto Alliance bragged that “a Washington-to-Dallas journey in a 2000 car is less polluting than a Baltimore-to-Washington commute in a 1966 car,”³⁷—but it also created an opportunity for auto manufacturers to restrict repair to benefit their dealerships.

Unlike strictly mechanical systems, which a consumer or independent mechanic can physically disassemble and troubleshoot, computational systems require diagnostic tools.³⁸ Many consumers and independent repair shops could not get access to these tools or the associated repair manuals,³⁹ meaning a driver’s only choice was to take their car to the dealer for certain repairs. In defense of this practice, manufacturers have claimed this information as intellectual property.⁴⁰

In 2012, the state of Massachusetts put automotive Right to Repair on the ballot.⁴¹ The measure passed with an overwhelming 86 percent of Bay Staters calling for access to the tools and information for independent mechanics.⁴² Following the passage of this referendum, all major auto manufacturers signed a Memorandum of Understanding that extended the results in Massachusetts to the entire country.⁴³

Some farmers have decided to avoid software-run machines all together. Machinery Pete, a used farm equipment marketplace that has been tracking and recording tractor auction prices since the late 1980's, has noted the comparatively high prices that thirty-year-old machines are catching today.⁴⁶

According to Machinery Pete, the highest price a roughly thirty-year-old John Deere tractor sold for in 1989 was just over \$7,200 in 2019 dollars. In 2019, a 1989 John Deere tractor sold for \$71,000.⁴⁷

Farmers are seeking these older models not only because of their sturdy design, but also because they are easy to repair. With new machines ranging from \$150,000 to \$250,000 and dealer labor rates as high as \$150 per hour,⁴⁸ this makes simple financial sense to Kris Folland of Minnesota.

"The main reason we [buy older equipment] is to make money," he said. "Older equipment is a way to reduce your cost per bushel to become more profitable."⁴⁹ If Folland is correct, that means that the innovations touted by equipment manufacturers are actually adding to costs and making food more expensive.

TRACTOR HACKERS

Some farmers who have chosen to continue using their more modern machines have turned to another unexpected source for help: cracked software from Eastern Europe.⁵⁰

Kyle Schwarting of Lincoln, Nebraska is one of these farmers-turned-hackers. When Schwarting's tractor broke down, he had two options. He could either pay an estimated \$2000 to load the machine on a truck and haul it to a dealership, plus the cost of the repair and lost time,⁵¹ or he could find a creative way to solve the problem.

This drove Schwarting to the internet. Through invite-only, paid online forums, he was able to buy a pirated version of John Deere's Service Advisor, which is used for issue diagnosis and recalibration.⁵² Farmers can buy this program, as well as John Deere Payload files that directly program certain parts of the machine, John Deere Electronic Data Link drivers that enable a computer to communicate with the tractor, physical cables to connect a tractor to a computer and more through forums like those Schwarting accessed.⁵³ Much of this software is pirated in Eastern Europe and then sold to American farmers.⁵⁴

Kyle's behavior might appear to be an illegal violation of the Digital Millennium Copyright Act (DMCA). But in 2015, the Library of Congress Copyright Office adopted

the following exemption to section 1201 of the DMCA to allow farmers to circumvent agricultural equipment manufacturers' digital locks for the purposes of repair and modification:

Computer programs that are contained in and control the functioning of a motorized land vehicle such as a ... mechanized agricultural vehicle, except for computer programs primarily designed for the control of telematics or entertainment systems for such vehicle, when circumvention is a necessary step undertaken by the authorized owner of the vehicle to allow the diagnosis, repair or lawful modification of a vehicle function; and where such circumvention does not constitute a violation of applicable law, including without limitation regulations promulgated by the Department of Transportation or the Environmental Protection Agency...⁵⁵

An updated version of this exemption was renewed as a part of the 2018 triennial process laid out by the DMCA.⁵⁶

| ANALYSIS

Farmers and other advocates across the country have supported Right to Repair reforms to remove repair restrictions on agricultural equipment. This legislation calls for open access to the parts, tools, embedded software and diagnostic information that is required to fix a piece of equipment.⁵⁷ Bills have been introduced in 32 states and counting;⁵⁸ with each introduction, a furious debate has followed.

Opponents of Right to Repair reforms, such as the Association of Equipment Manufacturers (AEM) and the Equipment Dealers Association (EDA), argue that the policy is an attempt to force manufacturers to turn over intellectual property in the form of source code.⁵⁹ They also claim that advocates seek to, “gain unfettered access to the embedded code in agriculture equipment, which could be dangerous and harm both farmers and general the [*sic*] public. Additionally, ‘right to repair’ legislation could give third-party repair shops the ability to illegally bypass emissions standards set by the Federal Government.”⁶⁰ They say that this, “would risk the safety, durability and environmental sustainability of farm equipment.”⁶¹

“Manufacturer claims about the code that farmers and advocates seek, the access they desire and the functionalities it would enable are disingenuous if not downright fallacious,” said Gay Gordon-Byrne, executive director of Repair.org.

To parse this, it is helpful to first discuss what is actually included in Right to Repair legislation. The Repair Association, a trade organization consisting of repair technicians from a range of fields and a leader in the Right to Repair movement, has model legislation⁶² on which many of the different state bills are based.⁶³

ACCESS TO EMBEDDED CODE WILL NOT ENABLE THEFT OF SOURCE CODE

The template Right to Repair bill makes no mention of source code, but does call for the manufacturer to make available embedded software “for purposes of diagnosis, maintenance, or repair, to any independent repair provider, or to the owner of digital electronic equipment manufactured by or on behalf of, or sold by, the original equipment manufacturer.”⁶⁴ Such language sets forth clear boundaries and therefore does not imply “unfettered” access.

What, then, is the difference between embedded software, which the bill calls for, and source code, which opponents claim advocates are really after? There is a world of difference; source code is compiled into embedded code, a process that makes it unreadable by humans.⁶⁵

Source code is instructions written by software engineers in a coding language like C or Java that tell a machine what to do. Any person who understands the programming language can read it, meaning that source code can be modified and put to use in a competing form. That means an agricultural equipment company that steals a competing manufacturer's source code could modify it to work in their machines—a possibility that manufacturers are looking to avoid.⁶⁶

However, an important change occurs when source code is compiled and turned into embedded software. This translates the human-legible coding language into computer-legible 1s and 0s.⁶⁷ In a combine, a farmer interacts with this embedded code through the controls in the cabin, which execute the embedded code to display a selectable button or list of settings on their screen.⁶⁸

New tractor computers (ECUs) come without software and have to be programmed before they can operate.⁶⁹ Access to embedded software would allow a farmer to program new parts, giving him the same access to a routine process that dealerships enjoy.⁷⁰

But translating this information back into the source code originally written by the software engineers is essentially impossible.⁷¹ That's why Apple,⁷² HP⁷³ and others freely make embedded code available for their products in the form of firmware updates.



Figure 2: Farmers interact with embedded code through selectable buttons or lists on their screen.

Because Right to Repair legislation only mandates access to embedded code required for diagnosis, maintenance or repair, and not the uncompiled source code behind it, there is no additional risk of source code leaking.

REPAIR IS NOT TAMPERING

The other concern raised by groups like AEM and EDA is that providing access to embedded software and other diagnostic information would enable illegal tampering⁷⁴ and, “risk the safety, durability and environmental sustainability of farm equipment.”⁷⁵ Our analysis, explored below, shows that Right to Repair does not change the fact that subverting environmental controls is illegal, nor do the repair resources included in model legislation allow for this illegal activity.

Title 40 of the Code of Federal Regulation, which is enforced by the Environmental Protection Agency (EPA), states:

Tampering. You may not remove or render inoperative any device or element of design installed on or in engines/equipment in compliance with the regulations prior to its sale and delivery to the ultimate purchaser. You also may not knowingly remove or render inoperative any such device or element of design after such sale and delivery to the ultimate purchaser... This prohibition does not apply in any of the following situations:

- (i) You need to repair the engine/equipment and you restore it to proper functioning when the repair is complete.
- (ii) You need to modify the engine/equipment to respond to a temporary emergency and you restore it to proper functioning as soon as possible.⁷⁶

It is notable that EPA regulation carves out exemptions for repair and emergencies. By preventing farmers from fixing their own equipment, manufacturers go further than required by law and limit emergency capabilities, potentially creating a different kind of safety concern.

But nothing in Right to Repair legislation suggests that farmers would be able to, “remove or render inoperative any device or element of design,”⁷⁷ that is installed to abide by safety and environmental regulations.

What the bill does require is for manufacturers to make available “any special documentation, tools, and parts needed to reset [an electronic security] lock or function when disabled in the course of diagnosis, maintenance, or repair of the equipment.”⁷⁸ That means that a farmer would be able to find a problem, fix it and then turn off the error code that indicated the issue, allowing the machine to return to full capacity. This allows for authorization of proper repair, but it does not allow for environmental or safety overrides.

Software locks in tractors work as follows: a sensor that forms part of a control system fails, indicating a problem in need of repair. This prompts an error message to be delivered to the equipment operator, activates the immobilizer and puts the machine into limp mode.⁷⁹

Certain software is then needed as a “key” to the digital lock so that the farmer can diagnose the exact issue, approve replacement parts as necessary and then indicate that the repair has been completed. This takes the tractor out of limp mode and allows the farmer to go back to her business.⁸⁰

If the repair is conducted improperly or a given emissions or safety control is not met, the given control system would again fail, starting the process over. A machine is not fully functional until a proper repair is made, and all environmental and safety requirements are met.⁸¹

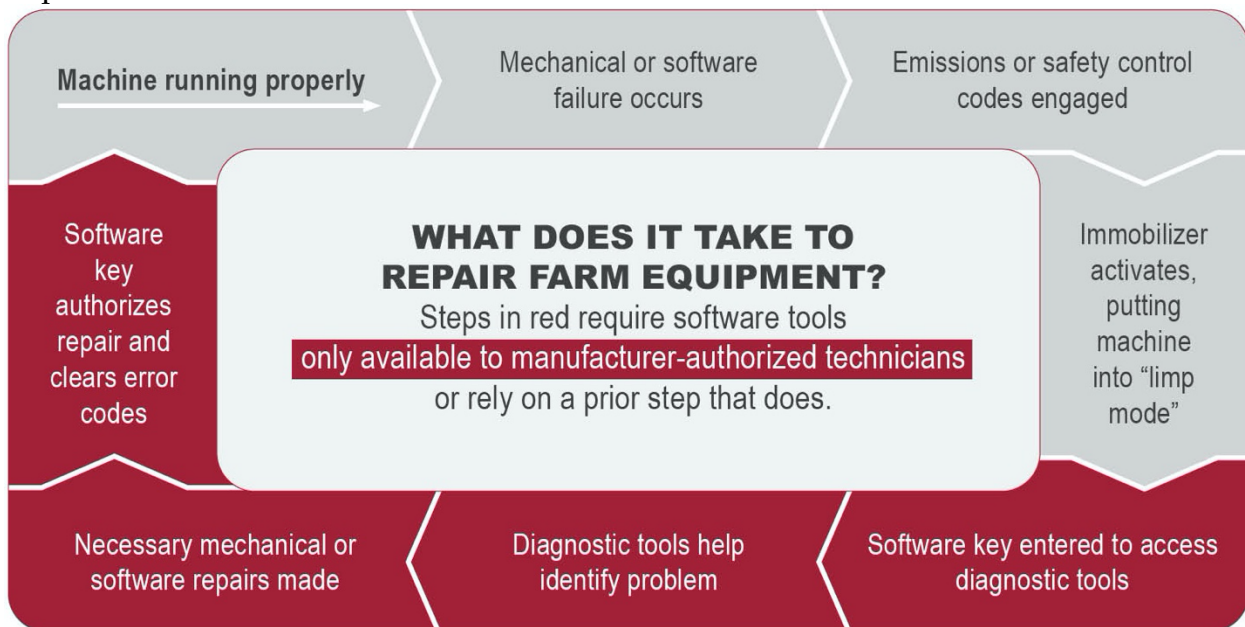


Figure 3: Farm equipment repair procedure. Steps in red require software tools only available to manufacturer-authorized technicians or relies on a prior step that does.

There is a clear difference between resetting an error code and ignoring or overriding safety codes. According to agricultural repair experts, overriding emissions or safety controls requires modification tools, not the tools used for diagnosis and repair that Right to Repair legislation provides. To override these controls, a farmer would have to first erase the operating system present on the machine, as they cannot access nor remove the included control systems. They would then have to upload new, modified software that either does not have emissions and safety controls or allows a farmer to ignore them.⁸² This is illegal, as it violates the tampering provision in laid out in Title 40 of the Code of Federal Regulations.⁸³

As long as a farmer uses the software that the manufacturer provides, they are unable to bypass environmental or safety regulations. “Right to Repair legislation, which provides farmers with access to diagnostic information and software keys available to manufacturer authorized technicians, just allows us to fix our broken tractors,” said Nebraska Farm Bureau member Willie Cade. “It does not allow for any foul play.”

FINANCIAL INCENTIVES FOR LIMITING REPAIR

By digging deeper into each of these arguments, it becomes clear that the concerns of groups like AEM and EDA are unfounded. What can be shown, however, is that manufacturers like John Deere are making money off of their current repair monopoly.

Company filings have pointed to trends that services and repair have been as much as three to six times as profitable as new equipment sales⁸⁴ for John Deere and its dealerships. From 2013 to 2019, annual sales of parts increased by 22% to \$6.7 billion.⁸⁵ Meanwhile, annual sales of equipment fell by 19% to \$23.7 billion.⁸⁶

It begs the question: by resisting calls for access to repair information, are manufacturers and dealers trying to protect their customers and the environment, or are they protecting their bottom line?

| CONCLUSION

FARMERS NEED ACCESS TO TOOLS NECESSARY TO REPAIR THEIR TRACTORS THEMSELVES

As shown by this report and our analysis, the increased presence of software in agricultural equipment has allowed manufacturers like John Deere to take control of the repair process at the expense of the equipment owner. The creation of software locks and keys required to authorize repair severely limits farmers and independent repair shops' ability to fix broken farm equipment themselves.

Groups like AEM and EDA have responded to calls for the Right to Repair by rolling out their own preemptive compromise measures, called R2R Solutions.⁸⁷ In their statement of principles, they commit to providing access to things like manuals, on-board diagnostics and more for, "tractors and combines put into service on or after January 1, 2021."⁸⁸

But their proposal falls short in a few key ways. First, there is no guarantee that the tools that are provided will be made available at an affordable price. Manufacturers in other industries like medical equipment have offered trainings required to get access to service information for as much as 80% of the original price of the device.⁸⁹ That would be a hefty price to pay on combines that can cost up to \$500,000 and may need to be replaced in as soon as one to three years for bigger farmers.⁹⁰ Sheer cost can effectively prevent the independent repair access promised by AEM and EDA.

The AEM/EDA outline also refuses to permit consumers to reset an immobilizer system or security-related controls.⁹¹ Without those capabilities, farmers will still be beholden to manufacturers and their affiliated dealerships to authorize repairs and get back to work. Again, a farmer's right to repair is withheld.

A third issue is that tractors and combines put into use before 2021 are not a part of the manufacturers' commitment. This creates an orphaned fleet of farm equipment whose owners still cannot repair their own tractors. Smaller farmers, who can use their combines for 15 to 20 years, are the most likely to get hurt in the process.

Finally, while AEM and EDA members have pledged to meet the standards they set for themselves, there is no guarantee that they will follow through and no opportunity for farmer recourse should they fail to live up to their promise.

“The manufacturers’ commitment is about stall tactics, not solutions,” said Cade.
“Farmers deserve better than these half measures—they deserve the right to repair.”

A real solution would give farmers unrestricted access to the same tools that the dealers have. These are not tools that will allow farmers to override safety or emissions controls, nor will they lead to encroachments on intellectual property. They will, however, provide farmers with what they need to diagnose, calibrate, authorize and perform repairs. All of this should be provided at a fair and reasonable price.

Manufacturers should adjust their plans to include those measures. If they fail to do so, legislators should enact policies such as Right to Repair reforms to make sure that farmers can fix their own equipment.

| NOTES

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