21DEC24   **ETN 240019 I**

Technical Note: User Guide for solanum-audio iOs app v.37 (Illustrated)

1. Safety

USE THIS PRODUCT ONLY FROM THE INSIDE THE PASSENGER COMPARTMENT, WHILE FOLLOWING ALL VEHICLE MANUFACTURER RECOMMENDATIONS FOR SAFE OPERATION.

2. Requirements, downloading, starting

This product works with iOs 16.0 or later. Internet access is required. Vehicle must be an electric or gasoline-fired passenger car or light truck.

Download the app from Apple's App Store. A link is available at solanum-service.com , the download page can also be found by searching for 'solanum-audio' on the App Store. Once the software is downloaded, click the app icon on the device's home screen. The software will automatically launch.

In internal testing, we found many iOs devices that have been in use for 2 or more years exhibit a behavior whereby the microphone will record crunch-like noises that aren't really there. Something else we observed is some waterproof cases have a membrane over the microphone grille, and this membrane can chafe against the microphone in such a way it creates acoustic artifacts in the recording. Most older devices and those in waterproof cases do work satisfactorily, but check the physical condition of the microphone if satisfactory results are consistently difficult to obtain.

This screen will display when the software loads correctly.

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Automotive Triage by Audio

🔴 **Start Recording**

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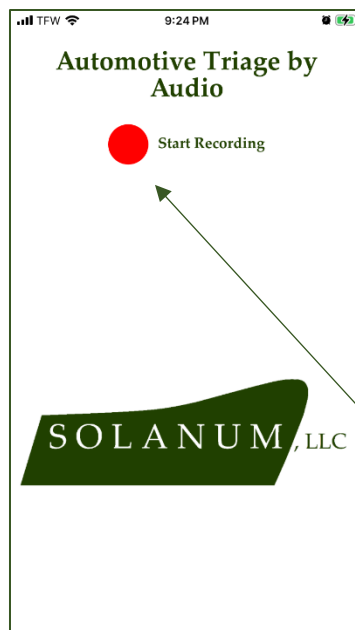
Push the red button to begin recording. No other buttons or function exist on the screen at this point.

3. Environment for Use, Using the built-in ambient noise meter

Before using, find a safe location. If the sound causing concern only occurs when the vehicle is moving, plan a safe path forward. If an assistant is available, have the assistant drive the vehicle. Remain seated safely in the passenger compartment- the software is not trained to recognize the sound of problems from any other location, and will only work properly when used inside the vehicle.

Minimize extraneous noises, like talking or music. Turn off the vehicle's audio system and HVAC system. Find the quietest location possible. The software is trained to recognize and ignore most of the extraneous noises commonly heard around cars- for example, traffic noise and pedestrians' voices- but best results are achieved in a quiet environment. The sounds made by orthopterans (crickets, grasshoppers, etc.) are highly similar to the automotive noises the model is trained to recognize. In locations where the sounds of these insects are unavoidable, the predictive performance of the model will be markedly reduced.
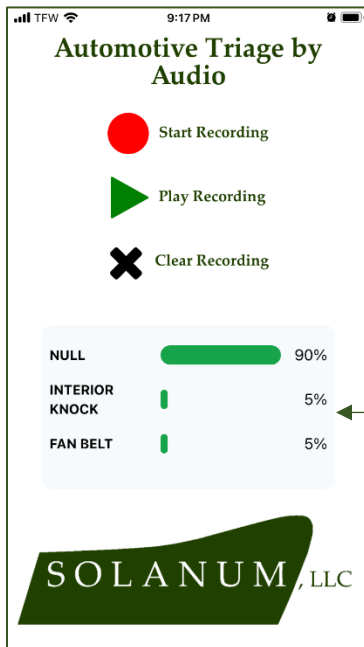
This response is shown when the ambient noise level is low enough.

The software includes a built-in ambient noise meter that can be used to rule out false positive results caused by ambient noise. We have calculated a specific level of ambient noise at which the model starts to lose its effectiveness at differentiating between the noise the vehicle makes and other noises in the environment. The model is hard-coded to give a response of "NULL 90%; INTERIOR KNOCK 5%; FAN BELT 5%" when the ambient noise level is low enough for good model performance. If, before starting the vehicle, some result other than this is displayed, the ambient noise level is too high for good results. Try finding a quieter location in which to take a recording of the vehicle.

The orientation of the iOs device does not matter much. Keeping it on the passenger seat, or any other soft surface in the vehicle, is recommended, but other locations work satisfactorily

if necessary. Avoid placing the device on a hard surface while the vehicle is moving, vibration will cause percussive artifacts in the recording.

4. Recording

Press the "Start Recording" button when the sound causing concern is heard. If using the software to figure out if any problems exist in the first place, press it 2-3 seconds before taking off from a stop, since the majority of audible vehicle problems will be most salient then.

5. Receiving Outputs

After pressing the "Start Recording" button, no further action is required. The software will automatically stop recording, and in about 3 seconds an on-screen notification of results will be displayed. At low-volume times of day (generally, outside of business hours), there may be a time-out error due to the server falling asleep- if you intend to chase an intermittent noise that is difficult and costly to duplicate, we recommend submitting at least one test recording beforehand, so as to verify the server is awake and ready when you are finally able to capture that elusive little noise that comes and goes as it pleases!
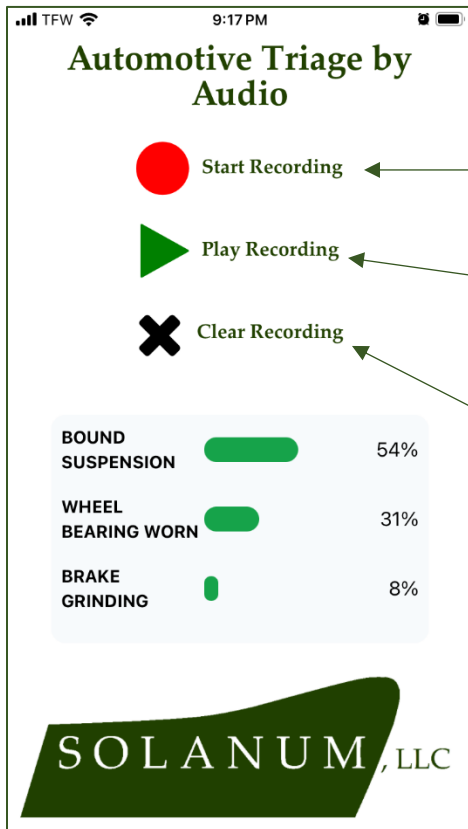
Results will show the three most likely categories of problem classes, along with an estimate of the probability for each. The "NUL" category is a lack of problems, if this category is the top result, it usually means no likely malfunctions were identified in the recording.

6. Other Buttons

To hear exactly what sound was sent for analysis, press the "Play Recording" button that appears after a recording is created. To de-clutter the screen, press the "Clear Recording" button (which also appears only after recording).

7. Taking another recording

To submit a new sample, or to use the software on another vehicle, press the "Start Recording" button again. Output notifications and data from previous recordings will automatically be overwritten. We recommend recording at least 5 samples from the vehicle before acting on the information given.

Automotive Triage by Audio

- ● Start Recording
- ▶ Play Recording
- ✖ Clear Recording

BOUND SUSPENSION		54%
WHEEL BEARING WORN		31%
BRAKE GRINDING		8%

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To analyze another recording, simply press this button again.

If desired, this button will play back the recording to which the results shown apply.

This button clears the screen so it will look like it did upon first start-up.

8. Interpreting Outputs

The app is not a "direct" diagnostic tool like a code reader or a compression tester, it cannot be used to prove the existence or non-existence of any vehicle malfunction. It simply suggests a place to start looking. Furthermore, it does not recognize all malfunction sounds, but rather the majority of common ones. Currently, the model is trained to distinguish the sounds of no problem ("NULL"), brake grinding, loose suspension and brake components, bound steering and suspension, knocks from the interior, fan belt slippage, wheel bearing wear, and mechanical engine malfunctions.

The model predicts the 3 most likely explanations of any acoustic signatures heard, and presents them together in a final result. The model is not precise enough that, for example, an 11% chance of "FAN BELT" and a 10% chance of "WHEEL BEARING" means, with certainty, that a problem with the fan belt is more likely. Therefore, in cases where no one result shows more than a 90% probability, all three results are worthy of further investigation.

The following brief overview explains each category of results and what it may mean about where to start looking for problems:

a. NULL

This category is the lack of any identified problem. In situations too quiet to have an automobile in them, such as an empty room or in most domestic settings, this result will be the top result. It also indicates that no audio signatures of the problem categories listed below were identified.

b. BRAKE GRINDING

This result indicates the signature of metal-to-metal contact from brake components was identified. In some cases loose heat shields can trigger this result- when this happens, whether or not the vehicle was moving was moving when the recording was taken is a key diagnostic criteria. If you believe a result of "BRAKE GRINDING" may have been caused by a loose heat shield, repeat the test with the vehicle parked. If the result still appears while parked, a brake problem is not possible and the result is most likely caused by a loose heat shield. The model is not trained to recognize high-pitched squeal caused by glazed brakes, this condition will not trigger the "BRAKE GRINDING" result.

c. BRAKE/SUSP LOOSE

This result indicates the signature of a loose component near the wheel was detected. The model differentiates between this type of noise and those caused by interior components, using our proprietary algorithm that takes frequency and temporal patterns into account. In some cases when the vehicle is equipped with low-profile tires, this result can be falsely triggered by driving over potholes.

d. FAN BELT

This result indicates the signature of fan belt slippage. The model is deliberately trained to be relatively insensitive to this noise as roughly 25% of vehicles exhibit a very slight belt chirp during the first cold start of the day, and this slight chirp is not problematic. Orthopteran insects are known to falsely trigger this result in some cases- in many locations during late summer and early fall, since the noises made by these insects are unavoidable, simply ignore this result during those times. See also (g) below.

e. WHEEL BEARING

This result indicates the signature of a worn ball bearing rotating under radial load has been detected. This result will rarely be triggered by other driveline bearings under radial load, such as pinion bearings. If your vehicle is equipped with an exhaust system that does not comply with applicable noise emissions standards, the sounds

emitted by the exhaust system may interfere with accurate identification of wheel bearing noises.

f. INTERIOR KNOCK

This result indicates the signature of a percussive noise caused by, or involving, a plastic interior component. The model uses our proprietary algorithms to differentiate this class of problem from the similar-sounding noises caused by loose suspension and wheel end components. This result can be deliberately triggered falsely by tapping on the device microphone with your finger while recording. This result is often triggered by rain drops- during heavy rain or when parked under trees after any rain, the model will correctly identify the sound of the rain drops as emanating from the interior of the vehicle- however, in this case, the presence of a knocking from the interior is not indicative of a problem.

g. BOUND SUSPENSION

This result indicates the signature of a galled suspension component moving under load. Ball joints and tie rod ends are usually the source of this noise, but in cases of severe corrosion coupled with severe wear, rubber bushings in control arms and similar components can cause the model to produce this result. False identification of this result can occur if loud music is played during recording or if the mating calls of orthopteran insects are audible in the environment. See also (d) above.

h. ENGINE

This result indicates any of 3 broad classes of problem with the engine are audible. The model is trained to recognize the acoustic signature of excessive play in the rotating assembly ("bottom end" or "short block"), in the valvetrain and other camshaft-driven components (timing chains, valves, high-pressure fuel pumps on GDI systems), and exhaust leaks. As of the date of this note we have chosen to amalgamate these three possible results into one "ENGINE" category, since in most use cases we explored the end result to the user is the same: Get the engine to a powertrain specialist.

9. **Alerts & Error Messages**

a. **"Welcome to Solanum Audio! A subscription is required after 10 recordings."** This message is displayed the first time the app is opened, and is serves only as a reminder that long-term use of the product requires a paid license.

b. **"There was an issue reaching the server. Please try again".** This alert may appear for either of two reasons. One, if the Internet connection is slow between your device and

the computer that analyzes the audio recording (currently located near Columbus, OH). Two, sometimes if you are the first person to use the software in a given business day, the server may have gone to sleep after a long period of disuse. In both cases, the solution is the same- check your signal strength, then submit another recording.

c. **"The subscription product is not available. Please try again later."** This alert appears when the Apple App Store is down or not reachable via the Internet connection between your device and Apple.

d. **"Purchase Successful. You are now subscribed!"** This alert serves to confirm payment for long-term use of the product has been successfully received by Apple.

e. **"Purchase Failed. There was an error processing your purchase."** Please contact Apple for further assistance with this alert- the issue is between you and Apple. In most cases they will send you an email or in-app message about your options.

f. **"You have used the recording feature 10 times. To continue using it, please subscribe…"** This alert appears when the free trial period is over.

g. **Other errors.** Please contact Solanum, LLC if any other error messages, bugs, or crashes are observed. If possible let us know the date, time, and location the error was observed, and the iOs version installed on your device.