

# REPORT DOCUMENTATION PAGE

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| 14. ABSTRACT<br>Final Report. Work under contract N00014-07-M-0127 to further the capabilities of LEEDS® were to be extended based upon the requirements collected for the E-CRAFT program. Requirements analysis will consider the following aspects of the E-CRAFT life cycle: ship design, construction, operation, maintenance, and recapitalization. Progress toward the development of LEEDS support tool enhancements was limited to the architectural design of a context-based diagnostic capability. A new version of the LEEDS web portal for E-Craft was successfully developed and deployed, with security enhancements, using preliminary ship work breakdown structure (SWBS) data. Further effort at decision support tools focused on the implementation of a case based reasoning tool for maintenance decisions support. The tool utilizes data commonly found in a Computerized Maintenance Management System (CMMS) to build a case base that may be searched for solutions to potential maintenance issues. The system finds cases with common problem indicators and recommends maintenance actions based on the fit of the problem. |                        |                         |                                      |                                 |                                                             |  |
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# **Enhancement of LEEDS Decision Tools for E-Craft**

## **Final Report**

**period**

**March 20, 2007 through March 13, 2012**

Prepared for:

Office of Naval Research  
Award No. N00014-07-M-0127

March 13, 2012

Systems Modernization and Sustainment Center  
Rochester Institute of Technology  
133 Lomb Memorial Drive  
Rochester, New York 14623

## **SUMMARY**

This program was a follow on to the LEEDS Decision Tools for E-CRAFT program, award # N00014-07-M-0121. In that program, LEEDS was to be implemented for the E-CRAFT program along with an initial set of algorithms and decision tools. This program was designed to allow for enhancement of those tools and algorithms.

Progress toward the development of LEEDS support tool enhancements was limited to the architectural design of a context-based diagnostic capability. A new version of the LEEDS web portal for E-Craft was successfully developed and deployed, with security enhancements, using preliminary ship work breakdown structure (SWBS) data.

Several concepts were also presented to MSB suggesting alternative LEEDS enhancements. A concept for configuration management within LEEDS based on the EIA-836 standard was rejected by MSB in favor of commercial fleet management software. Additional concepts were presented for performing predictive analysis using data from key ship systems and correlating operational characteristics of the data to maintenance records.

The project was delayed and extended multiple times due to delays in the E-Craft ship program and also lack of responsiveness from the E-Craft project team. In early discussions with the E-Craft team, the maintenance aiding decision support capability was identified as a high value enhancement to LEEDS. Due to lack of support and interest from the E-Craft team, and after discussion with the ONR Program Manager for this project, it was determined that the maintenance aiding capability should be developed without additional input or collaboration with the E-Craft program as the project deliverable.

The maintenance decisions support system is derived from the concept of case based reasoning. Utilizing data typically found in a Computerized Maintenance Management System (CMMS) and health data collected from a platform, a subject matter expert will develop a case that includes a set of indicators, the root cause of the failure and the maintenance actions that corrected the problem. Over time, the knowledgebase grows and can be utilized for retrieving suggestions for maintenance based on a set of indicators. Algorithms within the system identify the best fit between sets of indicators and root causes. Then based on the fit and likelihood of the problem, the system will provide a list of maintenance tasks that might resolve the issue. Once the issue is resolved, the case will be closed in the system and added to the knowledgebase.

## **TASKS**

### **1. Enhancement of methods and algorithm development**

- *Quantitative/qualitative algorithms will be further developed and refined for equipment assessments and analysis.*

- *Methods of user interaction will be further investigated and defined to improve data-mining capabilities and tool usability.*

Following the discovery phase, necessary algorithms and business logic were to be developed to meet the objectives of the functional specification. Information design and user report specifications would then be used to define software tool interaction methods. The lack of user requirements and a functional specification prevented any algorithm development.

During the application discovery phase of the project, RIT identified several areas of opportunity for LEEDS support tool enhancements and presented these to MSB for consideration. These opportunities included:

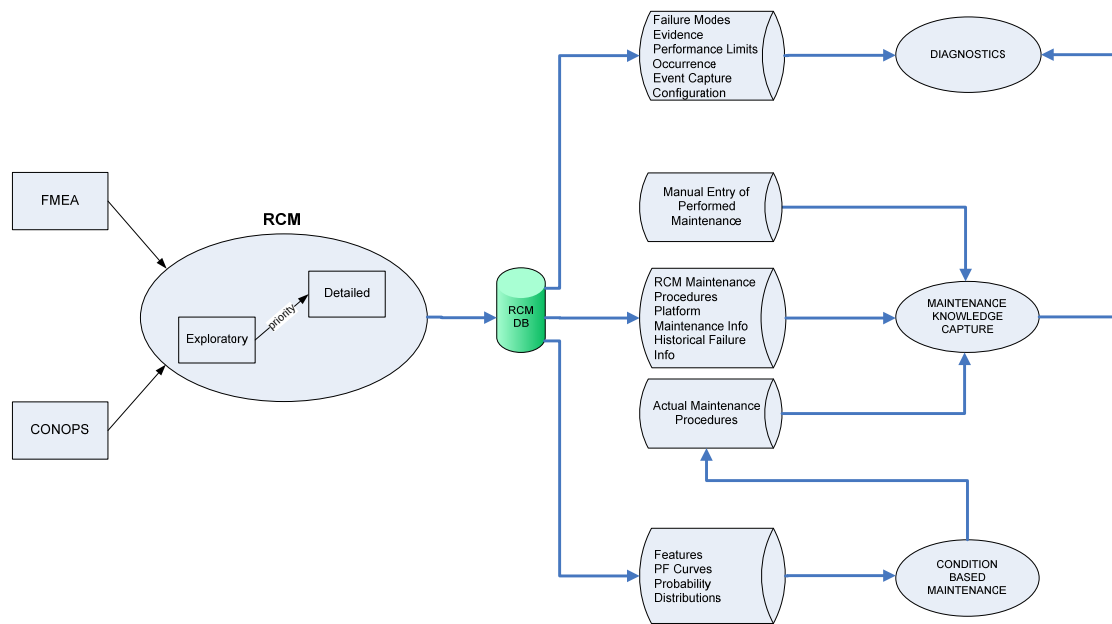
- a. operational monitoring
- b. health monitoring
- c. condition-based maintenance (CBM)
- d. health driven scheduling
- e. reliability, availability, maintainability strategies
- f. reliability centered maintenance (RCM)

MSB expressed interest but provided no useful feedback regarding which tools would be of most benefit to them in an enhanced LEEDS product.

It was the intent of RIT to conduct interviews with stakeholders from MSB to identify enhancements to LEEDS that would best serve MSB in its life-cycle management of the ship. In the absence of direct input from the stakeholders, it was the opinion of RIT that MSB would need assistance in the areas of Reliability Centered Maintenance and Economic Decision Support.

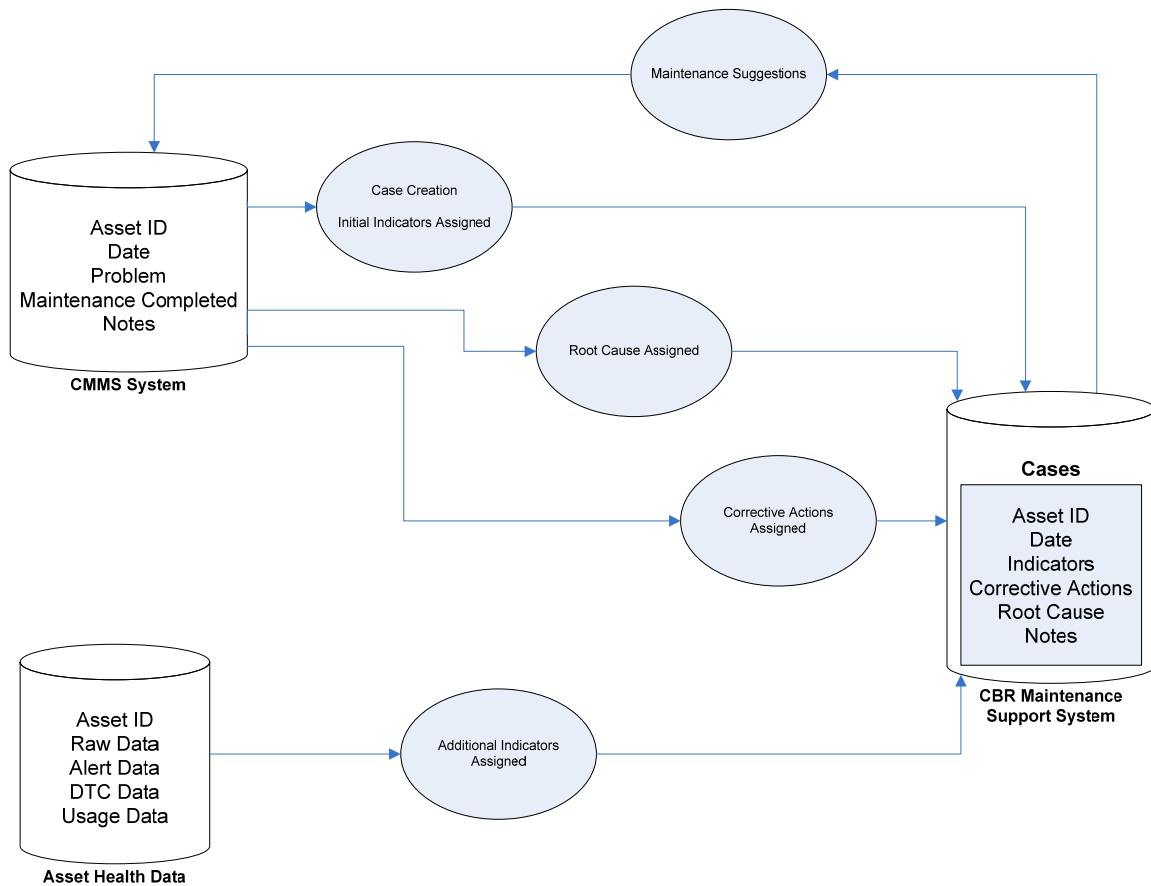
A survey of RIT's existing RCM software tool was conducted to determine how to best incorporate RCM into the FMEA process already a part of LEEDS. Plans were made to enhance the economic/cost analysis algorithms already utilized in LEEDS to provide meaningful evaluation methods for guiding equipment investment decisions. These plans were summarized in an Application Discovery document that was presented to MSB for stakeholder buy-in. This document is attached in Appendix A.

In a further attempt to foster the development of support tool enhancements, an architectural design of a context-based diagnostic capability was created by RIT and presented to MSB. RIT received no useful feedback on this design, depicted in Figure 1.



**Figure 1 - Information Architecture of a Context-based Diagnostic Tool**

Due to lack of support and interest from the E-Craft team, research efforts were redirected toward the case based reasoning decision support tool for maintenance. The system utilizes data from a CMMS system and puts the data through a process, managed by a subject matter expert, to identify all indicators of a problem, determine the root cause of the problem, and track the maintenance actions performed that correct the problem. Additionally, the tool allows the subject matter expert to add indicators based on data captured from monitoring system, further enhancing the diagnostic capabilities of the system. The conceptual system is depicted in Figure 2.



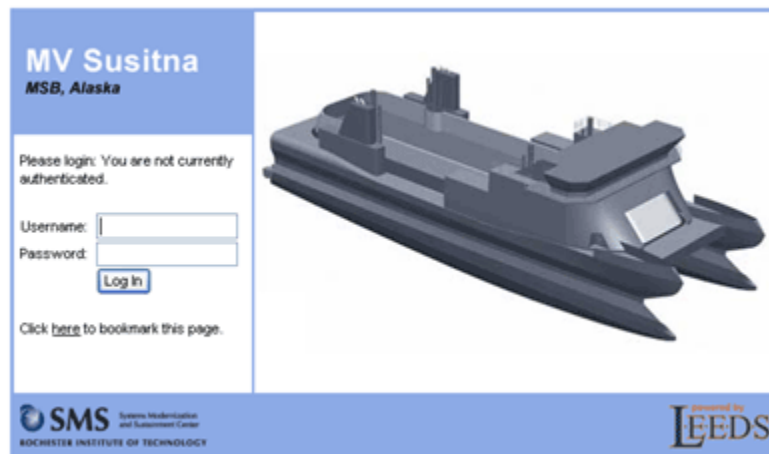
**Figure 2 - Maintenance Decision Support**

## 2. Software tools development

- *User interface prototypes will be developed based upon developed methods and algorithms. User testing and resulting feedback will be used to refine design.*
- *Development of software tools will occur, guided by prioritized functional specification*
- *Software tool enhancements will be implemented and tested within populated E-Craft LEEDS® portal to demonstrate intended function.*

Software development was planned to commence after acceptance of a prototyped software demonstration. Deployment of the new tools within LEEDS would be deemed complete after system testing. Final demonstration of the decision support tools was to be given for a selected ship system.

One of the project objectives was the enhancement of a LEEDS E-Craft web portal. Such a portal was successfully developed, with security enhancements, and its database was populated with data from a preliminary ship work breakdown structure (SWBS), see Figure 3 and Figure 4. This website and database was hosted on a web server at RIT. It was the intent of RIT to use this as the starting point for tool enhancements based on interviews with stakeholders.



**Figure 3 - LEEDS E-Craft Login Screen**

This website was developed and its database populated using a preliminary ship work breakdown structure (SWBS). The SWBS allowed only the platform hierarchy (system tree) to be populated. RIT was unable to carry out further population of the database due to the unavailability of ship documents (drawings, manuals, maintenance procedures, etc). RIT has not received a SWBS document since the preliminary copy received in October 2006.

Detailed instructions on the administration and usage of LEEDS E-Craft were provided. These documents are included in Appendix A.

- Guidelines on getting started
- Instructions to users requesting access to LEEDS
- Steps for creating a new LEEDS user
- Instructions for adding data via the LEEDS portal
- System requirements for hosting LEEDS
- LEEDS portal security features

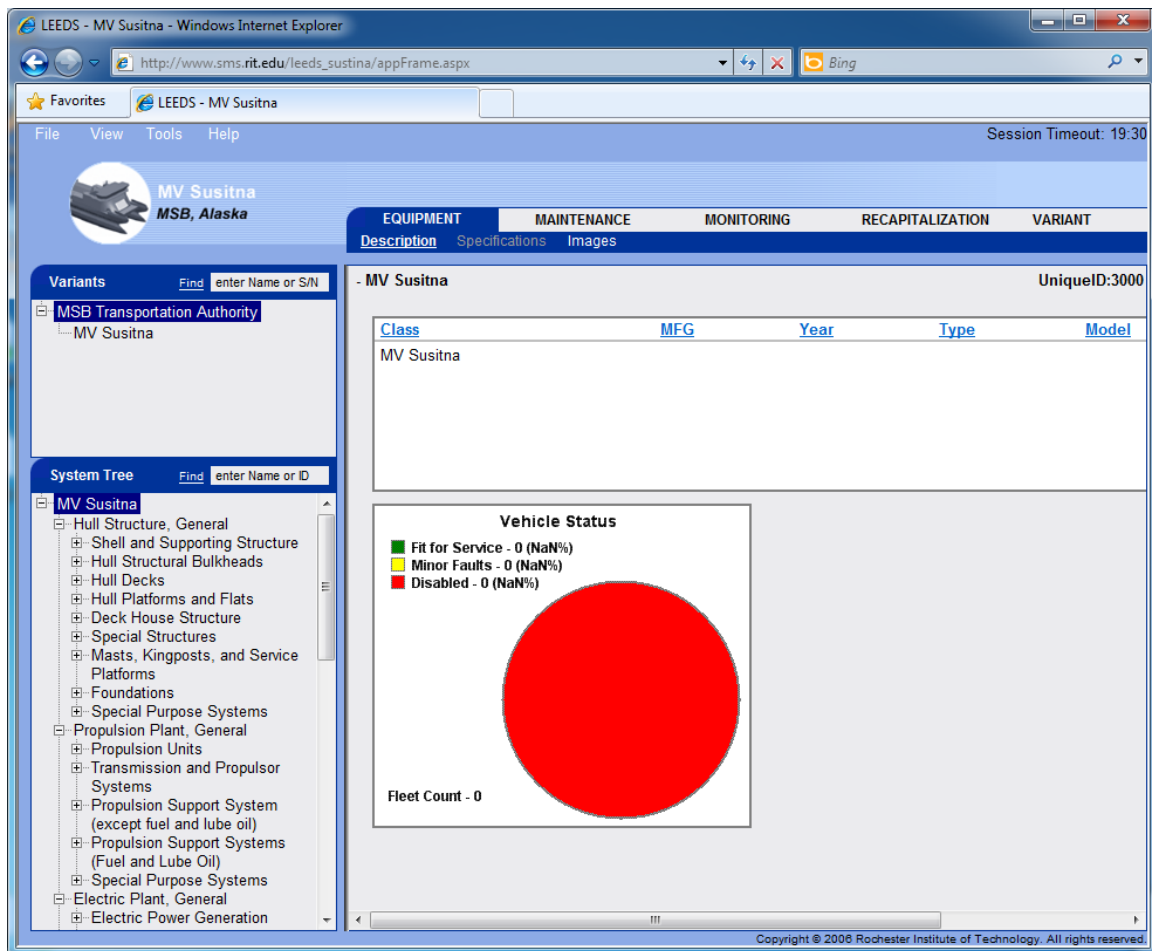


Figure 4 - LEEDS E-Craft Main Page

Due to delays in the ship construction schedule, work on this contract was placed on indefinite hold in October 2008.

In May 2009 an attempt was made to re-engage with MSB by presenting a new LEEDS design concept for ship/equipment configuration management and health monitoring of key ship system(s), with an emphasis on configuration management adhering to the EIA-836 standard. However, MSB stated their decision to use Fleet Management software from the American Bureau of Shipping (ABS) instead of LEEDS.

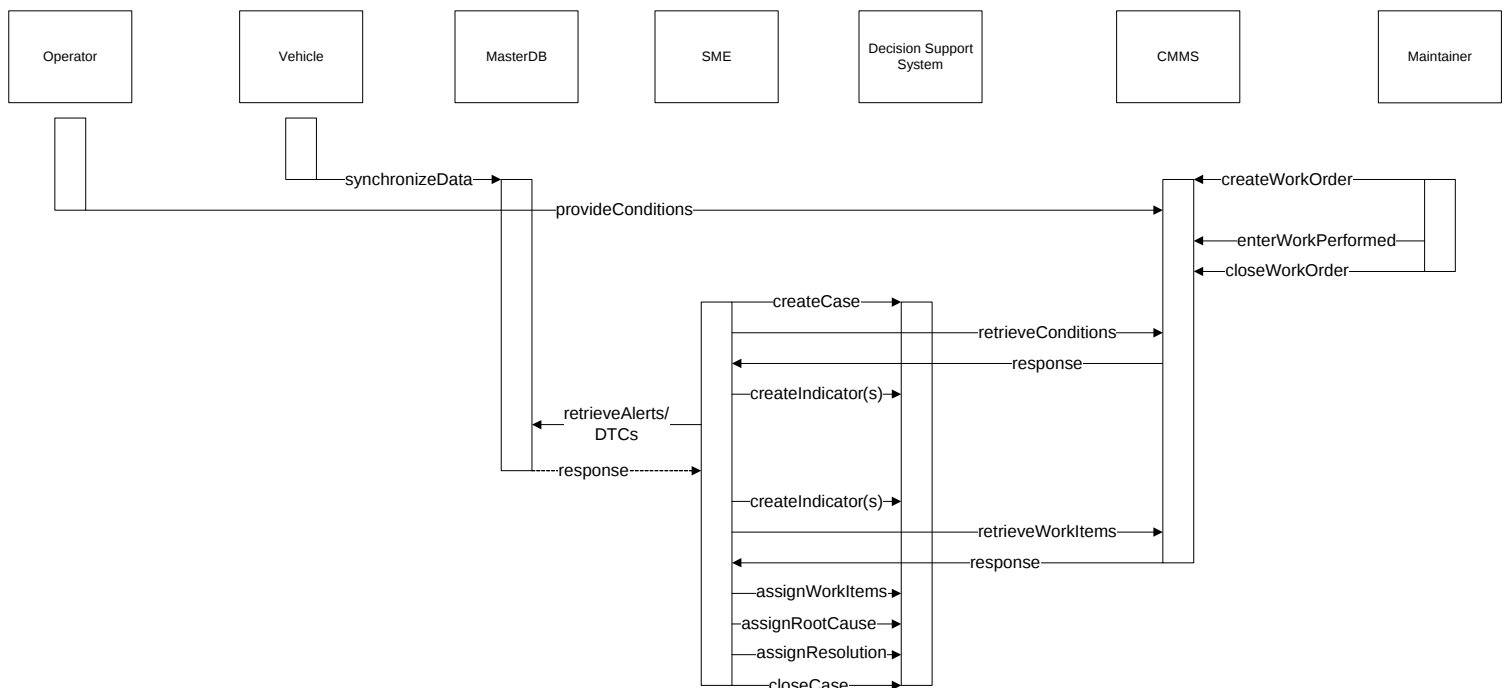
In November 2009, RIT presented a preliminary concept for performing predictive analysis using data from a key ship system and correlating operational characteristics of the data to maintenance records. Based on feedback received from MSB, RIT presented a second concept in December 2009 in which several candidate systems for monitoring were presented. The concept document presented in December 2009 is included in Appendix A.

Due to lack of support and interest from the E-Craft team, development was redirected toward the development of the case based reasoning maintenance decision support system. System design was based on a few assumptions:

- 1) Initially, the subject matter expert (SME) is required to be an active, in the loop participant in the decision support system.
- 2) The decisions support system would utilize data from a CMMS system, but initially would not be integrated into a CMMS system. I.e. the system does not pull data from or push data to a CMMS system.
- 3) If a maintainer is having trouble solving a problem, they will ask the SME for a suggested course of action.
- 4) The SME will only build cases from existing Work Orders in the CMMS.
- 5) If the SME notices alerts or DTCs that indicate a problem, but no Work Order exists, they will notify the maintainer to open a Work Order.

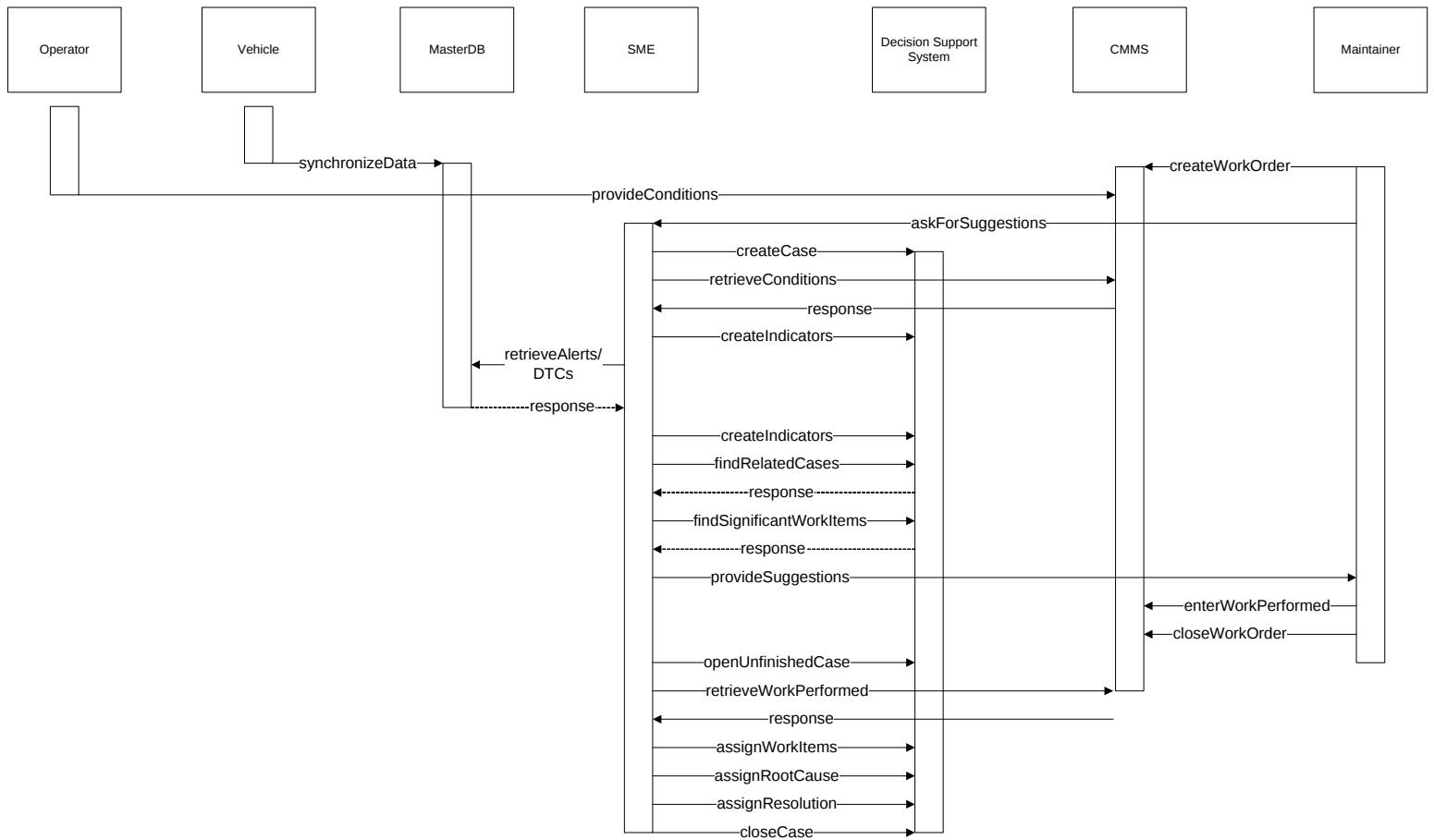
This design is the first in an iterative process. Future iterations would include the ability to integrate directly with the CMMS, including the ability to retrieve and push data to the system, open Work Orders, and suggest work actions; a text interpreter for processing the work order problems and actions into standard formats; integration into a health management software for automated identification of problems, allowing for opening work orders and providing suggestions for corrective actions.

User interfaces were developed based on the sequences of events that an SME would follow for: 1) populating the system with closed work orders, building the knowledge base, or 2) providing suggestions for an open work order at the maintainer's request. The sequence diagrams for these two events are shown in Figure 5 & Figure 6.



## Creation of cases from Completed Work Orders

Figure 5 - Completed Work Order Entry Sequence



## Maintainer Retrieving Decision Support System Suggestions

Figure 6 - Maintainer Needs Suggestion Sequence

Based on these sequences, user screens were developed to step a user through the process of creating a case, creating indicators, assigning work items, assigning root cause, closing the case; or in the case of making suggestions, retrieving related cases and suggesting work.

A demonstration system was developed that implements the required data object model, utilizes XML files for storage of the data, allows population of Work Orders (for demonstration purposes), and implements the user screens; thus allowing a rudimentary demonstration of the system.

## **DELIVERABLES**

### **1. LEEDS E-Craft Portal development**

As summarized above, a LEEDS E-Craft website and database was successfully developed and deployed, with security enhancements, using preliminary ship work breakdown structure (SWBS) data. A web portal hosted on an RIT web server was set-up and detailed instructions were provided describing how to access the site and populate the database with ship engineering data and articles. However, when it was determined that MSB was not going to utilize LEEDS, the system was packaged up for delivery.

Attached as Appendix A are the following supporting documents.

- MV Susitna LEEDS Portal – Application Discovery Document
- MV Susitna LEEDS Portal – Server Setup
- MV Susitna LEEDS Portal – Getting Started
- LEEDS Implementation for E-Craft – Concept Document

### **2. Maintenance Decision Support Demonstration Tool**

As summarized above, a Case Based Reasoning Maintenance Decision Support Tool was developed to allow development of a knowledgebase for corrective maintenance actions. This knowledgebase may then be used to suggest maintenance. The demonstration tool was developed and is packaged as a java executable jar file. Included with the file are the XML sample data files that allow demonstration of the system.

Attached as Appendix B are the following support documents.

- Maintenance Decision Support Tool – Getting Started

**Contract Number  
N00014-07-M-0127  
Dated 3/20/07 through 3/13/12**

**FISCAL STATUS AS OF March 13, 2012**

**Award No. N00014-07-M-0127:**

Contract Amount is \$34,600

Up to June 15, 2007 – Item No. 000201 ACRN: AA: \$11,533

Up to December 15, 2007 – Item No. 000301 ACRN: AA: \$11,533

Final amount billed – item No. 000501: \$11,534

**Appendix A**  
LEEDS E-Craft  
Portal Development Documents



# **MV Susitna – LEEDS Portal Implementation**

## **Application Discovery**

Author: Jeff Heintz  
Email: [jphasp@rit.edu](mailto:jphasp@rit.edu)  
Telephone: (585) 475-6359

## Version Control

| Version | Date       | Author      | Comments                                    |
|---------|------------|-------------|---------------------------------------------|
| 0.1     | 24 May 07  | Jeff Heintz | First Draft                                 |
| 0.2     | 02 July 07 | Jeff Heintz | Added 2.3, "Data Interoperability"<br>scope |
|         |            |             |                                             |
|         |            |             |                                             |
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|   |                           |   |
|---|---------------------------|---|
| 1 | Overview.....             | 2 |
| 2 | Summary of Findings ..... | 2 |
| 3 | Application Choice.....   | 3 |
| 4 | Sign Off.....             | 3 |

# 1 Overview

This document summarises the outcome of the Application discovery process that was carried out as part of the analysis performed by Rochester Institute of Technology, absent of customer-input. The findings here form the starting point for the more detailed requirements and functional analysis phases of the project. They do not constitute a definition of the scope of the project.

# 2 Summary of Findings

It is the intent of this project to carry out interviews with stakeholders and representatives from MSB that will be managing the MV Susitna ferry. The purpose of these interviews will be to identify the work processes and tools the organization plans to employ for ship operations and maintenance, and identify potential challenges and obstacles they will face with ship life-cycle support. The purpose of this project will be to attempt to create software tools that will allow MSB to effectively manage these life-cycle support challenges.

In the absence of direct customer input, it is the opinion of RIT that MSB will need assistance in the areas of Reliability Centered Maintenance and Economic Decision Support. It is not the intent of RIT to develop a maintenance management system as there exist software applications that effectively provide this function.

## 2.1 Reliability Centered Maintenance (RCM)

RCM is a systematic process of preserving a system's function by prescribing preventative maintenance (PM) tasks, as opposed to implementing a strictly scheduled and costly equipment maintenance program. Utilizing the FMEA process already a part of LEEDS®, software tools would be developed in order to lead the RCM process in order to define the failure management policy that would prescribe what should be done, and when, to predict or prevent each functional failure. The results of the RCM solution would serve as input to the configuration of the ship's preventative maintenance management system.

Scope:

- Replicate MS Access-based RCM software tool in LEEDS
- Modify process to resemble Reliability Centered Design Analysis
- Enhance tie-in to CBM strategy

Benefits:

- Is necessary for determining CBM strategies for ship, very useful to MSB
- Is a good fit for LEEDS tool development,

Risks:

- Availability of CIMS' RCM-facilitators is unknown
- This will not be a traditional RCM exercise (it will more closely resemble a reliability centered-design analysis):
  - Availability of data to fuel RCM process before ship launch is unknown
  - Availability of SME's, operators and maintainers to participate in RCM is unknown
- RCM analysis (exploratory and detailed) scope is large and will likely rely on being funded outside of the ONR contracts; will rely on ONR grant or other unknown source.

## 2.2 Economic Decision Support

Building upon economic/cost analysis algorithms already utilized LEEDS®, additional enhancements will be made to provide meaningful evaluation methods for guiding equipment investment decisions. Potential enhancements include refinement of optimization algorithms and inclusion of methods for adjusting costs to reflect time-value of money, such as net present value.

## 2.3 Data Interoperability

The greatest concern MSB has expressed is the ability for future migration of data from the proprietary LEEDS database to another proprietary maintenance management software. In order to mitigate the risk of the data being non-transferable, research and development will be conducted to transform the LEEDS database schema or build an external software interface that conforms to industry standards or suggested guidelines for areas such as: configuration management, unique identification, and interactive electronic technical publications.

## 3 Application Choice

Final application choice cannot be made without customer input. However, progress can be made developing the aforementioned tools if the workgroup agrees there would be resulting benefits. Phone discussion with the MSB workgroup lead should be held as soon as possible to discuss these potential tools and to discuss the context of the expected ship operations and maintenance workflows.

## 4 Sign Off

RIT (Program Manager or PM): \_\_\_\_\_ Date: \_\_\_\_\_

ONR Sponsor: \_\_\_\_\_ Date: \_\_\_\_\_

MSB PM: \_\_\_\_\_ Date: \_\_\_\_\_

## MV Susitna LEEDS® Portal – Server Setup

1. Web Server Requirements
  - 1.1. Windows 2003 32 Bit, with IIS 6.0 and .Net 3.5 and ASP.NET 2.0
2. SQL Server Requirements
  - 2.1. SQL Server 2008R2
3. On SQL Server, restore SQL Database
  - 3.1. Restore LEEDS database 'LEEDS F Susitna\_SQL\_Server\_backup\_2012\_03\_12.bak' as 'LEEDS F Susitna'
  - 3.2. In restored database remove the user 'SusitnaLeedsUser'
  - 3.3. Create user 'SusitnaLeedsUser' with password '903kd9As99'
  - 3.4. In User Mapping, add new user to role 'LEEDS User'
4. On web server install Sentinel Super Pro
  - 4.1. Install file: Sentinel Protection Installer 7.6.x.exe (included)
    - 4.1.1. <http://www.safenet-inc.com/support-downloads/sentinel-drivers/>
  - 4.2. Do custom install and unselect Sentinel Protection Server, Sentinel Keys Server and Parallel Port Driver.
  - 4.3. Install purple license key dongle
  - 4.4. To check for successful install go to Computer management>Device Manager>USB Controllers should see "Safenet USB SuperPro/UltraPro"
5. On web server install ABC Upload Component so that binary is installed in Global Assembly Cache
  - 5.1. Setup file inside of abcupload.net.zip
  - 5.2. Ensure All Users is checked.
6. Setup IIS
  - 6.1. Copy website directory 'Susitna IIS Files' onto server
  - 6.2. Start/Open IIS
  - 6.3. Ensure that Web Service Extensions for ASP.NET 2.0 are allowed.
  - 6.4. Make a new Website or Virtual Directory "LEEDS"
    - 6.4.1. During wizard step ensure allow Read and Run ASP Scripts
    - 6.4.2. After the wizard creates the site, open properties and go to the Documents tab and set the default document to "secLogIn.aspx"
    - 6.4.3. On the properties tab 'ASP.NET'
      - 6.4.3.1. Check that the version is 2.0
      - 6.4.3.2. Edit the configuration line 'LeedsD' to the name of your SQL Server used in step 3.

## 6.5. Tree Control Setup

- 6.5.1.1. If the site was installed as a virtual directory then relative location of the Tree Control must be set. Otherwise an error will be thrown looking for "ob\_tree\_505.js".
- 6.5.1.2. Go into Web.Config
- 6.5.1.3. Scroll all the way down to bottom of document, look for AppSettings section.
- 6.5.1.4. Look for TREE CONTROL ICONS section (last subsection)
- 6.5.1.5. Change the XML comments that bracket the virtual directory section to bracket the standalone website section.

## 7. Run LEEDS

- 7.1. Using MS Internet Explorer 6.0, browse to the URL set in step 6.
- 7.2. Admin account: LeedsAdmin password: cmk29wp
- 7.3. See the document 'User Getting Started Instructions' for additional instructions.
- 7.4. See the online Help for additional information on using LEEDS.

## MV Susitna LEEDS<sup>®</sup> Portal – Getting Started

### *Computer requirements:*

- Have an Internet connection
- Microsoft Internet Explorer 5.0, 6.0 or 7.0
- Monitor with a resolution at least 1024x768 dpi

### *Logging-In:*

1. **Navigate to the portal homepage** at {your installation URL, see your IT Admin} using Microsoft's IE browser.
2. **Enter your username and password.** You should have received your username and password with your account notification. If logging in for the first time, be sure to change your password.
3. **Select >Enter Database** from the splash screen to view ship data.

### *Site use:*

Navigation within the portal is achieved through the left and top menus. Special functions are available from the pull-down menu in the upper-left corner of the screen. For more information on using the portal refer to the *LEEDS Help* utility accessible from the *Help* pull-down menu.

Your ability to view and modify data within the portal is dependent on the group privileges to which your account has been assigned. An *Update Page* button will appear at the bottom of the screen if you are allowed to modify data within the portal. Notify LEEDS support from the Help pull-down menu if you If you would like to request additional privileges.

To improve security, the portal automatically logs out after 20 minutes of inactivity.

### *Common Problems:*

- If the system does not accept your username and password, check to make sure 'Caps Lock' is not on - password is case-sensitive.
- If you require additional assistance, you may contact the LEEDS administrator at your organization, or use the LEEDS Help utility found under the Help topic from the top pull-down menu within the LEEDS application.

*Terms of use of this site are in accordance with guidelines set forth in Proprietary Information Exchange Agreements executed with Matanuska-Susitna Borough.*

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For further inquiries regarding LEEDS, please contact Sean McConky by email at [Sean.McConky@rit.edu](mailto:Sean.McConky@rit.edu) or by phone: (585) 475-5522, weekdays between the hours of 8-5 EST.

## LEEDS Implementation for E-Craft

### *RIT Working Concept Document for LEEDS Application to E-Craft* *December 7, 2009*

#### ***Vision***

To perform predictive analysis on data from one or more ship systems and correlate operational characteristics of the data to maintenance records.

Based on the signal lists that have been provided, and feedback from ONR and MSB, the following systems are suggested as candidate systems for monitoring (in rough priority order):

- Gearboxes
- Engines
- Power Generation (Ship Service Generators)
- Water Jets and Thrusters
- Power Storage (DC Power)

MSB noted that gearboxes are a critical ship maintenance item on high speed ferries and that the current sensors only provide oil temperature. There was some discussion around means of implementing a ***gearbox vibration*** monitoring system. There are some challenges with respect to development and deployment of gearbox vibration monitoring technologies that will need further discussion.

MSB also noted that they thought that there was additional value in collecting/trending the data coming from the Carderock ***hull stress monitoring*** system. RIT believes that interpretation of the hull stress data is a significant research endeavor. In addition, there was discussion about monitoring the ship's lifting system. However, from the initial signal analysis, it seems that there is limited data from this system that could be used for analysis. This should be revisited – to cross reference data that may be available from the hydraulic system.

With respect to DC Power storage, MSB noted that they already have voltage monitoring capability. RIT has previously developed vehicle monitoring algorithms that take into account battery voltage and current to assess battery health. Currently there is not a plan to monitor DC currents on the ship. RIT recommends that we continue to include this as a monitored system – there may be some features from particular

operational scenarios that can provide additional insight into the charge and health state of the batteries.

***Additional Points that were raised in RIT, MSB, ONR discussion:***

Relative to previous sets of signal lists that were passed to RIT:

- The “I/O List” are signals that were not on the Serial Modbus and not available from the MTU engine monitoring system. These signals were added to the CAN bus by expansion (PIM) and will be available from the MCS5.
- All of the signals on the Serial List are also available from the MCS5.

The ABS Fleet Management System will be at port, not on the ship. There may be a remote copy of the DB that might be carried on the ship on a laptop. The system that RIT envisions will need periodic access to the maintenance histories stored within the ABS system.

Further, MSB noted that space on the ship is very limited and that there may not be room to add an additional computer to host the LEEDS system. There are several different architectural options for deploying a system to the E-craft – one option may be the use of a small embedded system on-board the ship that collects data from the MCS5, and communicates it to a LEEDS server that is collocated with the ABS system in port. It may also be possible, ultimately, to run the RIT data collection software on an existing computer on the ship.

MSB asked about coupling the LEEDS and ABS databases. It may be possible to use a single DB server, or to integrate more fully long term, however this may be beyond the current project scope to do in the short term.

With respect to the specific maintenance tasks that are planned for the ship, this effort has not yet been completed. It is anticipated that most of this information – at least the scheduled tasks – will come from the equipment manual recommendations. Not much thought has been given yet to condition based maintenance.

***Assumptions***

We can access the data from the MTU engine monitoring system, the Modbus, and the additional added signals (I/O List) via the MCS5 using the NetDDE interface, and that performance of this task will not impact the MCS5.

Maintenance data from the ABS NS5 Fleet Management System is accessible via a suitable interface.

Space (or a host computer) for the MCS5 data collection interface can be identified, and the LEEDS server will have periodic updates from the ABS maintenance system.

### ***Short Term Open Issues***

MSB has provided detailed schematics and design documents for the monitoring system, however schematics for ship systems (electrical - AC and DC, mechanical power transmission, hydraulic, etc.) will be needed going forward. RIT would like to get copies of OEM and maintenance task lists (as those are defined). This information will only be needed for those systems specifically to be studied.

A decision needs to be made with respect to retrofitting additional monitoring capability to the gearboxes. In comparing the MTU Ship Automation System M3M/003110167/030907/02 document to the various signal lists, we are not 100% clear about what gearbox signals are already available. However, vibration monitoring is not an existing system capability and would require added hardware and software. Using a PIM to link into the existing CAN bus is one option that could be explored.

### ***Longer Term Open Issues***

Arrive at a deployment architecture concept (hardware and software).

Identify contact for discussions regarding data structures or interfaces for reading ABS maintenance data.

**Appendix B**  
Maintenance Decision Support  
Demonstration Tool Documents

## Maintenance Decision Support tool – Getting Started

### *Package:*

The software is delivered as a zip file named “SolutionTracker.zip” containing:

- lib: Folder containing application libraries.
- SolutionTracker.war: Deployable web application archive (war) file.
- SolutionTracker.jar: Executable jar file.

The executable jar file executes an embedded Jetty server (version 8.1.1). The Jetty server runs on port 8080 and hosts the war file as a web application.

### *Computer requirements:*

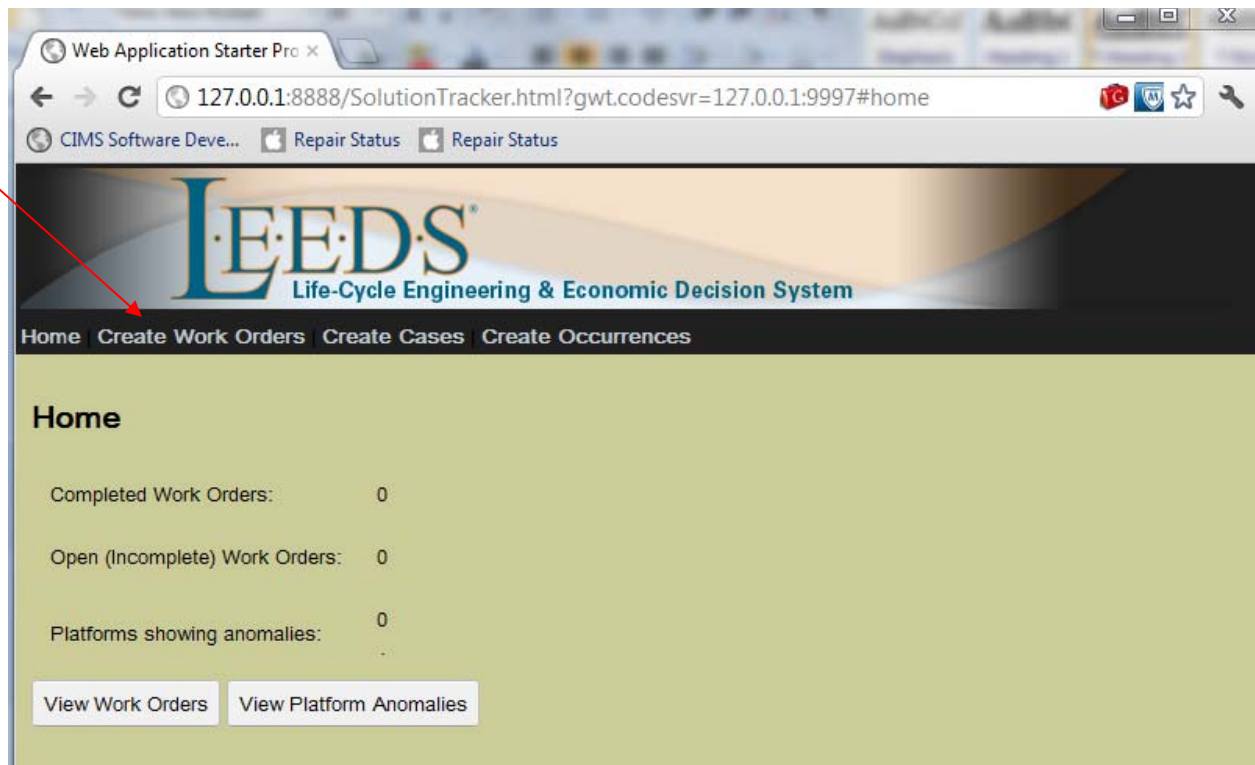
- Java Runtime version 1.6 (tested using Java(TM) SE Runtime Environment (build 1.6.0\_30-b12))
- Developed and tested on Windows 7.

### *How to run the Application:*

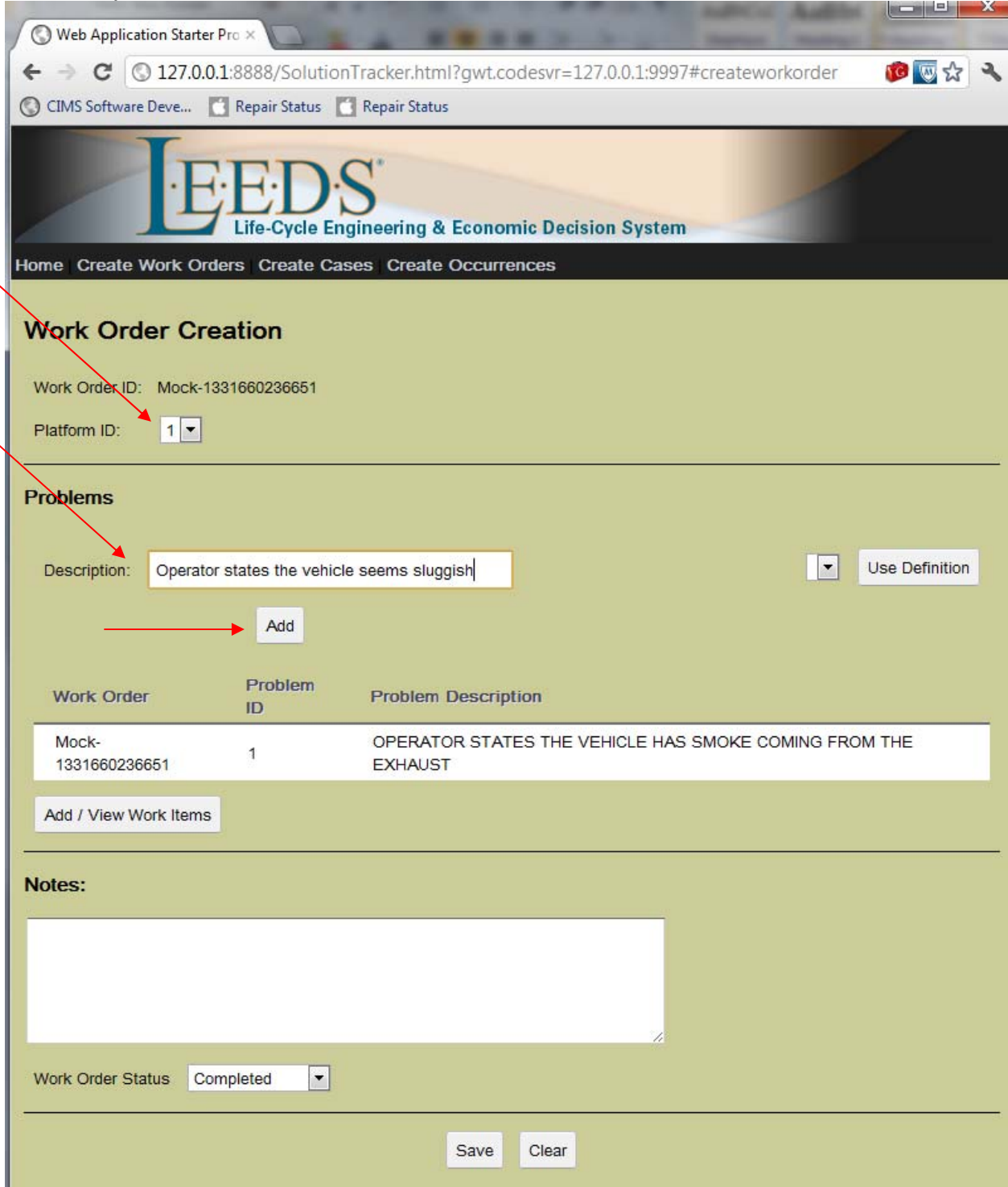
- Unzip the package file “SolutionTracker.zip” to a folder of your choice. The following steps will assume the folder is named “SolutionTracker”.
- Open a command prompt in the SolutionTracker folder.
- Start the Jetty server and run the application with the following command
  - a. `java -jar SolutionTracker.jar`
- The Jetty server may take some time to analyze the war file and start. It will output to the command prompt as it is starting.
- When the Jetty server has started, it will stop writing to the command prompt. The last line will show: “Started [SelectChannelConnector@0.0.0.0:8080](#)”.
- Open a browser and enter the following into the location bar:
  - a. <http://localhost:8080/SolutionTracker.html>
- This will bring up the home page of the application.
- To stop the application, enter CTRL-C in the command prompt, or exit the command prompt.

### *Creating Sample Work Orders:*

- From the Home screen, click on **Create Work Orders**



- On the Work Order Creation Screen, select a platform ID. Enter a Description in the Problems section and click Add.
- A Work Order may contain any number of problems by repeating the previous step



Web Application Starter Pro x

127.0.0.1:8888/SolutionTracker.html?gwt.codesvr=127.0.0.1:9997#createworkorder

CIMS Software Deve... Repair Status Repair Status

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Home Create Work Orders Create Cases Create Occurrences

## Work Order Creation

Work Order ID: Mock-1331660236651

Platform ID:

### Problems

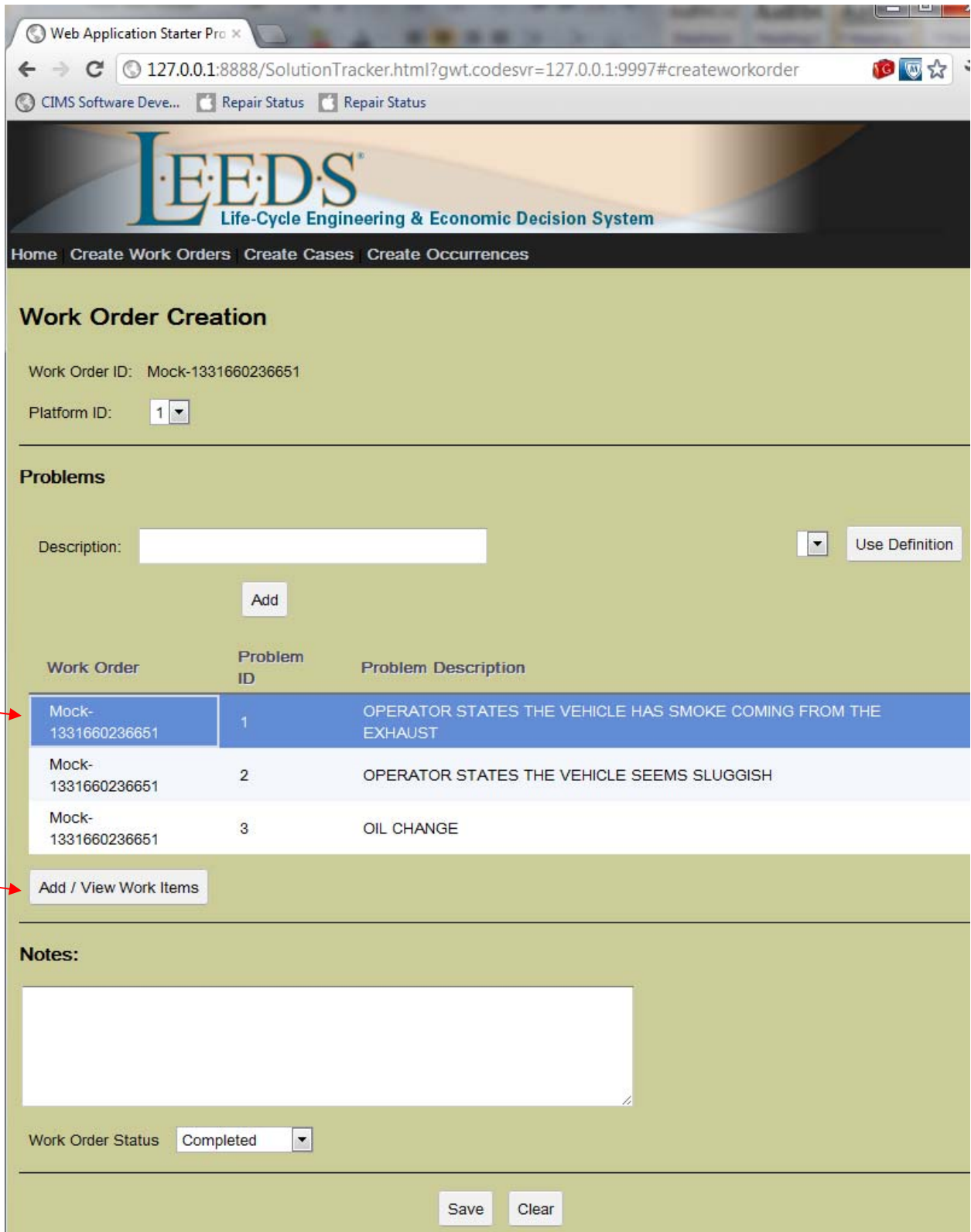
Description:

| Work Order         | Problem ID | Problem Description                                           |
|--------------------|------------|---------------------------------------------------------------|
| Mock-1331660236651 | 1          | OPERATOR STATES THE VEHICLE HAS SMOKE COMING FROM THE EXHAUST |

### Notes:

Work Order Status

- To add the work items performed on this Work Order, select a Problem from the list and click the Add / View Work items button.



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127.0.0.1:8888/SolutionTracker.html?gwt.codesvr=127.0.0.1:9997#createworkorder

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### Work Order Creation

Work Order ID: Mock-1331660236651

Platform ID: 1

#### Problems

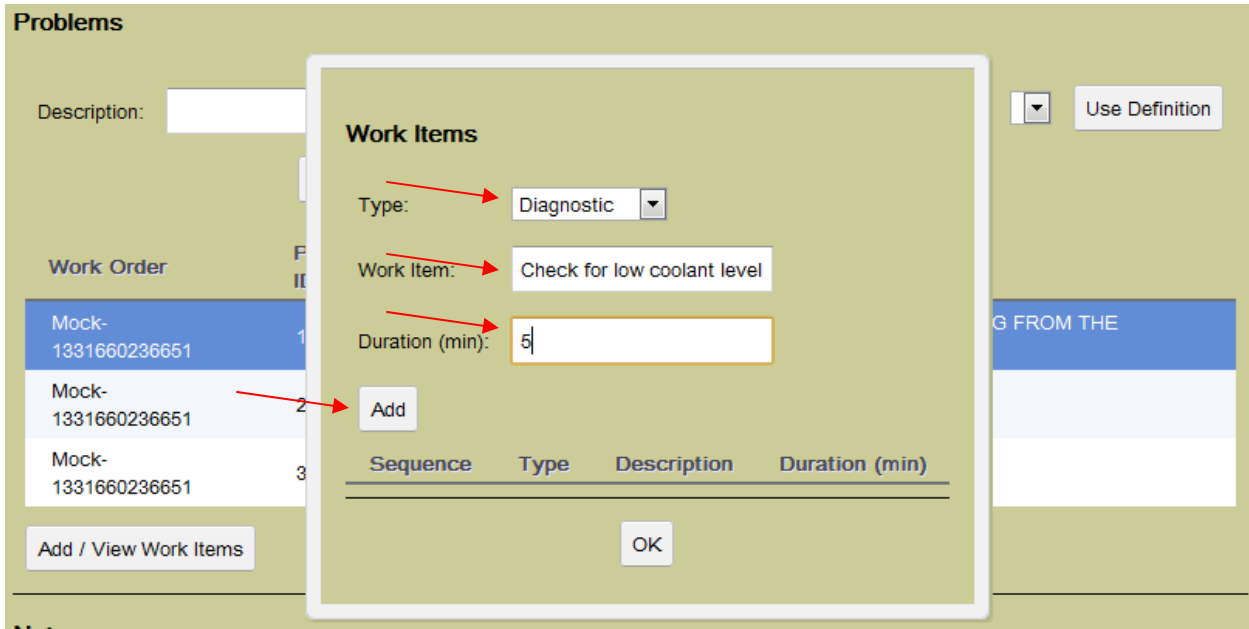
Description:

| Work Order         | Problem ID | Problem Description                                           |
|--------------------|------------|---------------------------------------------------------------|
| Mock-1331660236651 | 1          | OPERATOR STATES THE VEHICLE HAS SMOKE COMING FROM THE EXHAUST |
| Mock-1331660236651 | 2          | OPERATOR STATES THE VEHICLE SEEMS SLUGGISH                    |
| Mock-1331660236651 | 3          | OIL CHANGE                                                    |

#### Notes:

Work Order Status: Completed

- On the Work Items pop-up screen, select the work type, enter the action performed and the duration of the of the action and click the Add button. *Note: if a sequence of work items are done, please enter them in order. i.e. Test battery, test alternator, replace alternator.*



**Problems**

Description:

Work Order

| Mock-              |   |
|--------------------|---|
| 1331660236651      | 1 |
| Mock-1331660236651 | 2 |
| Mock-1331660236651 | 3 |

Add / View Work Items

**Work Items**

Type:

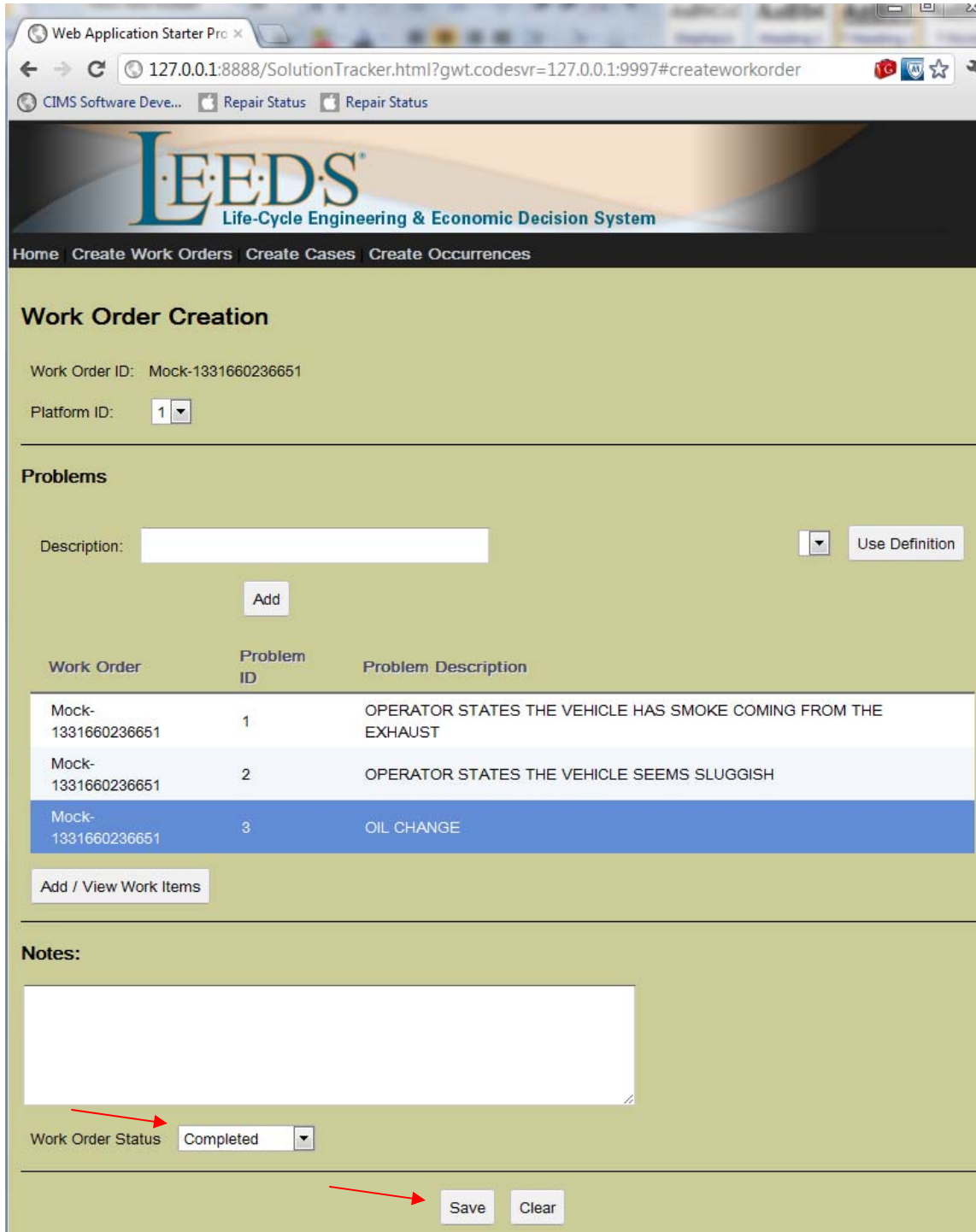
Work Item:

Duration (min):

| Sequence             | Type | Description | Duration (min) |
|----------------------|------|-------------|----------------|
| <input type="text"/> |      |             |                |

- Repeat the last 2 steps to add multiple work items for the same Problem or to add work items for other problems.

- Once all work items have been entered, the work order status may be set using the drop down. Then select the Save button on the Work Order Creation screen.  
*Note: Closed work orders may be used to make complete cases in the next step. Only incomplete (anything but Complete) may be used for providing maintenance suggestions.*



Web Application Starter Pro x

127.0.0.1:8888/SolutionTracker.html?gwt.codesvr=127.0.0.1:9997#createworkorder

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### Work Order Creation

Work Order ID: Mock-1331660236651

Platform ID: 1

#### Problems

Description:  ▼ Use Definition

Add

| Work Order         | Problem ID | Problem Description                                           |
|--------------------|------------|---------------------------------------------------------------|
| Mock-1331660236651 | 1          | OPERATOR STATES THE VEHICLE HAS SMOKE COMING FROM THE EXHAUST |
| Mock-1331660236651 | 2          | OPERATOR STATES THE VEHICLE SEEMS SLUGGISH                    |
| Mock-1331660236651 | 3          | OIL CHANGE                                                    |

Add / View Work Items

#### Notes:

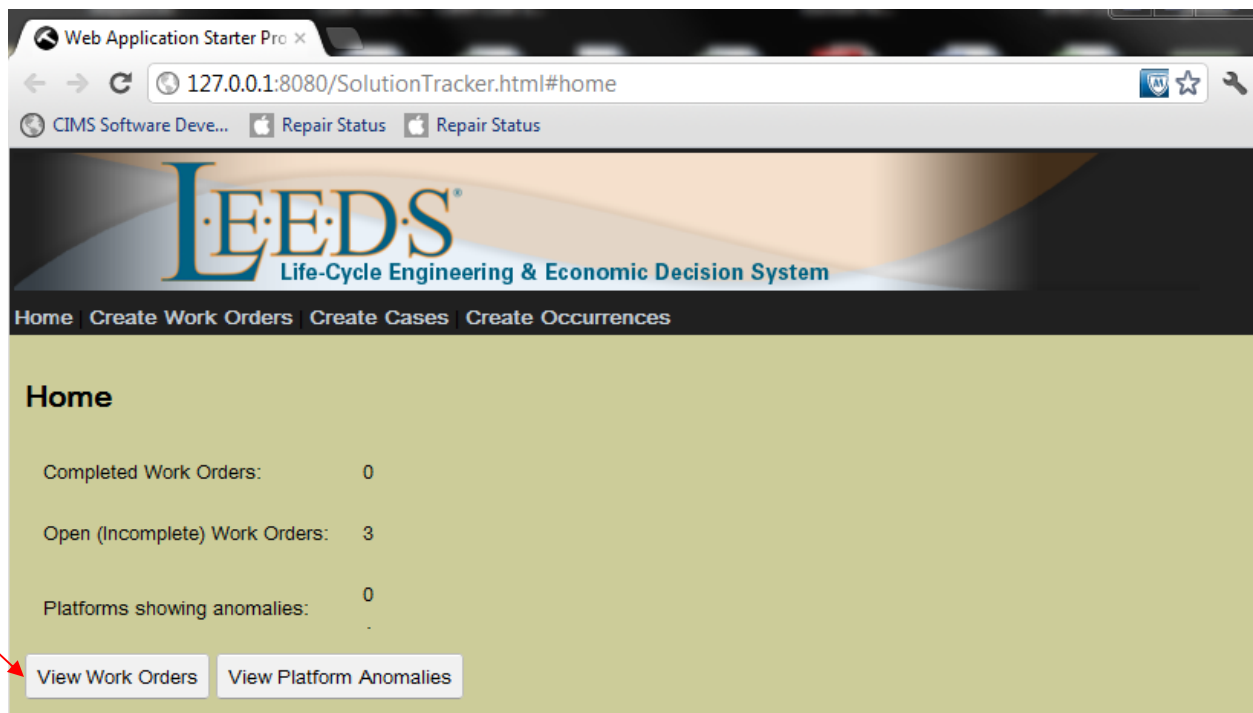
Work Order Status: Completed ▼

Save Clear

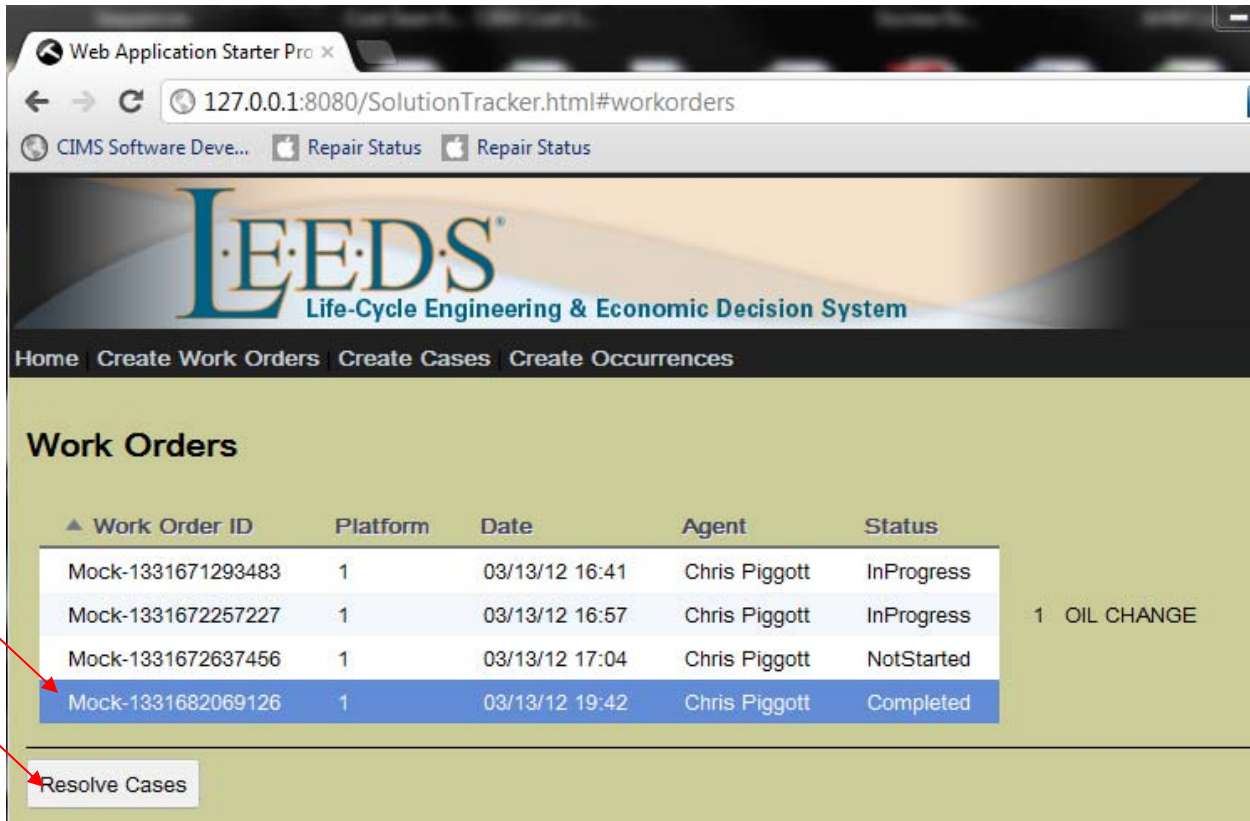
As many work orders may be created as you would like. This is a demonstration system and the creation of work orders is done solely to show the utility of the system. Future versions of the tool will be connected to an actual CMMS system and the Work Order data will be readily available from that system. Thus, in the future system iterations, the next two steps would be the only two processes to be performed.

### *Processing a Completed Work Order:*

- From the home screen, click the View Work Orders button



- From the Work Orders screen, select a completed work order from the list
- Click the Resolve Cases button



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#workorders

CIMS Software Deve... Repair Status Repair Status

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Home | Create Work Orders | Create Cases | Create Occurrences

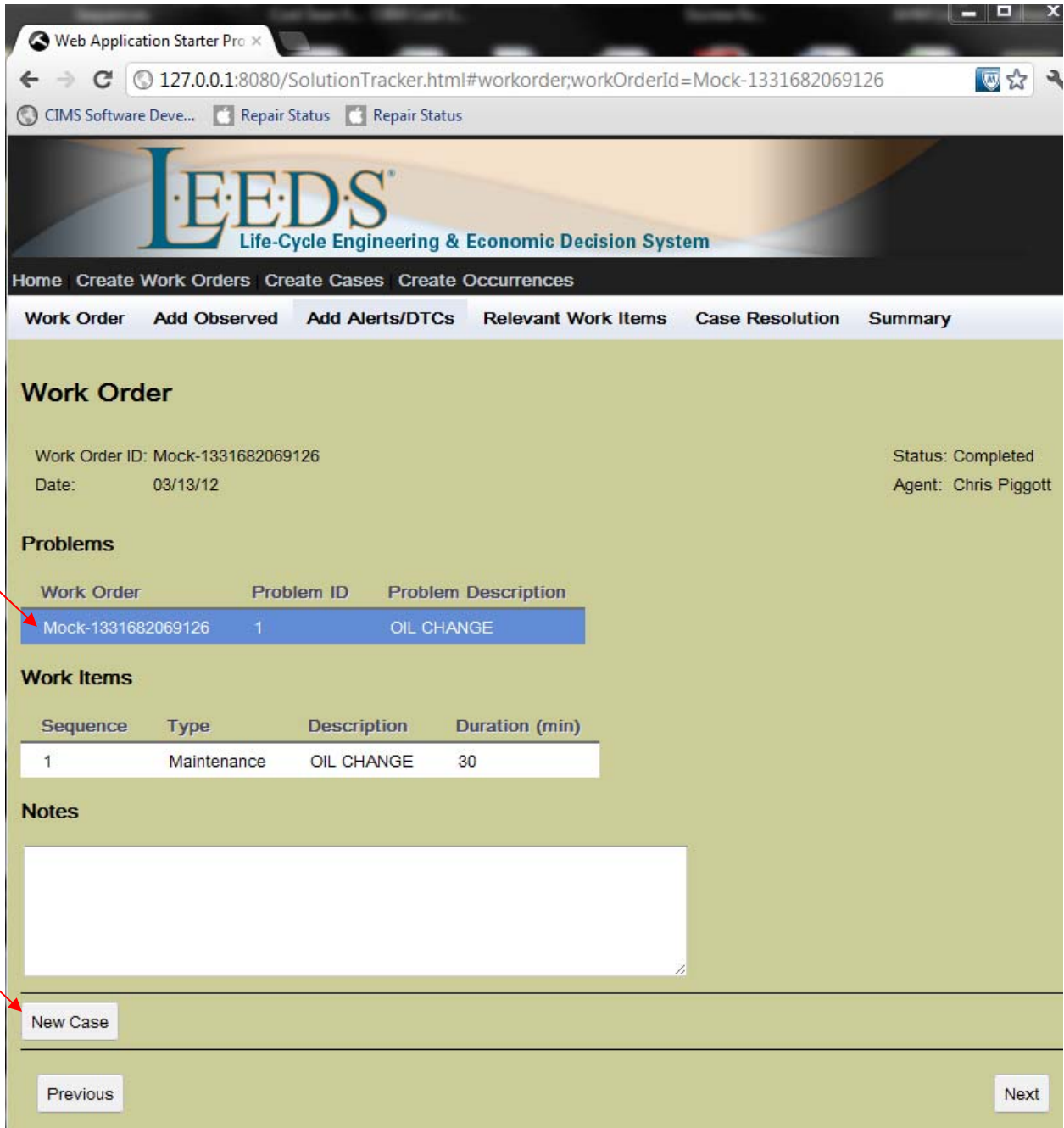
## Work Orders

| ▲ Work Order ID    | Platform | Date           | Agent         | Status     |
|--------------------|----------|----------------|---------------|------------|
| Mock-1331671293483 | 1        | 03/13/12 16:41 | Chris Piggott | InProgress |
| Mock-1331672257227 | 1        | 03/13/12 16:57 | Chris Piggott | InProgress |
| Mock-1331672637456 | 1        | 03/13/12 17:04 | Chris Piggott | NotStarted |
| Mock-1331682069126 | 1        | 03/13/12 19:42 | Chris Piggott | Completed  |

1 OIL CHANGE

Resolve Cases

- On the next screen, under Problems, select the Problem that you want to create a case for and click New Case.



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127.0.0.1:8080/SolutionTracker.html#workorder;workOrderId=Mock-1331682069126

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

## Work Order

Work Order ID: Mock-1331682069126 Status: Completed  
Date: 03/13/12 Agent: Chris Piggott

### Problems

| Work Order         | Problem ID | Problem Description |
|--------------------|------------|---------------------|
| Mock-1331682069126 | 1          | OIL CHANGE          |

### Work Items

| Sequence | Type        | Description | Duration (min) |
|----------|-------------|-------------|----------------|
| 1        | Maintenance | OIL CHANGE  | 30             |

### Notes

New Case

Previous Next

- Under Associated Case, you may add a description for the case. Otherwise, the description will be the description of the problem. Click the Next button.

Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#workorder;workOrderId=Mock-1331682069126

CIMS Software Deve... Repair Status Repair Status

Mock-1331682069126 1 OIL CHANGE

### Work Items

| Sequence | Type        | Description | Duration (min) |
|----------|-------------|-------------|----------------|
| 1        | Maintenance | OIL CHANGE  | 30             |

### Notes

### Associated Case

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

Set Case Description

### Indicators

| Date | Platform | ID | Type | Name | Description |
|------|----------|----|------|------|-------------|
|------|----------|----|------|------|-------------|

### Relevant Work Items

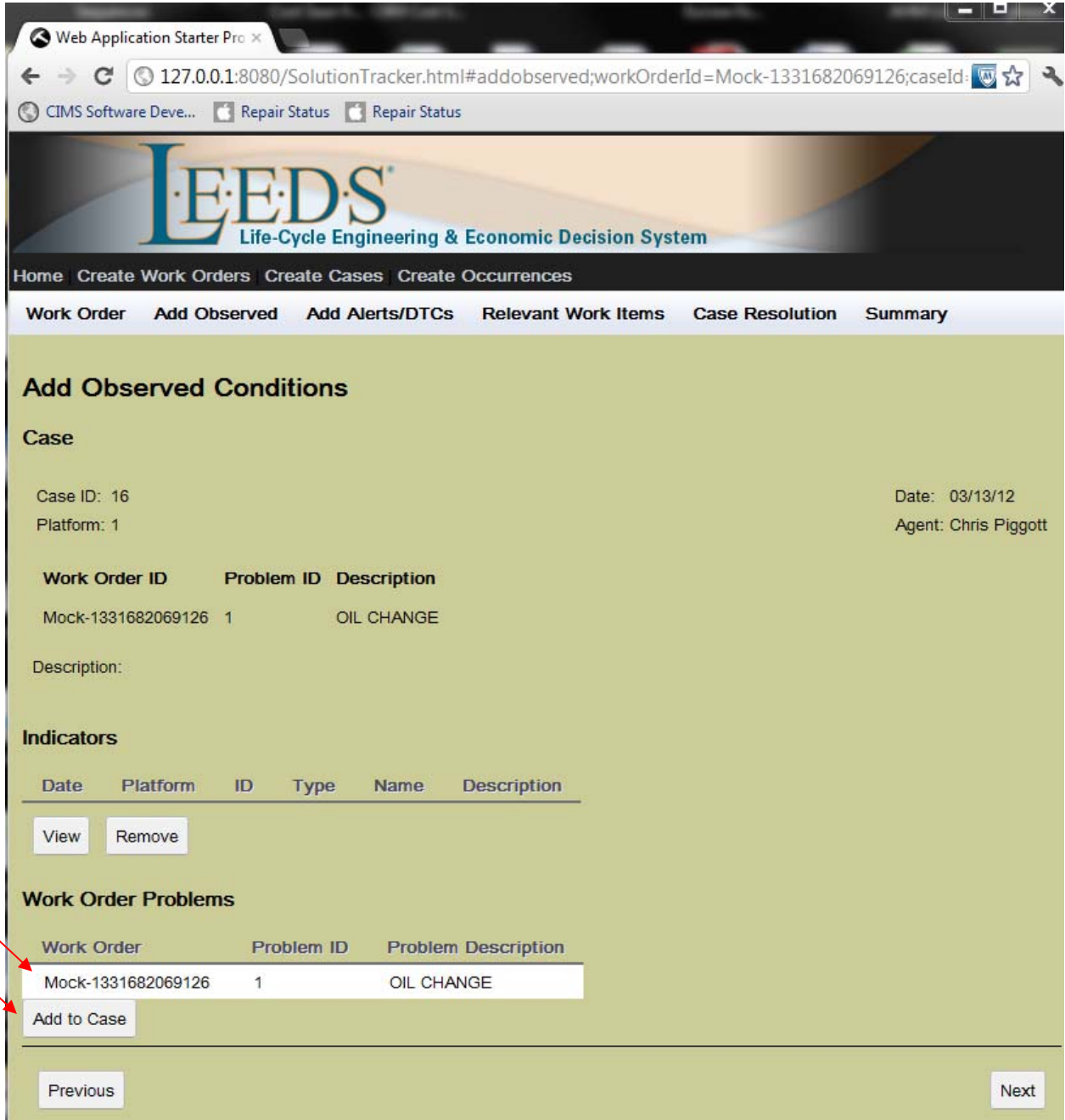
| Sequence | Type | Description | Duration (min) |
|----------|------|-------------|----------------|
|----------|------|-------------|----------------|

Failure Mode:

Resolution: InProgress

Previous Next

- On the Add Observed Indicator screen, select a problem under the Work Order Problems section and click Add to Case to make an indicator for that problem.



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127.0.0.1:8080/SolutionTracker.html#addobserved;workOrderId=Mock-1331682069126;caseId:

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

## Add Observed Conditions

### Case

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

### Indicators

| Date | Platform | ID | Type | Name | Description |
|------|----------|----|------|------|-------------|
|------|----------|----|------|------|-------------|

View Remove

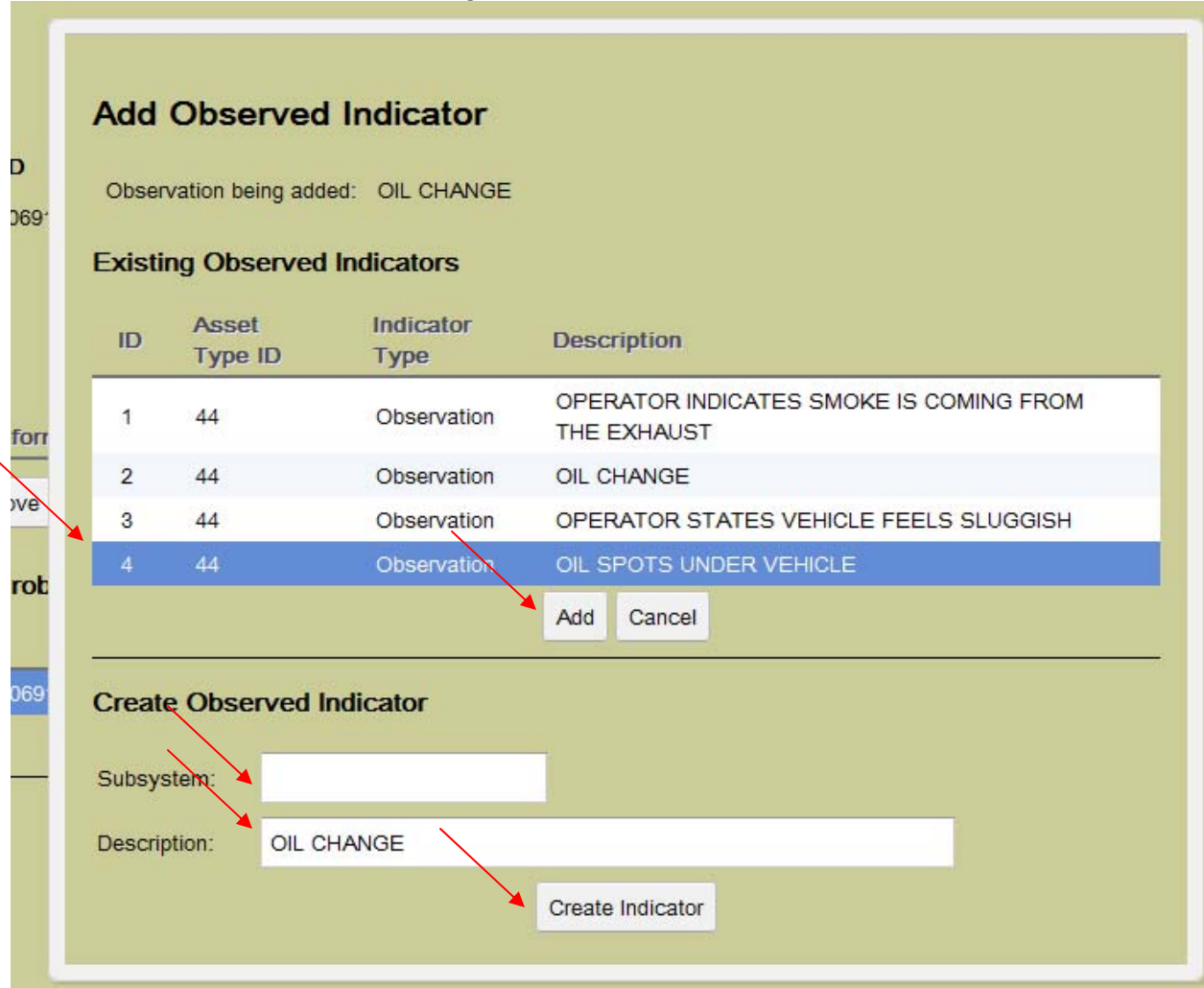
### Work Order Problems

| Work Order         | Problem ID | Problem Description |
|--------------------|------------|---------------------|
| Mock-1331682069126 | 1          | OIL CHANGE          |

Add to Case

Previous Next

- In the pop-up window, the user may choose to add an already existing indicator description from the list at the top by selecting the indicator and clicking Add, or the user may create a new indicator by entering the subsystem and a description for the indicator and clicking Create Indicator.



**Add Observed Indicator**

Observation being added: OIL CHANGE

**Existing Observed Indicators**

| ID | Asset Type ID | Indicator Type | Description                                         |
|----|---------------|----------------|-----------------------------------------------------|
| 1  | 44            | Observation    | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |
| 2  | 44            | Observation    | OIL CHANGE                                          |
| 3  | 44            | Observation    | OPERATOR STATES VEHICLE FEELS SLUGGISH              |
| 4  | 44            | Observation    | OIL SPOTS UNDER VEHICLE                             |

Add Cancel

---

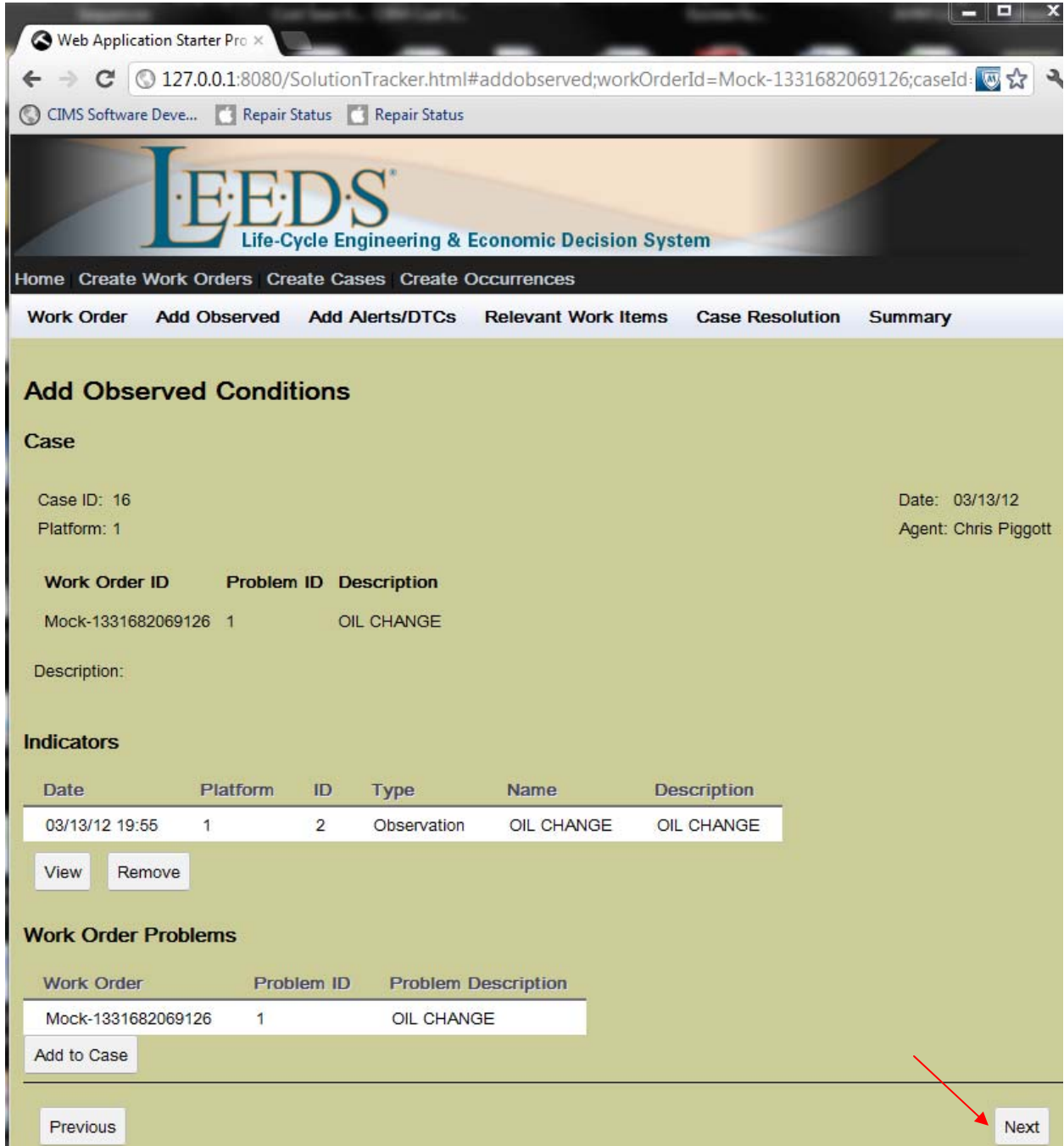
**Create Observed Indicator**

Subsystem:

Description:

Create Indicator

- The above step may be repeated until all observed indicators of the problem have been added. The user will then click the Next button from the Add Observed Conditions screen.



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127.0.0.1:8080/SolutionTracker.html#addobserved;workOrderId=Mock-1331682069126;caseId=16

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

## Add Observed Conditions

### Case

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

### Indicators

| Date           | Platform | ID | Type        | Name       | Description |
|----------------|----------|----|-------------|------------|-------------|
| 03/13/12 19:55 | 1        | 2  | Observation | OIL CHANGE | OIL CHANGE  |

View Remove

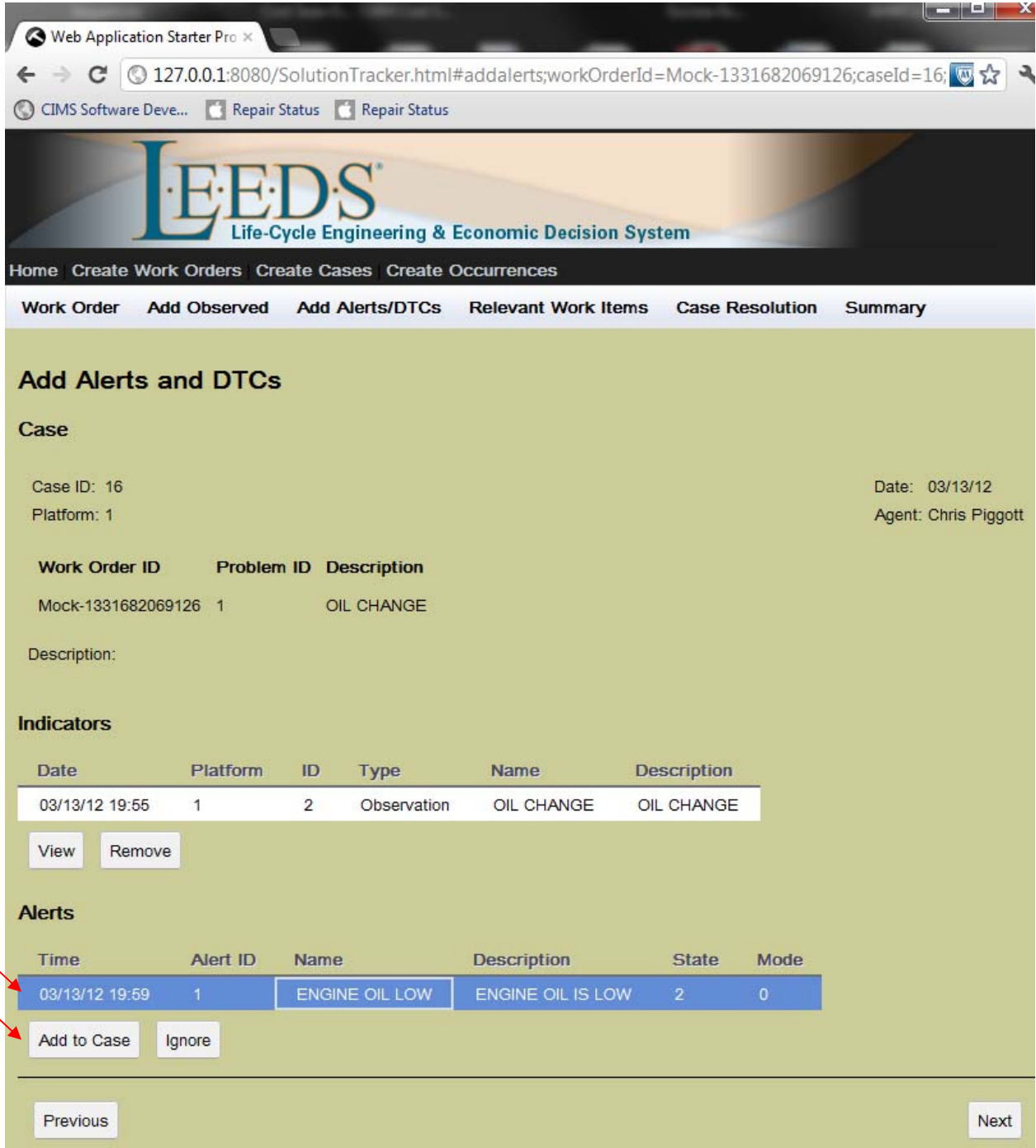
### Work Order Problems

| Work Order         | Problem ID | Problem Description |
|--------------------|------------|---------------------|
| Mock-1331682069126 | 1          | OIL CHANGE          |

Add to Case

Previous Next

- If the system is linked to a Health Monitoring application, Alerts and DTCs from that system will show up on the next screen. To add one to the case, simply select the alert and click the Add to Case Button.



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#addalerts;workOrderId=Mock-1331682069126;caseId=16

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

## Add Alerts and DTCs

**Case**

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

**Indicators**

| Date           | Platform | ID | Type        | Name       | Description |
|----------------|----------|----|-------------|------------|-------------|
| 03/13/12 19:55 | 1        | 2  | Observation | OIL CHANGE | OIL CHANGE  |

View Remove

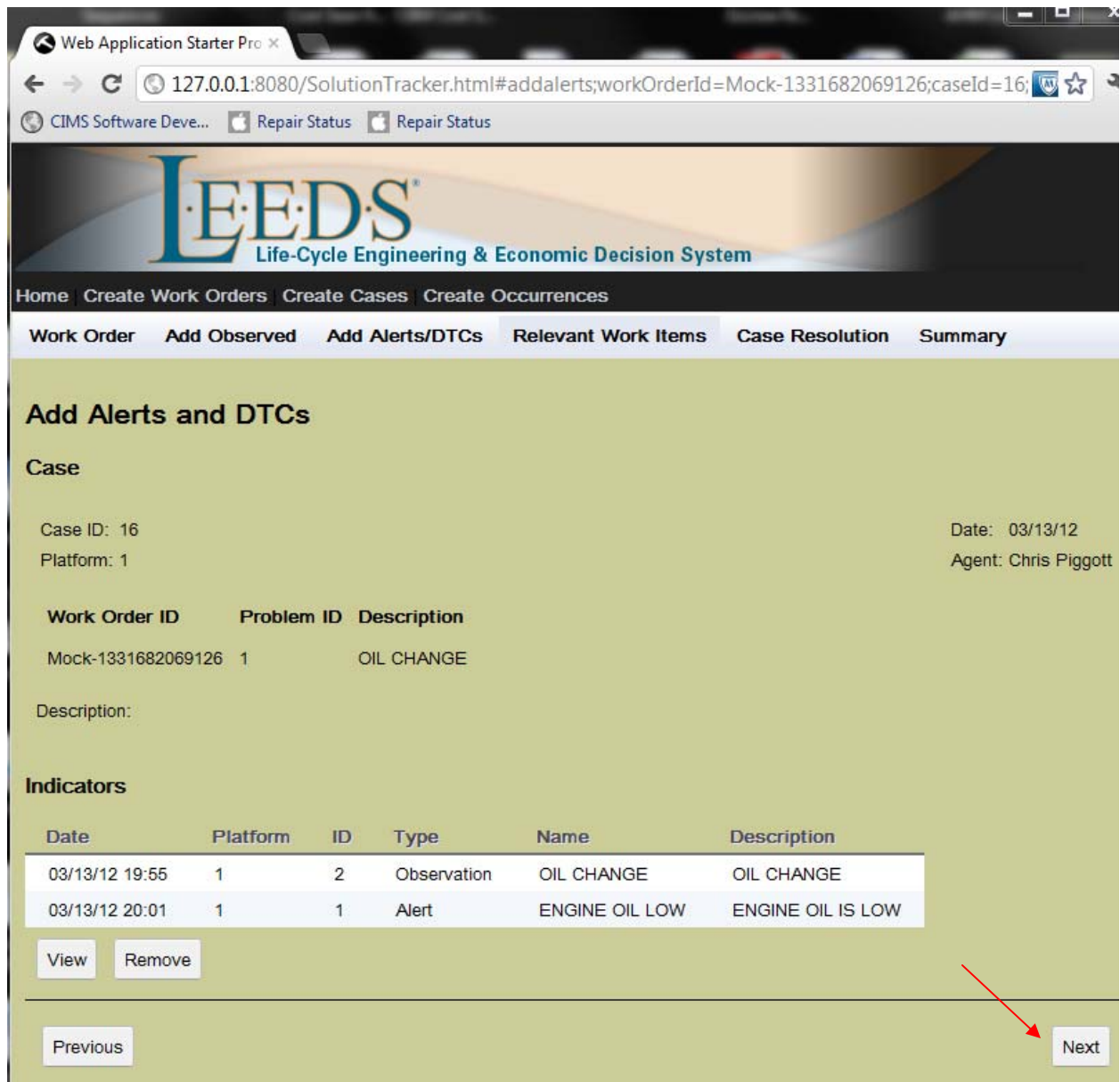
**Alerts**

| Time           | Alert ID | Name           | Description       | State | Mode |
|----------------|----------|----------------|-------------------|-------|------|
| 03/13/12 19:59 | 1        | ENGINE OIL LOW | ENGINE OIL IS LOW | 2     | 0    |

Add to Case Ignore

Previous Next

- Once all alerts that are applicable to the case are added, click the Next button.



Web Application Starter Pro

127.0.0.1:8080/SolutionTracker.html#addalerts;workOrderId=Mock-1331682069126;caseId=16;

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

## Add Alerts and DTCs

### Case

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

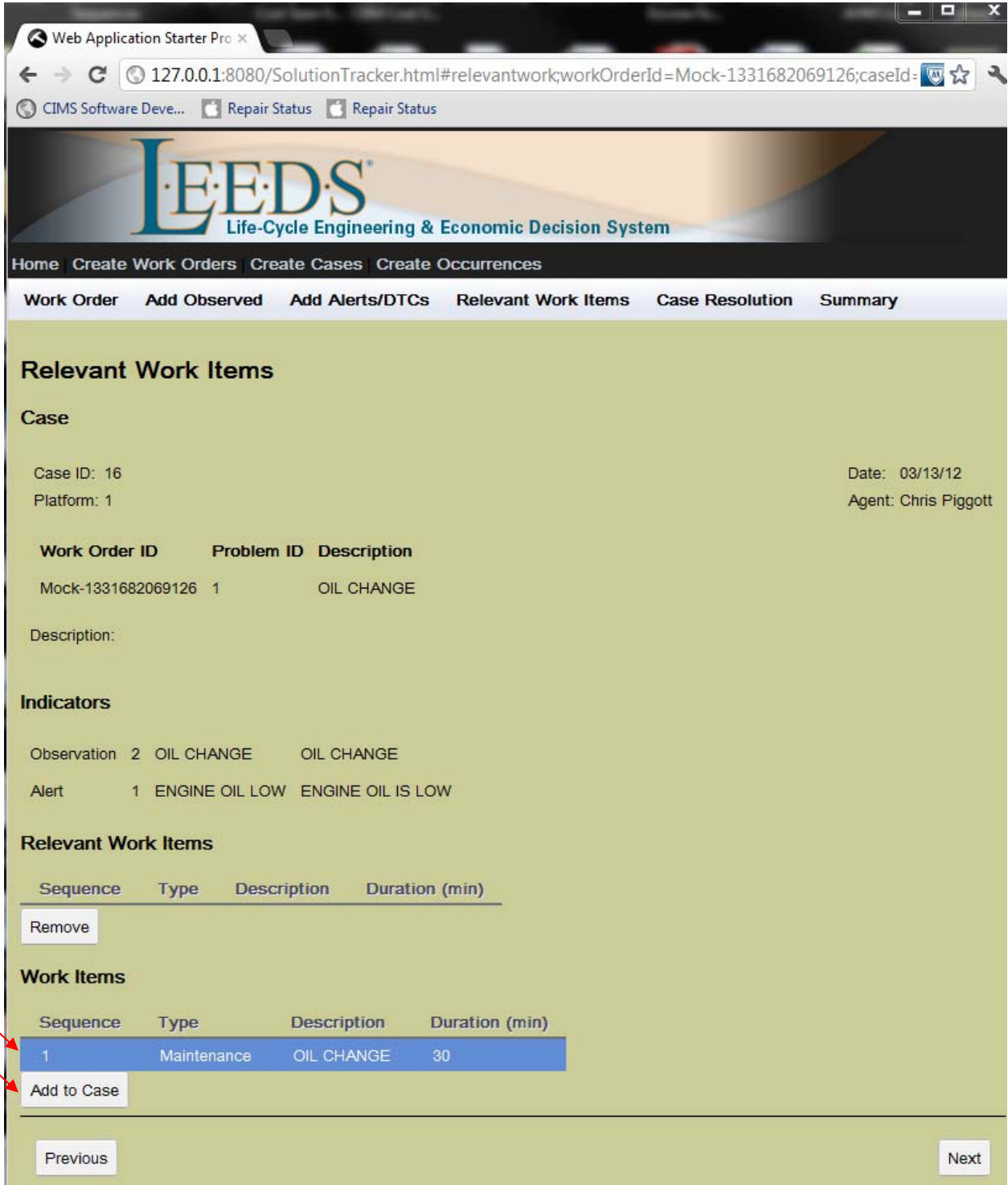
### Indicators

| Date           | Platform | ID | Type        | Name           | Description       |
|----------------|----------|----|-------------|----------------|-------------------|
| 03/13/12 19:55 | 1        | 2  | Observation | OIL CHANGE     | OIL CHANGE        |
| 03/13/12 20:01 | 1        | 1  | Alert       | ENGINE OIL LOW | ENGINE OIL IS LOW |

View Remove

Previous Next

- On the relevant work items screen, select the work items that are applicable to the resolution of the case and click the Add to Case button.



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#relevantwork;workOrderId=Mock-1331682069126;caseId=16

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

### Relevant Work Items

**Case**

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

**Indicators**

|             |   |                |                   |
|-------------|---|----------------|-------------------|
| Observation | 2 | OIL CHANGE     | OIL CHANGE        |
| Alert       | 1 | ENGINE OIL LOW | ENGINE OIL IS LOW |

**Relevant Work Items**

| Sequence | Type        | Description | Duration (min) |
|----------|-------------|-------------|----------------|
| 1        | Maintenance | OIL CHANGE  | 30             |

Add to Case

Previous Next

- Once all relevant work items have been added, click the Next button.

Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#relevantwork;workOrderId=Mock-1331682069126;caseId=

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

## Relevant Work Items

### Case

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

### Indicators

|             |   |                |                   |
|-------------|---|----------------|-------------------|
| Observation | 2 | OIL CHANGE     | OIL CHANGE        |
| Alert       | 1 | ENGINE OIL LOW | ENGINE OIL IS LOW |

### Relevant Work Items

| Sequence | Type        | Description | Duration (min) |
|----------|-------------|-------------|----------------|
| 1        | Maintenance | OIL CHANGE  | 30             |

Remove

### Work Items

| Sequence | Type        | Description | Duration (min) |
|----------|-------------|-------------|----------------|
| 1        | Maintenance | OIL CHANGE  | 30             |

Add to Case

Previous Next

- On the Case Resolution screen, the user will review the data that has been added to the case. Additionally, the user will click the Assign Failure Mode button to reach a dialog for adding the failure mode.

Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#caseresolution;workOrderId=Mock-1331682069126;caseId=...

CIMS Software Deve... Repair Status Repair Status

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

## Case Resolution

### Case

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

### Indicators

| Date           | Platform | ID | Type        | Name           | Description       |
|----------------|----------|----|-------------|----------------|-------------------|
| 03/13/12 19:55 | 1        | 2  | Observation | OIL CHANGE     | OIL CHANGE        |
| 03/13/12 20:01 | 1        | 1  | Alert       | ENGINE OIL LOW | ENGINE OIL IS LOW |

### Relevant Work Items

| Sequence | Type        | Description | Duration (min) |
|----------|-------------|-------------|----------------|
| 1        | Maintenance | OIL CHANGE  | 30             |

### Work Order Notes

Failure Mode: <Not Assigned> [Assign Failure Mode...](#)

Resolution: InProgress

[Previous](#) [Next](#)

- On the pop-up window, the user may select an existing failure mode from the list, or enter a New Failure Mode. Once the mode is selected, the user will click the OK button.

Platform: 1 Agent: Chris Piggott

**Work Order ID**      **Prot**

Mock-1331682069126    1

Description:

**Indicators**

| Date           | Platform |
|----------------|----------|
| 03/13/12 19:55 | 1        |
| 03/13/12 20:01 | 1        |

**Relevant Work Items**

| Sequence | Type        |
|----------|-------------|
| 1        | Maintenance |

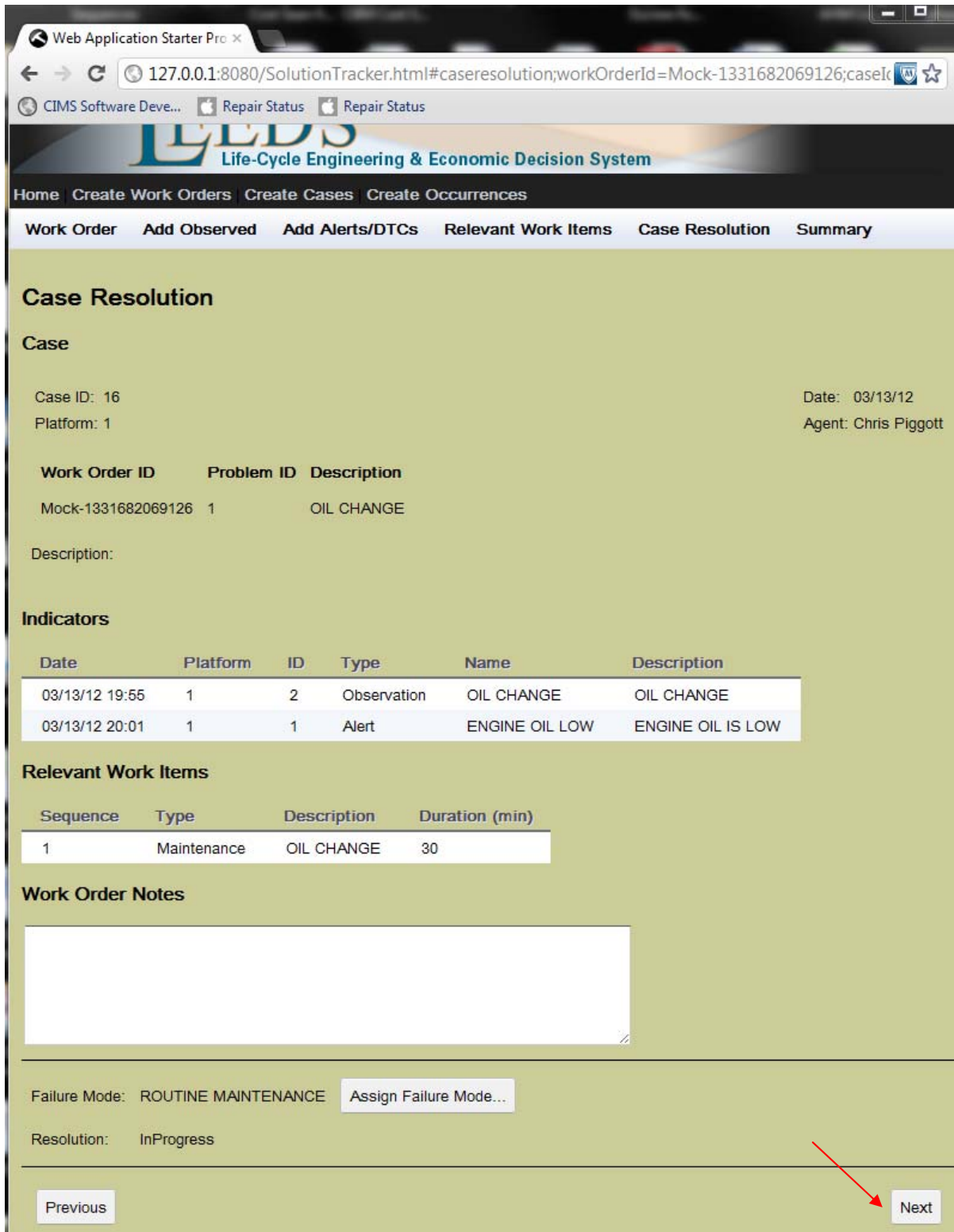
**Work Order Notes**

**Failure Modes**

- BLOWN HEAD GASKET
- FUEL INJECTORS CLOGGED
- OIL LEAK
- ROUTINE MAINTENANCE**

New Failure Mode:

- Once the Failure Mode has been set, the user will click on the Next button.



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#caseresolution;workOrderId=Mock-1331682069126;caseId=Mock-1331682069126

CIMS Software Deve... Repair Status Repair Status

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Relevant Work Items Case Resolution Summary

### Case Resolution

#### Case

Case ID: 16 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

#### Indicators

| Date           | Platform | ID | Type        | Name           | Description       |
|----------------|----------|----|-------------|----------------|-------------------|
| 03/13/12 19:55 | 1        | 2  | Observation | OIL CHANGE     | OIL CHANGE        |
| 03/13/12 20:01 | 1        | 1  | Alert       | ENGINE OIL LOW | ENGINE OIL IS LOW |

#### Relevant Work Items

| Sequence | Type        | Description | Duration (min) |
|----------|-------------|-------------|----------------|
| 1        | Maintenance | OIL CHANGE  | 30             |

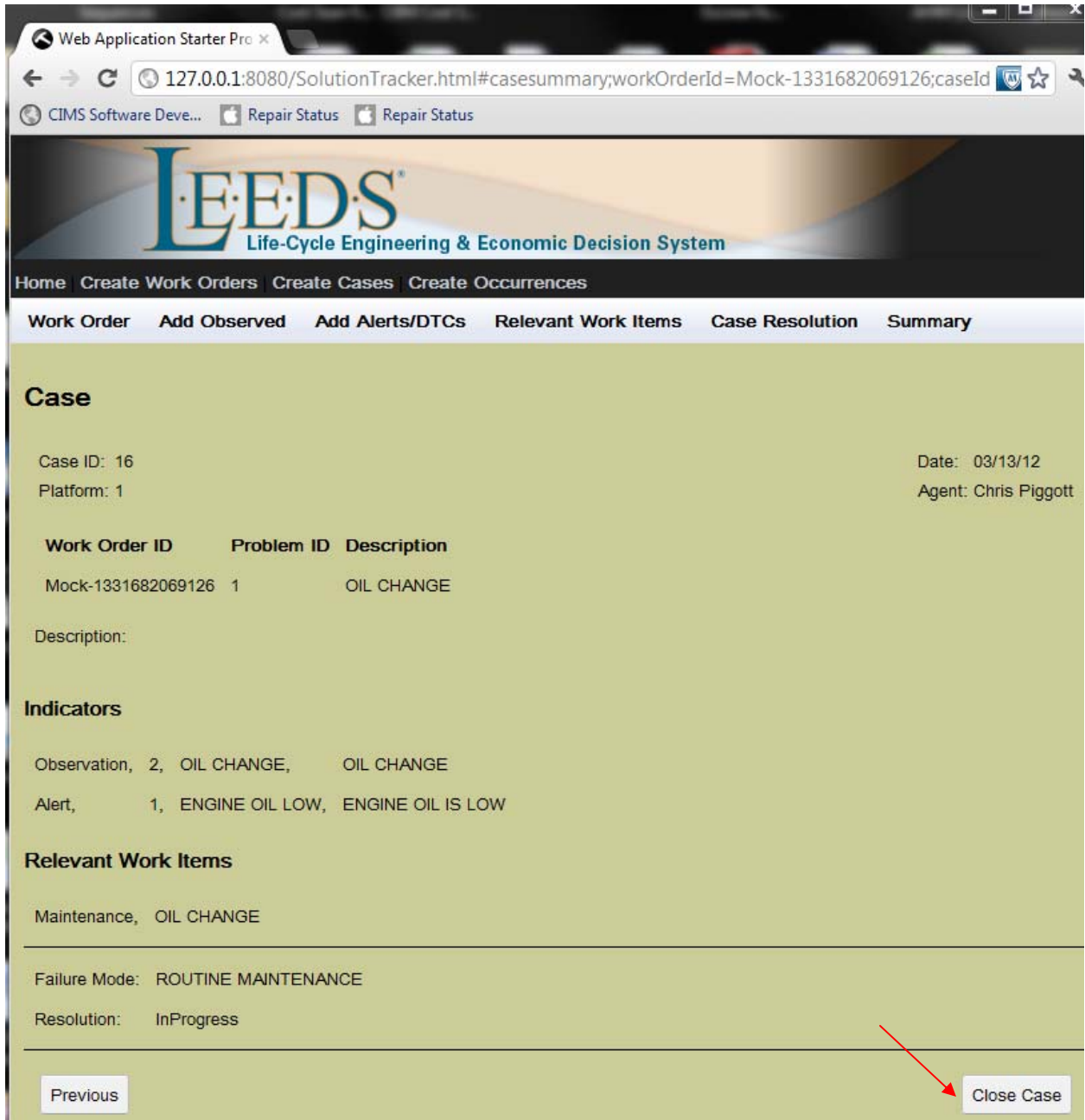
#### Work Order Notes

Failure Mode: ROUTINE MAINTENANCE Assign Failure Mode...

Resolution: InProgress

Previous Next

- On the next screen, the user will see all applicable data for the case. Clicking Close Case will finalize the case and add it to the knowledgebase.



The screenshot shows a web browser window with the URL `127.0.0.1:8080/SolutionTracker.html#casesummary;workOrderId=Mock-1331682069126;caseId`. The application header features the **LEEDS** logo and the text "Life-Cycle Engineering & Economic Decision System". A navigation bar includes links: Home, Create Work Orders, Create Cases, Create Occurrences, Work Order, Add Observed, Add Alerts/DTCs, Relevant Work Items, Case Resolution, and Summary. The main content area is titled "Case" and displays the following information:

Case ID: 16  
Platform: 1  
Date: 03/13/12  
Agent: Chris Piggott

| Work Order ID      | Problem ID | Description |
|--------------------|------------|-------------|
| Mock-1331682069126 | 1          | OIL CHANGE  |

Description:

**Indicators**

Observation, 2, OIL CHANGE, OIL CHANGE  
Alert, 1, ENGINE OIL LOW, ENGINE OIL IS LOW

**Relevant Work Items**

Maintenance, OIL CHANGE

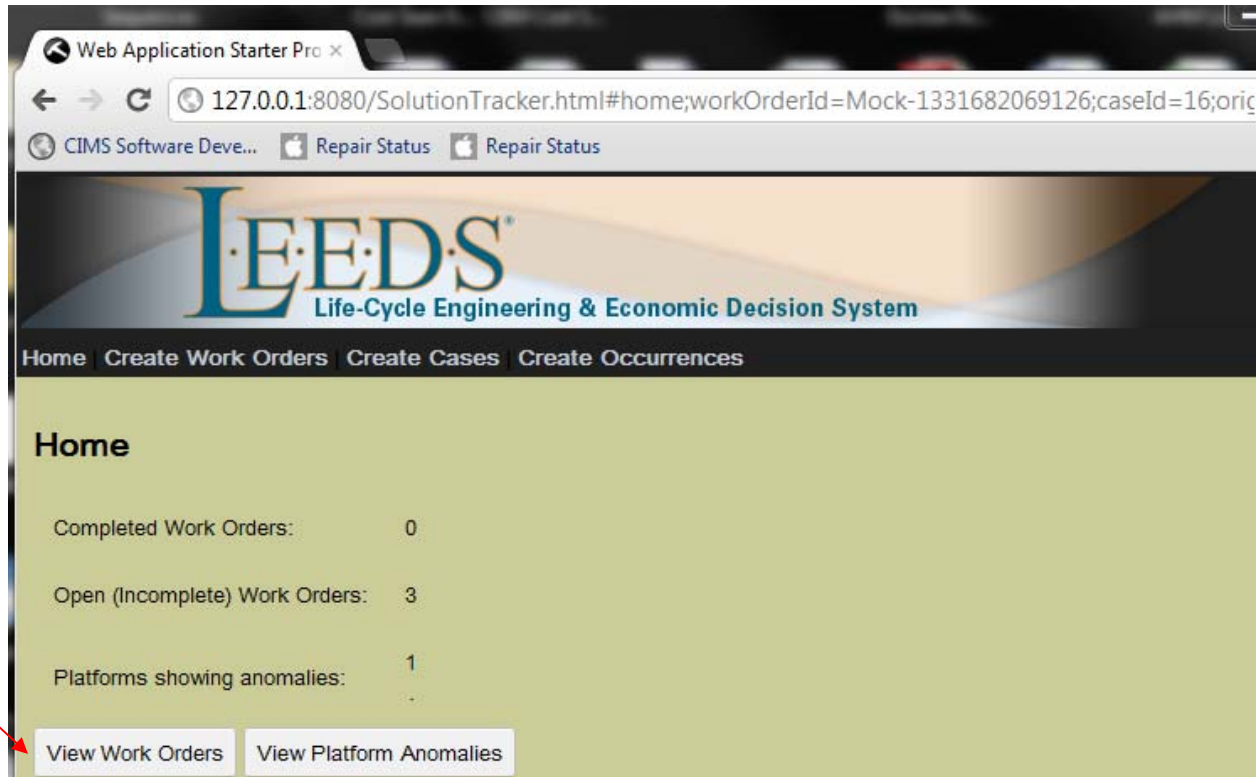
Failure Mode: ROUTINE MAINTENANCE  
Resolution: InProgress

At the bottom, there are two buttons: "Previous" and "Close Case". A red arrow points to the "Close Case" button.

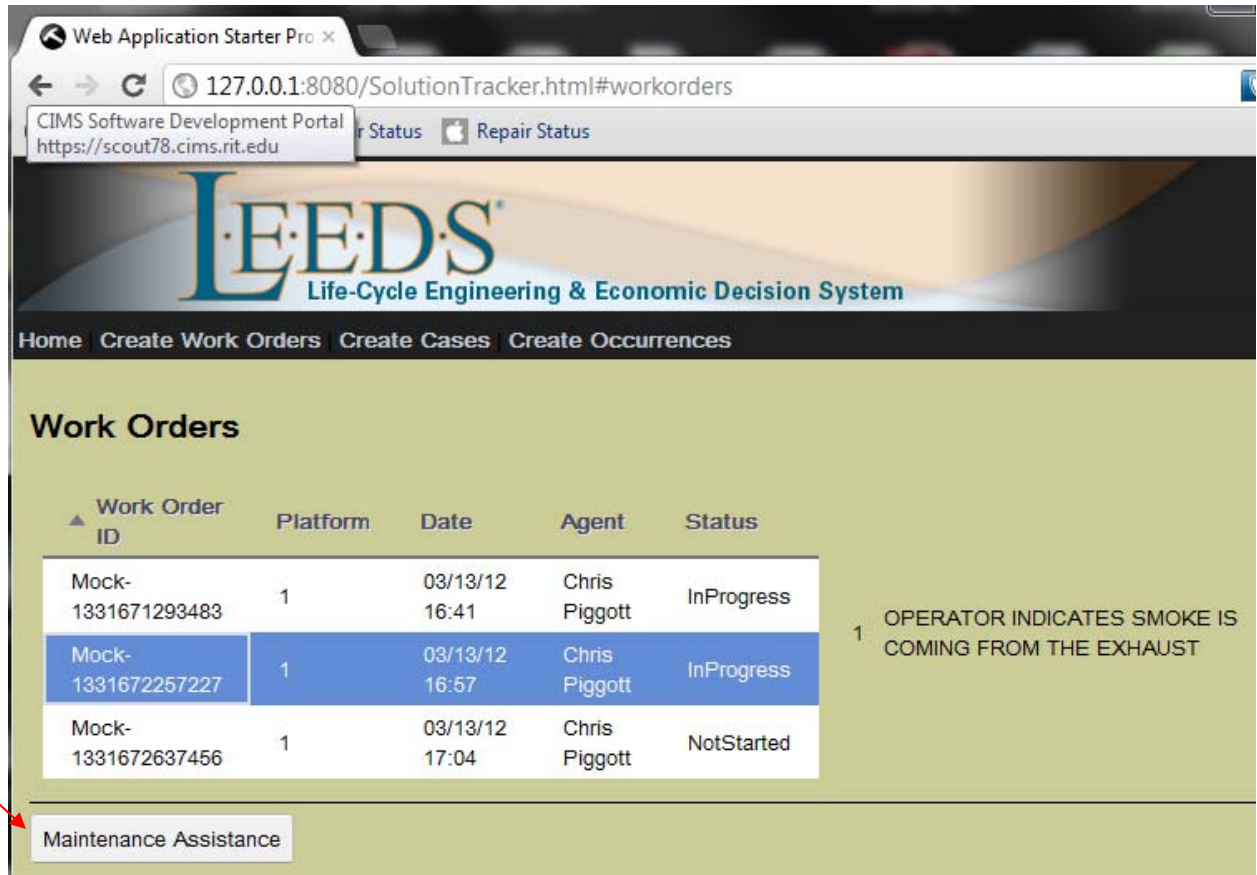
- Upon click Close Case, the user will be returned to the Home screen.

*Providing a Maintenance Suggestion for a Work Order:*

- From the Home Screen, click the View Work Orders button to see all completed or incomplete work orders.



- Select the work order I need of suggestions (must not be complete) and click the Maintenance Assistance Button.



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127.0.0.1:8080/SolutionTracker.html#workorders

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https://scout78.cims.rit.edu

Repair Status

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Home | Create Work Orders | Create Cases | Create Occurrences

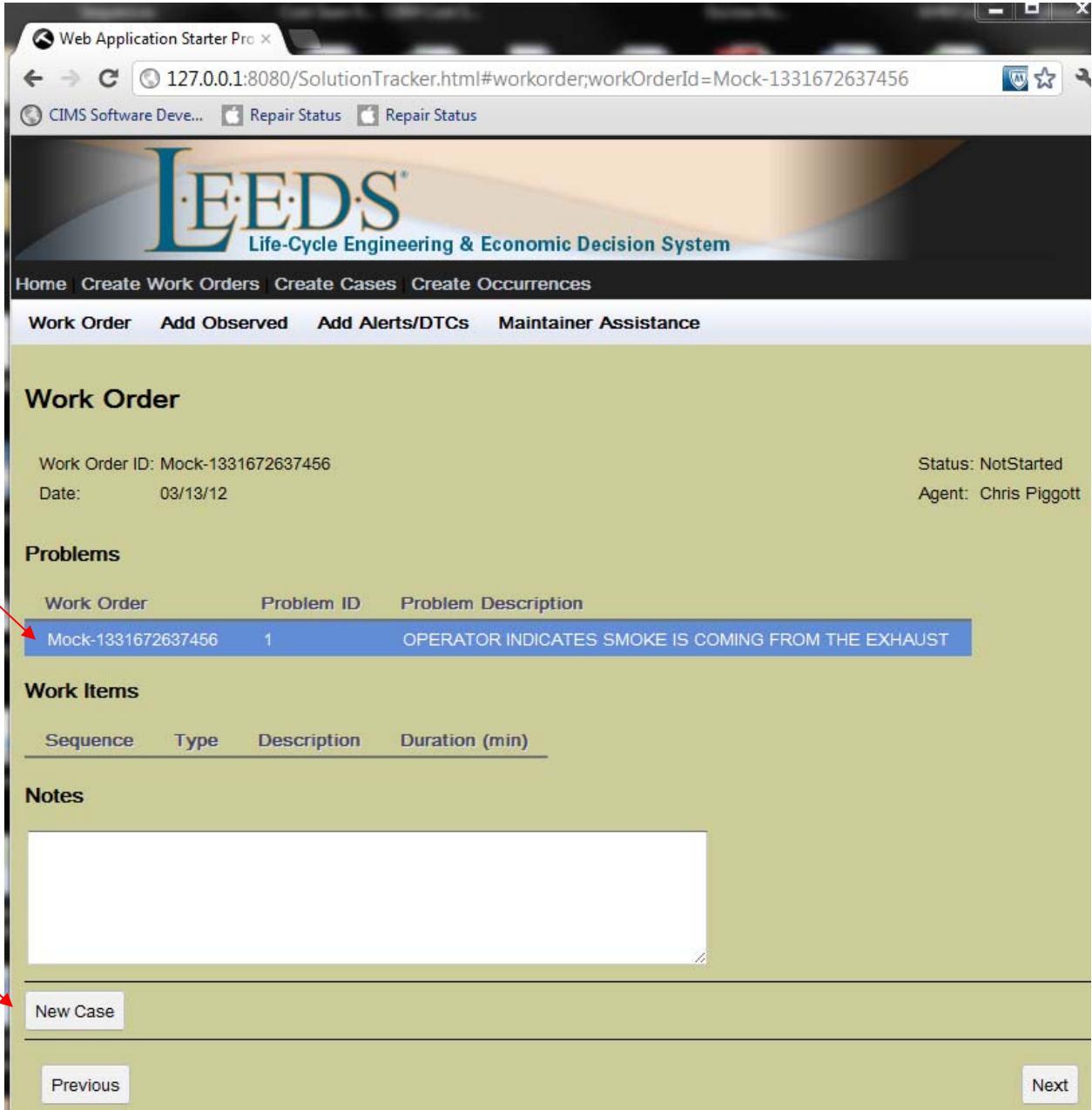
### Work Orders

| Work Order ID      | Platform | Date           | Agent         | Status     |
|--------------------|----------|----------------|---------------|------------|
| Mock-1331671293483 | 1        | 03/13/12 16:41 | Chris Piggott | InProgress |
| Mock-1331672257227 | 1        | 03/13/12 16:57 | Chris Piggott | InProgress |
| Mock-1331672637456 | 1        | 03/13/12 17:04 | Chris Piggott | NotStarted |

1 OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST

Maintenance Assistance

- On the Work Order screen, select the problem from the work order and click the New Case button.



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#workorder;workOrderId=Mock-1331672637456

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Maintainer Assistance

## Work Order

Work Order ID: Mock-1331672637456 Status: NotStarted  
Date: 03/13/12 Agent: Chris Piggott

### Problems

| Work Order         | Problem ID | Problem Description                                 |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672637456 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

### Work Items

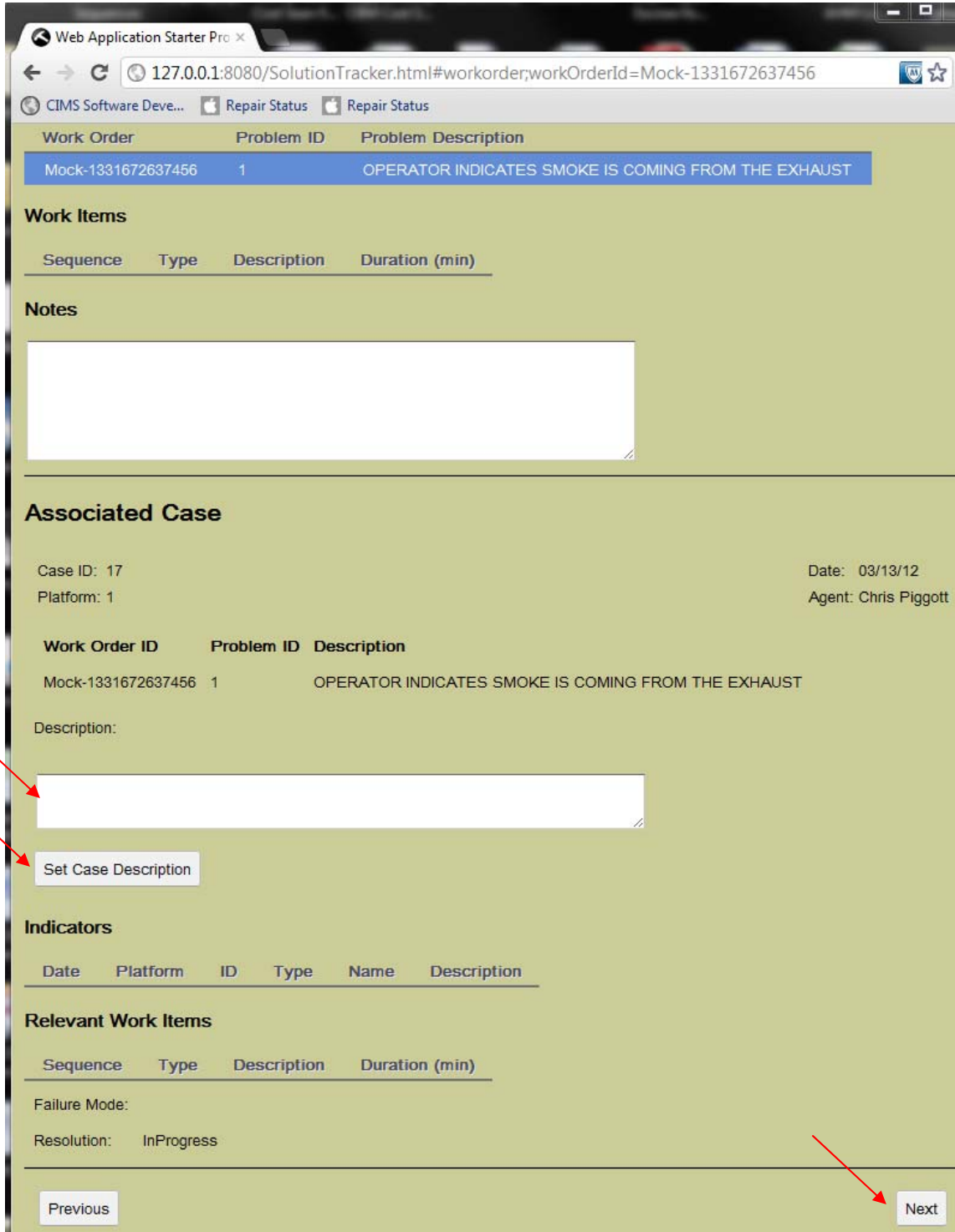
| Sequence | Type | Description | Duration (min) |
|----------|------|-------------|----------------|
|----------|------|-------------|----------------|

### Notes

New Case

Previous Next

- Under Associated Case, you may add a description for the case. Otherwise, the description will be the description of the problem. Click the Next button.



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#workorder;workOrderId=Mock-1331672637456

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| Work Order         | Problem ID | Problem Description                                 |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672637456 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

**Work Items**

| Sequence | Type | Description | Duration (min) |
|----------|------|-------------|----------------|
|----------|------|-------------|----------------|

**Notes**

**Associated Case**

Case ID: 17 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description                                         |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672637456 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

Description:

Set Case Description

**Indicators**

| Date | Platform | ID | Type | Name | Description |
|------|----------|----|------|------|-------------|
|------|----------|----|------|------|-------------|

**Relevant Work Items**

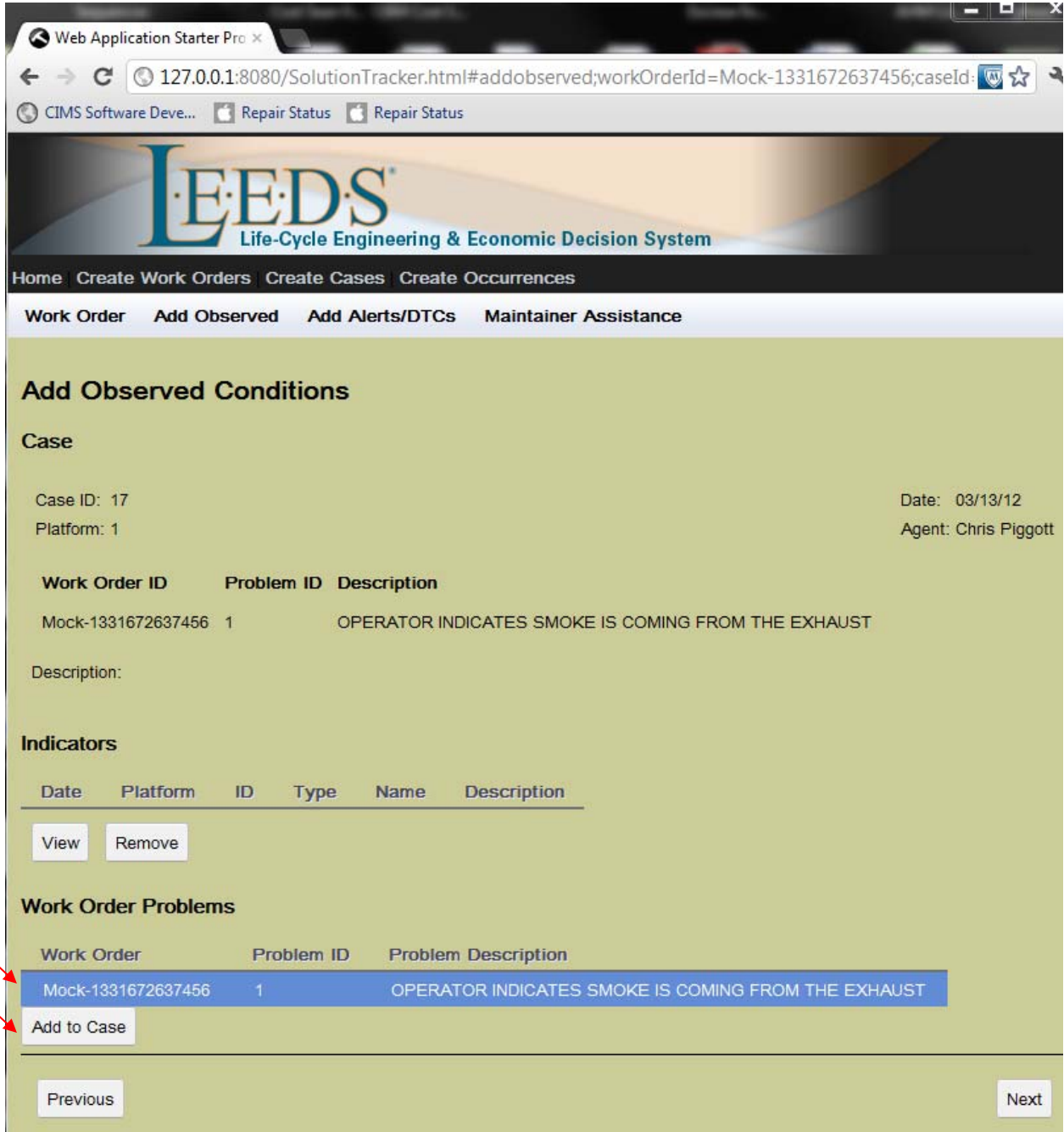
| Sequence | Type | Description | Duration (min) |
|----------|------|-------------|----------------|
|----------|------|-------------|----------------|

Failure Mode:

Resolution: InProgress

Previous Next

- On the Add Observed Indicator screen, select a problem under the Work Order Problems section and click Add to Case to make an indicator for that problem.



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#addobserved;workOrderId=Mock-1331672637456;caseId:

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Maintainer Assistance

## Add Observed Conditions

### Case

Case ID: 17 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description                                         |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672637456 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

Description:

### Indicators

| Date | Platform | ID | Type | Name | Description |
|------|----------|----|------|------|-------------|
|------|----------|----|------|------|-------------|

View Remove

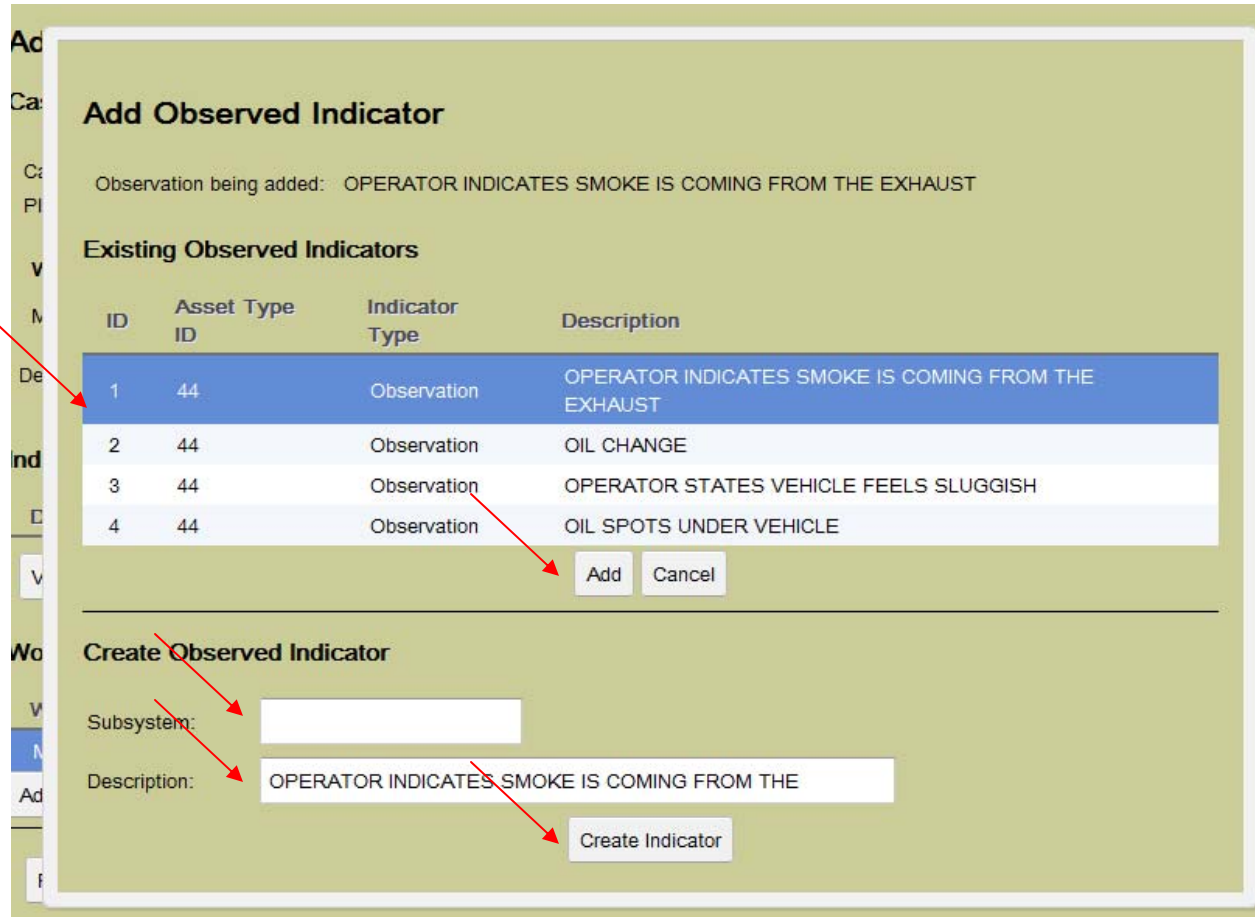
### Work Order Problems

| Work Order         | Problem ID | Problem Description                                 |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672637456 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

Add to Case

Previous Next

- In the pop-up window, the user may choose to add an already existing indicator description from the list at the top by selecting the indicator and clicking Add, or the user may create a new indicator by entering the subsystem and a description for the indicator and clicking Create Indicator.



**Add Observed Indicator**

Observation being added: OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST

**Existing Observed Indicators**

| ID | Asset ID | Type        | Description                                         |
|----|----------|-------------|-----------------------------------------------------|
| 1  | 44       | Observation | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |
| 2  | 44       | Observation | OIL CHANGE                                          |
| 3  | 44       | Observation | OPERATOR STATES VEHICLE FEELS SLUGGISH              |
| 4  | 44       | Observation | OIL SPOTS UNDER VEHICLE                             |

Add Cancel

---

**Create Observed Indicator**

Subsystem:

Description:

Create Indicator

- The above step may be repeated until all observed indicators of the problem have been added. The user will then click the Next button from the Add Observed Conditions screen.

Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#addobserved;workOrderId=Mock-1331672637456;caseId: CIMS Software Deve... Repair Status Repair Status

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Maintainer Assistance

### Add Observed Conditions

**Case**

Case ID: 17 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description                                         |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672637456 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

Description:

**Indicators**

| Date              | Platform | ID | Type        | Name                                                | Description                                         |
|-------------------|----------|----|-------------|-----------------------------------------------------|-----------------------------------------------------|
| 03/13/12<br>20:51 | 1        | 1  | Observation | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

View Remove

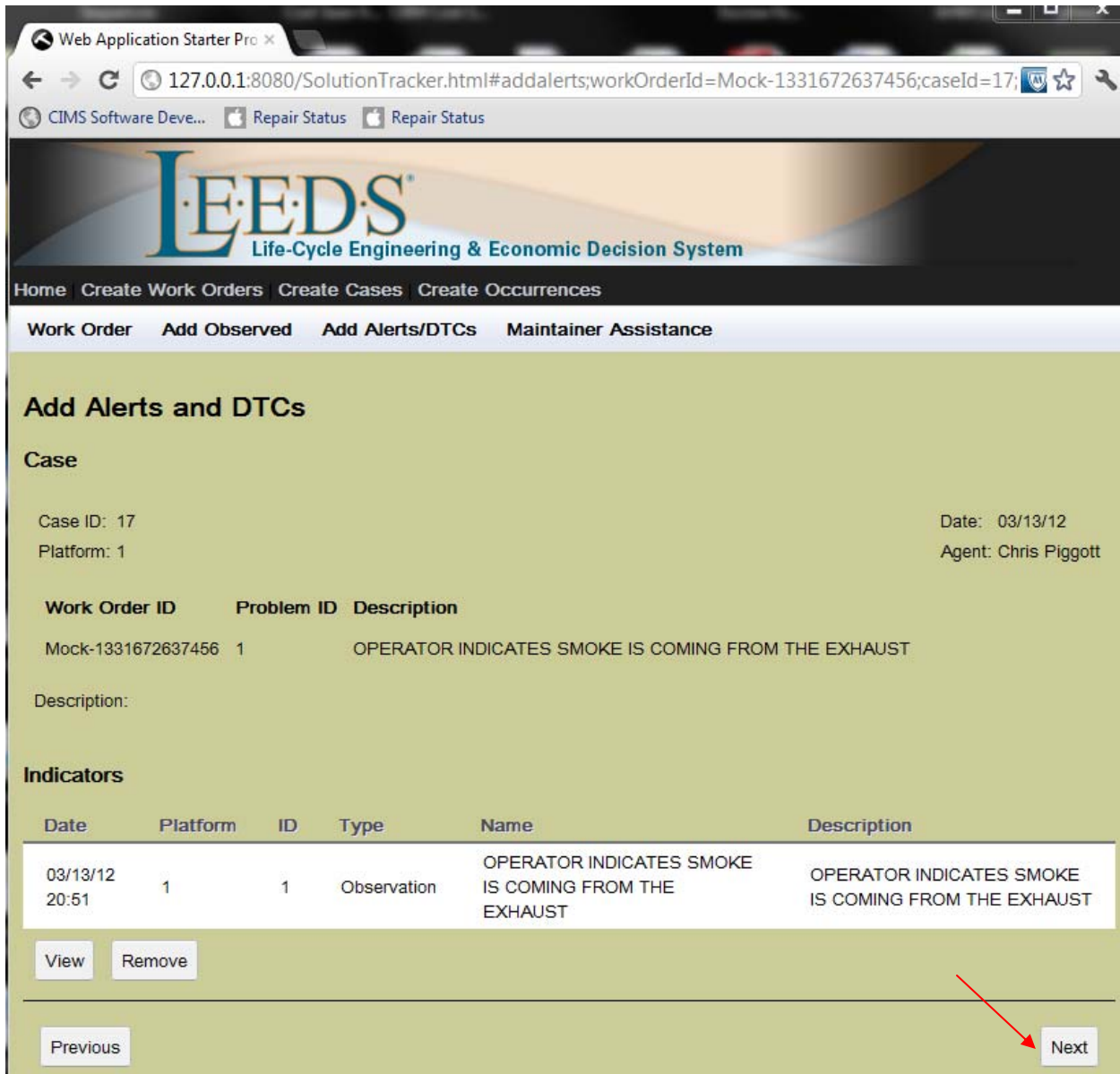
**Work Order Problems**

| Work Order         | Problem ID | Problem Description                                 |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672637456 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

Add to Case

Previous Next

- If the system is linked to a Health Monitoring application, Alerts and DTCs from that system will show up on the next screen. For this scenario, no alerts will be added, so the user will click the Next button. *Note: However, adding an alert is done in the same way was shown in the previous example for entering closed work orders.*



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#addalerts;workOrderId=Mock-1331672637456;caseId=17;

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Maintainer Assistance

## Add Alerts and DTCs

### Case

Case ID: 17 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description                                         |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672637456 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

Description:

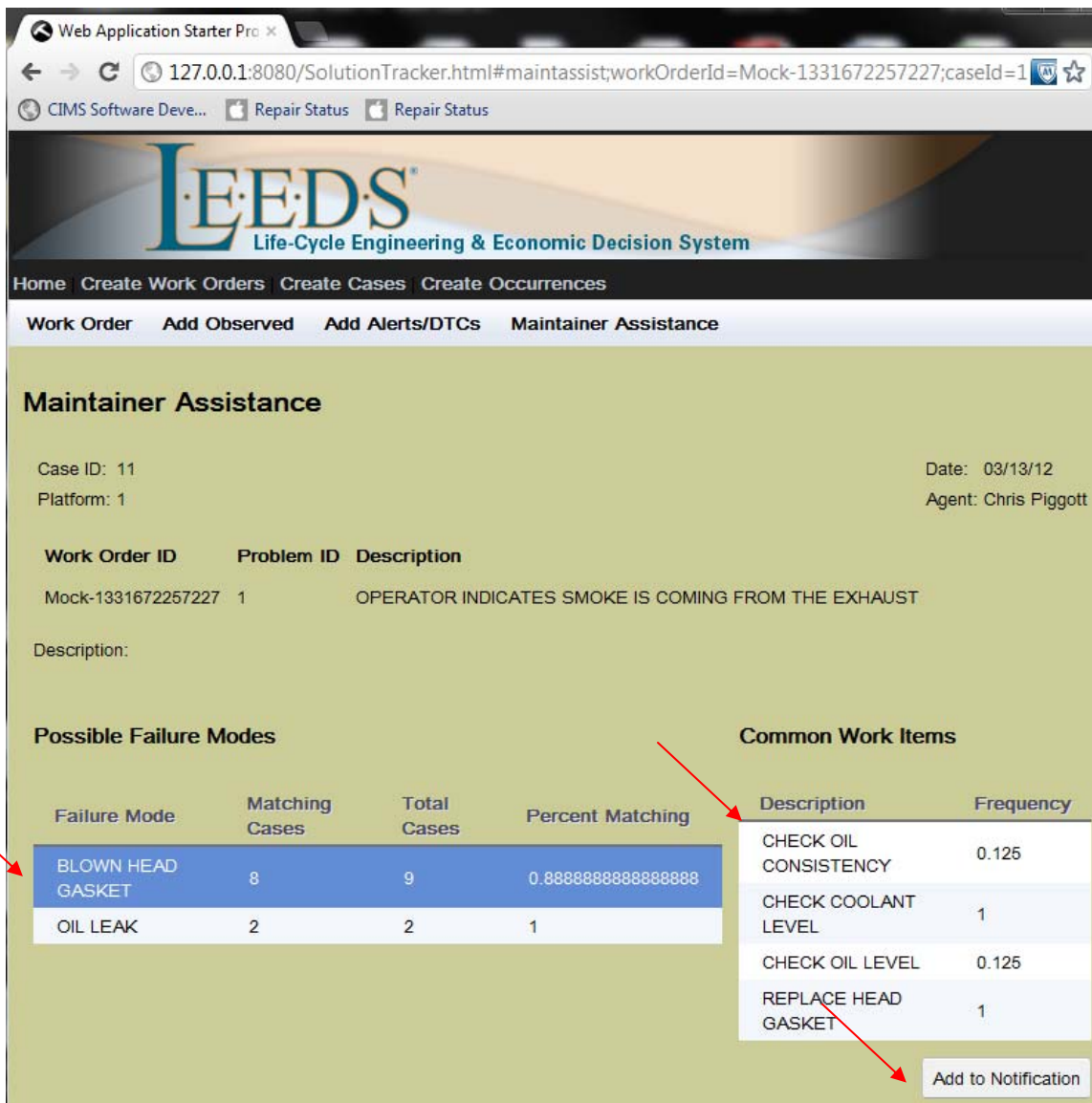
### Indicators

| Date           | Platform | ID | Type        | Name                                                | Description                                         |
|----------------|----------|----|-------------|-----------------------------------------------------|-----------------------------------------------------|
| 03/13/12 20:51 | 1        | 1  | Observation | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

View Remove

Previous Next

- The user is now taken to the Maintainer Assistance screen. This screen will show the user the possible failure modes for the problem, including the number of cases for each failure mode that match the problem in question. For the purposes of this system, a case matches if at least 50% of the indicators for the cases match. For example, when looking at Blown Head Gasket as a Failure mode for the problem, there are 9 cases in the system with Blown Head Gasket as the Failure Mode, however, only 8 cases have at least a 50% match on the indicators for this problem. That would indicate that 8 cases have this indicator and maybe 1 additional indicator. A case that has this indicator but 2 additional indicators would be thrown out. If the user selects a Failure Mode, the Common work Items for that failure mode will appear, along with a frequency of occurrence for that failure mode. The user can select the Work items that should be suggested and click the Add to Notification button.



Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#maintassist;workOrderId=Mock-1331672257227;caseId=1

CIMS Software Deve... Repair Status Repair Status

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Home Create Work Orders Create Cases Create Occurrences

Work Order Add Observed Add Alerts/DTCs Maintainer Assistance

### Maintainer Assistance

Case ID: 11 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description                                         |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672257227 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

Description:

#### Possible Failure Modes

| Failure Mode      | Matching Cases | Total Cases | Percent Matching   |
|-------------------|----------------|-------------|--------------------|
| BLOWN HEAD GASKET | 8              | 9           | 0.8888888888888888 |
| OIL LEAK          | 2              | 2           | 1                  |

#### Common Work Items

| Description           | Frequency |
|-----------------------|-----------|
| CHECK OIL CONSISTENCY | 0.125     |
| CHECK COOLANT LEVEL   | 1         |
| CHECK OIL LEVEL       | 0.125     |
| REPLACE HEAD GASKET   | 1         |

Add to Notification

- If no work items seem applicable or additional work items that are not listed are deemed applicable by the SME, the SME may add them by clicking the New Work Item button.



REPLACE HEAD GASKET 1

Add to Notification

### Notification

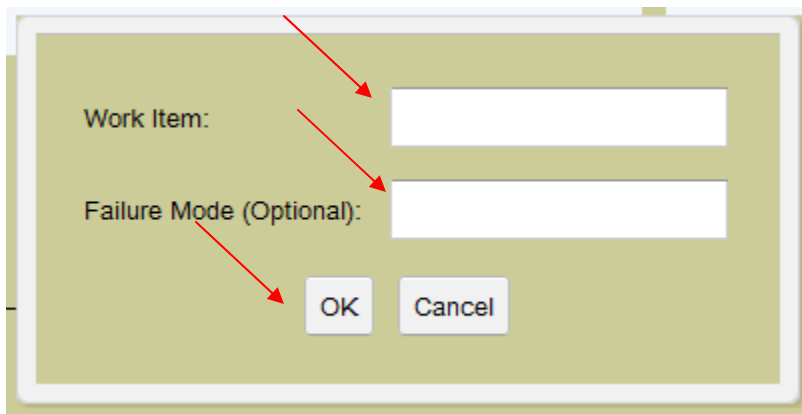
| Work Item           | Failure Mode      |
|---------------------|-------------------|
| CHECK COOLANT LEVEL | BLOWN HEAD GASKET |
| REPLACE HEAD GASKET | BLOWN HEAD GASKET |

New Work Item Remove

### Notes

Previous Notify Maintainer

- The new work item may be added to the pop-up and the user may click OK. In the case that no failure mode was found on the previous screen, the user may optionally suggest the failure mode that the work item would be associated with.



Work Item:

Failure Mode (Optional):

OK Cancel

- Once all relevant work items have been added to the notification, the user can click on Notify Maintainer.

Web Application Starter Pro x

127.0.0.1:8080/SolutionTracker.html#maintassist;workOrderId=Mock-1331672257227;caseId=1

CIMS Software Deve... Repair Status Repair Status

### Maintainer Assistance

Case ID: 11 Date: 03/13/12  
Platform: 1 Agent: Chris Piggott

| Work Order ID      | Problem ID | Description                                         |
|--------------------|------------|-----------------------------------------------------|
| Mock-1331672257227 | 1          | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |

Description:

#### Possible Failure Modes

| Failure Mode      | Matching Cases | Total Cases | Percent Matching   |
|-------------------|----------------|-------------|--------------------|
| BLOWN HEAD GASKET | 8              | 9           | 0.8888888888888888 |
| OIL LEAK          | 2              | 2           | 1                  |

#### Common Work Items

| Description           | Frequency |
|-----------------------|-----------|
| CHECK OIL CONSISTENCY | 0.125     |
| CHECK COOLANT LEVEL   | 1         |
| CHECK OIL LEVEL       | 0.125     |
| REPLACE HEAD GASKET   | 1         |

Add to Notification

### Notification

| Work Item           | Failure Mode      |
|---------------------|-------------------|
| CHECK COOLANT LEVEL | BLOWN HEAD GASKET |
| REPLACE HEAD GASKET | BLOWN HEAD GASKET |

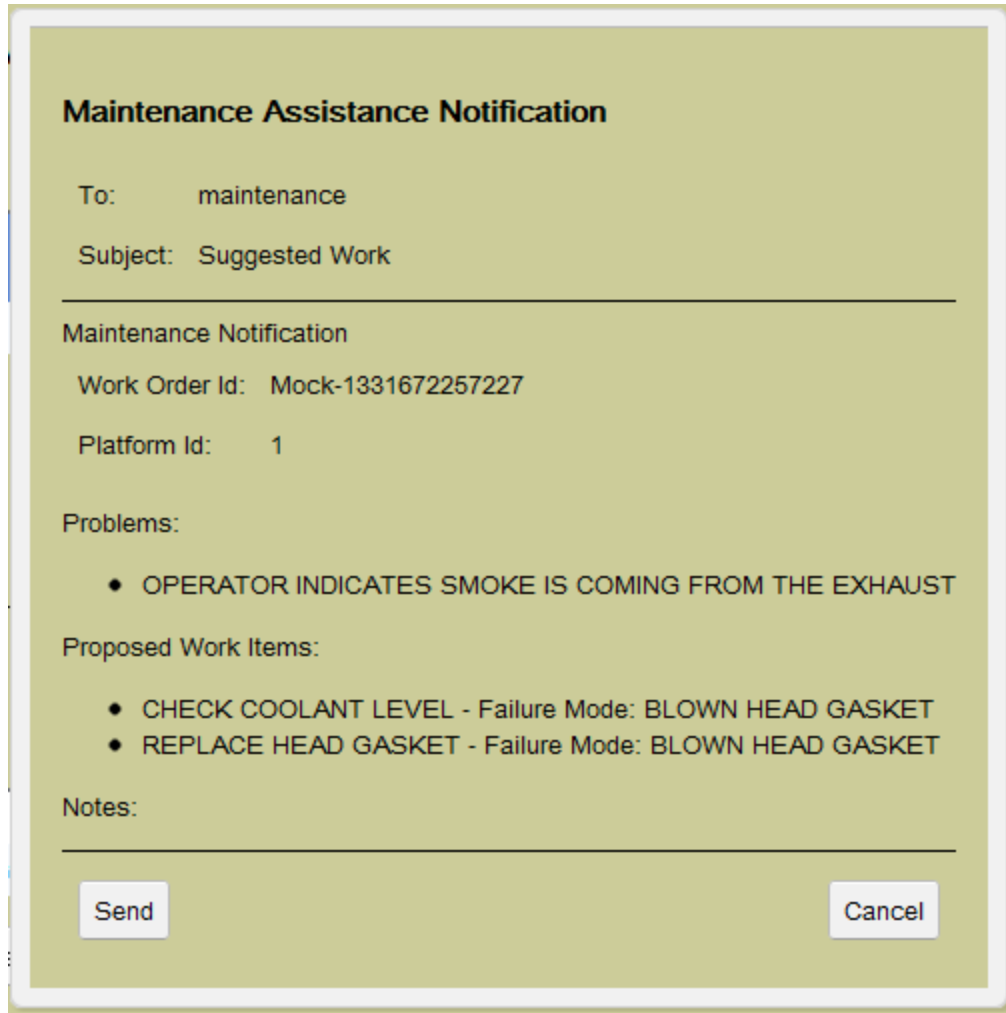
New Work Item Remove

### Notes

Previous

Notify Maintainer

- This will pop-up a summary of the maintenance assistance information to be sent. For this demo system, clicking Send will not do anything, but in a real system, this would likely send an email to a maintainer. As a longer term goal, the user would create a work order in the CMMS and propose the work for the work order directly.



**Maintenance Assistance Notification**

To: maintenance

Subject: Suggested Work

---

Maintenance Notification

Work Order Id: Mock-1331672257227

Platform Id: 1

Problems:

- OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST

Proposed Work Items:

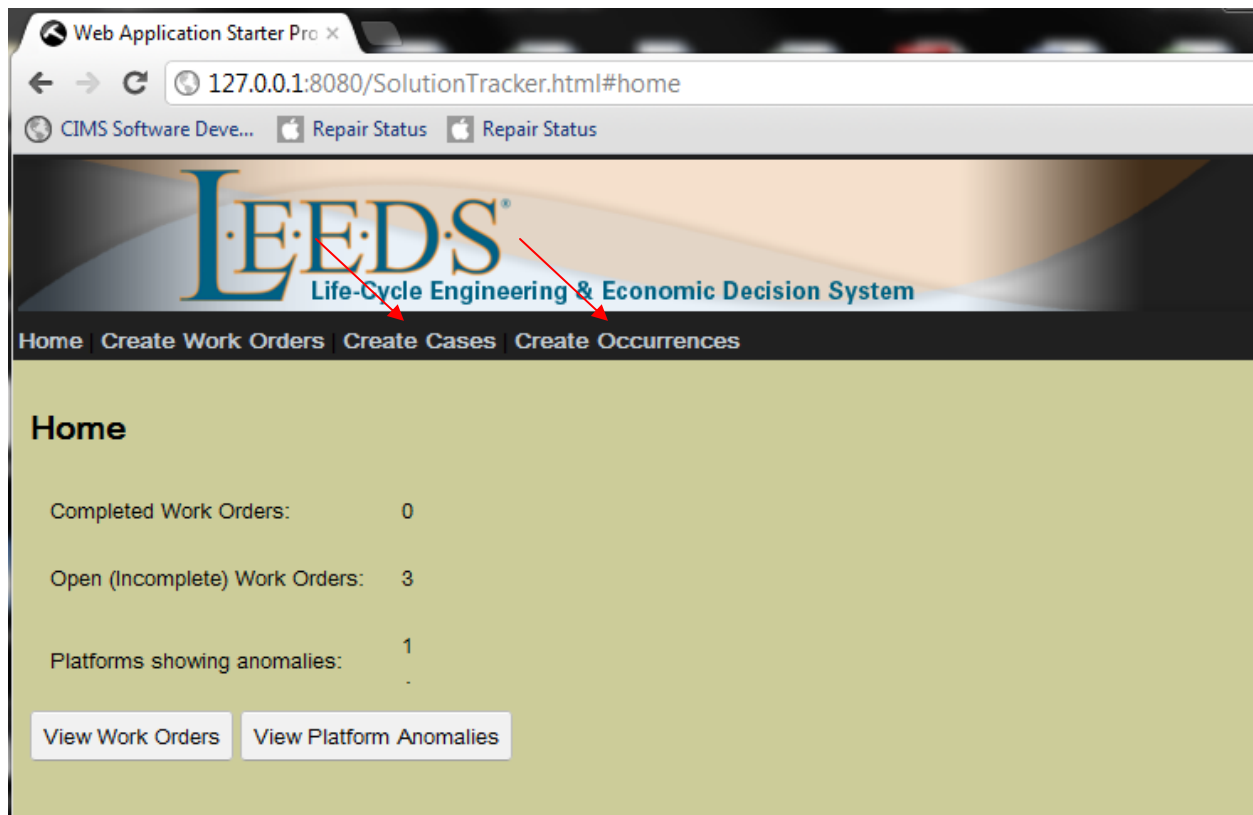
- CHECK COOLANT LEVEL - Failure Mode: BLOWN HEAD GASKET
- REPLACE HEAD GASKET - Failure Mode: BLOWN HEAD GASKET

Notes:

---

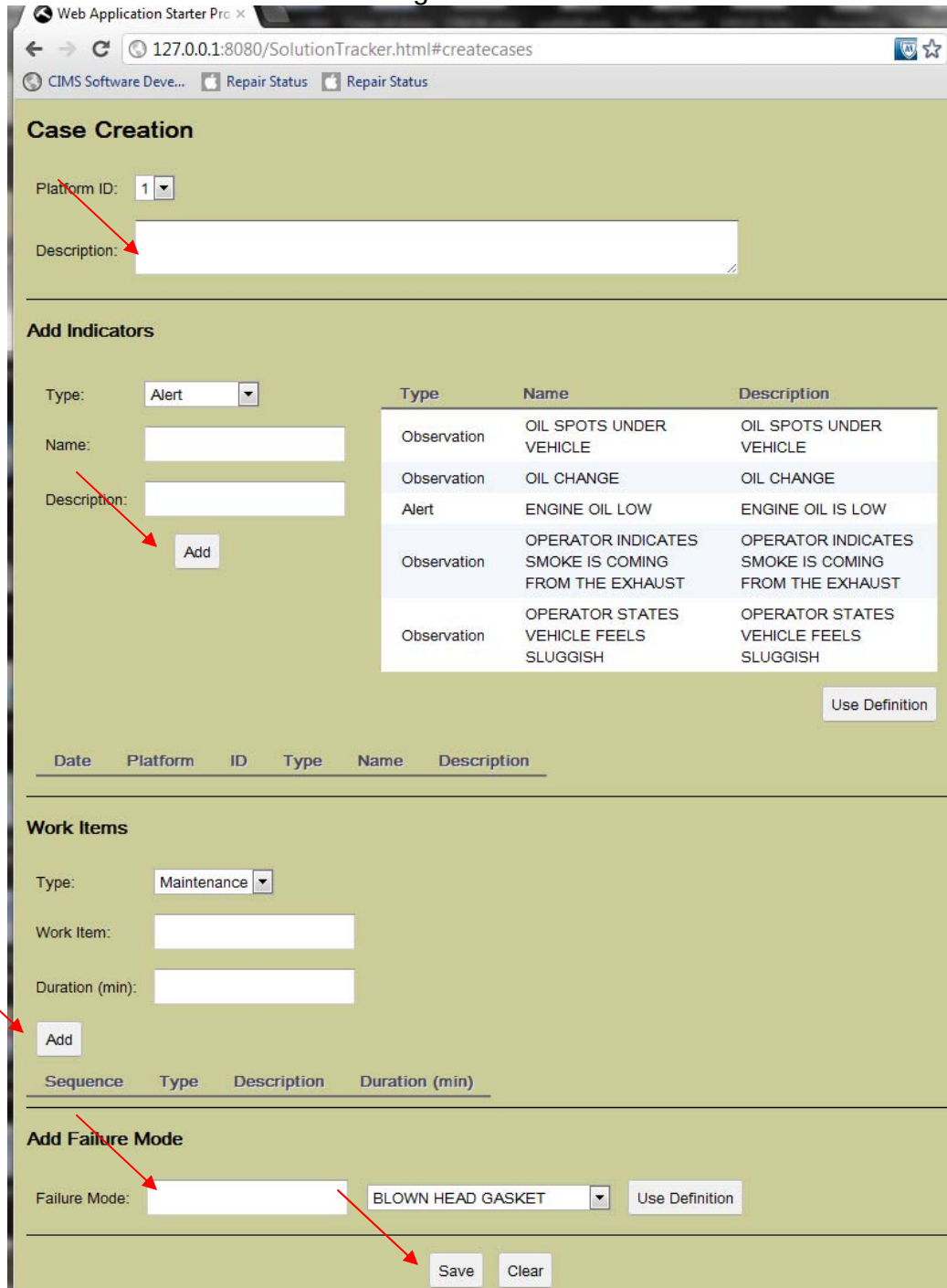
### *Additional Input Methods for Sample Data:*

In order to facilitate data entry into the system, additional data entry screens were added. These screens allow entry of Alerts and DTCs by following the Create Occurrences link or to create a larger set of knowledgebase cases by clicking on the Create Cases Link.



## Creating Cases to Build the Knowledgebase

- A Case Creation screen will appear. On the screen, the user may enter a description, Add various types of indicators, add work items, and assign a failure mode. These may be done by selecting from a list and clicking the Use Definition button, or by entering the data into the fields manually. Once data is in the fields, clicking the Add button will add that item to the case. Clicking Save will add it to the Knowledgebase.



**Case Creation**

Platform ID:

Description:

---

**Add Indicators**

Type:

Name:

Description:

| Type        | Name                                                | Description                                         |
|-------------|-----------------------------------------------------|-----------------------------------------------------|
| Observation | OIL SPOTS UNDER VEHICLE                             | OIL SPOTS UNDER VEHICLE                             |
| Observation | OIL CHANGE                                          | OIL CHANGE                                          |
| Alert       | ENGINE OIL LOW                                      | ENGINE OIL IS LOW                                   |
| Observation | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST | OPERATOR INDICATES SMOKE IS COMING FROM THE EXHAUST |
| Observation | OPERATOR STATES VEHICLE FEELS SLUGGISH              | OPERATOR STATES VEHICLE FEELS SLUGGISH              |

---

**Work Items**

Type:

Work Item:

Duration (min):

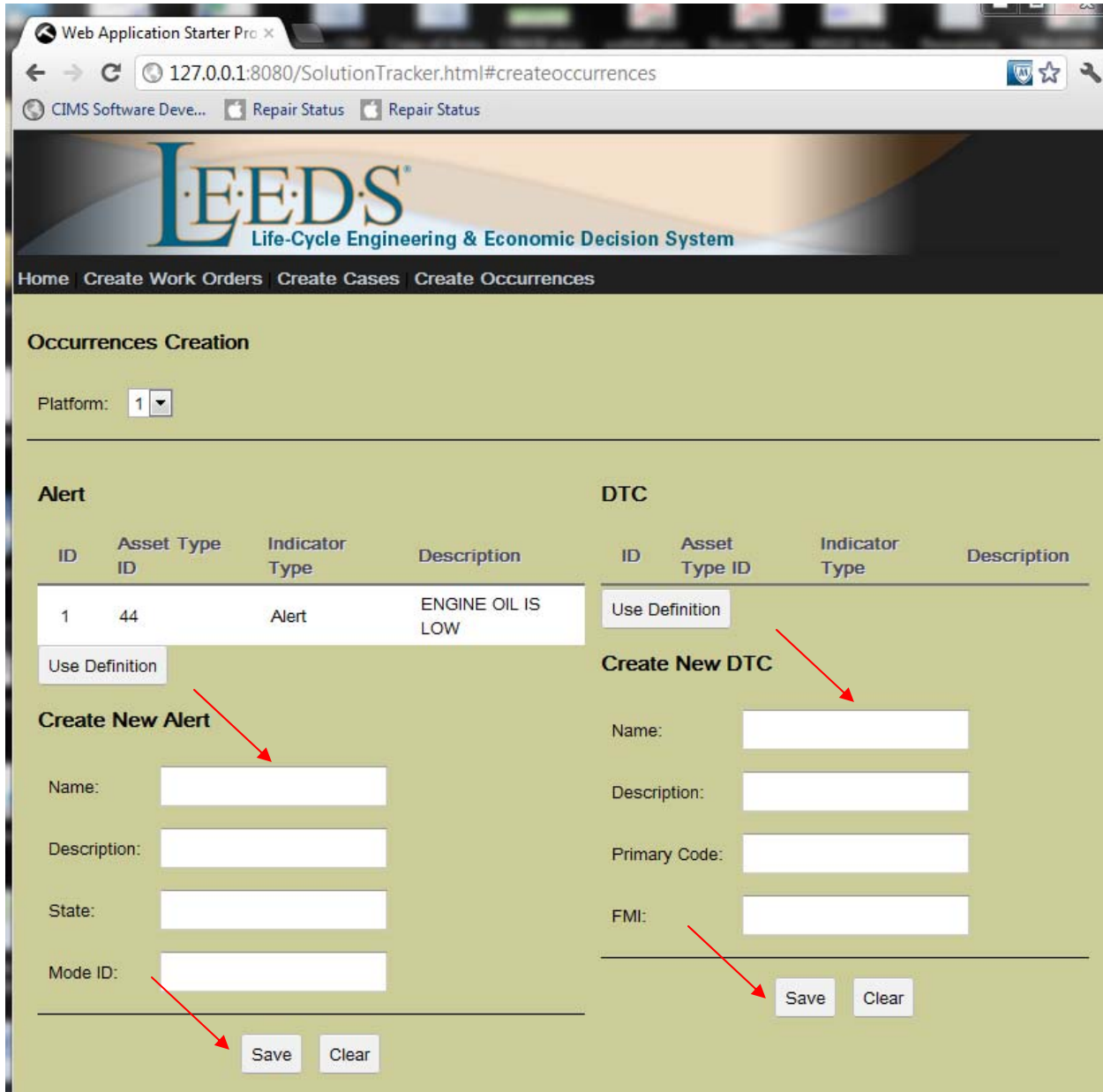
---

**Add Failure Mode**

Failure Mode:

## Creating Occurrences (Alerts and DTCs)

- Alerts and DTCs may be added by entering the information into the data fields and clicking Save. They will then appear in the list above. These alerts will be tied to the selected platform on the Platform Anomalies screen.



Web Application Starter Pro X

127.0.0.1:8080/SolutionTracker.html#createoccurrences

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Home Create Work Orders Create Cases Create Occurrences

### Occurrences Creation

Platform: 1

#### Alert

| ID | Asset Type ID | Indicator Type | Description       |
|----|---------------|----------------|-------------------|
| 1  | 44            | Alert          | ENGINE OIL IS LOW |

Use Definition

#### Create New Alert

Name:

Description:

State:

Mode ID:

Save Clear

#### DTC

Use Definition

#### Create New DTC

Name:

Description:

Primary Code:

FMI:

Save Clear

From the home screen, select the “View Platform Anomalies” button. This will bring you to the Platform Anomalies screen shown below.


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Life-Cycle Engineering & Economic Decision System

[Home](#)
[Create Work Orders](#)
[Create Cases](#)
[Create Occurrences](#)

### Platform Anomalies

#### Platforms

| Platform ID | Asset Type | Occurrence Count |
|-------------|------------|------------------|
| 1           | 44         | 1                |
| 2           | 55         | 0                |
| 3           | 44         | 0                |

#### DTCs

| Time           | DTC ID | Name             | Description          | Primary Code | FMI |
|----------------|--------|------------------|----------------------|--------------|-----|
| 03/14/12 15:13 | 1      | OIL PRESSURE DTC | OIL PRESSURE IS HIGH | 123          | 45  |

#### Work Orders

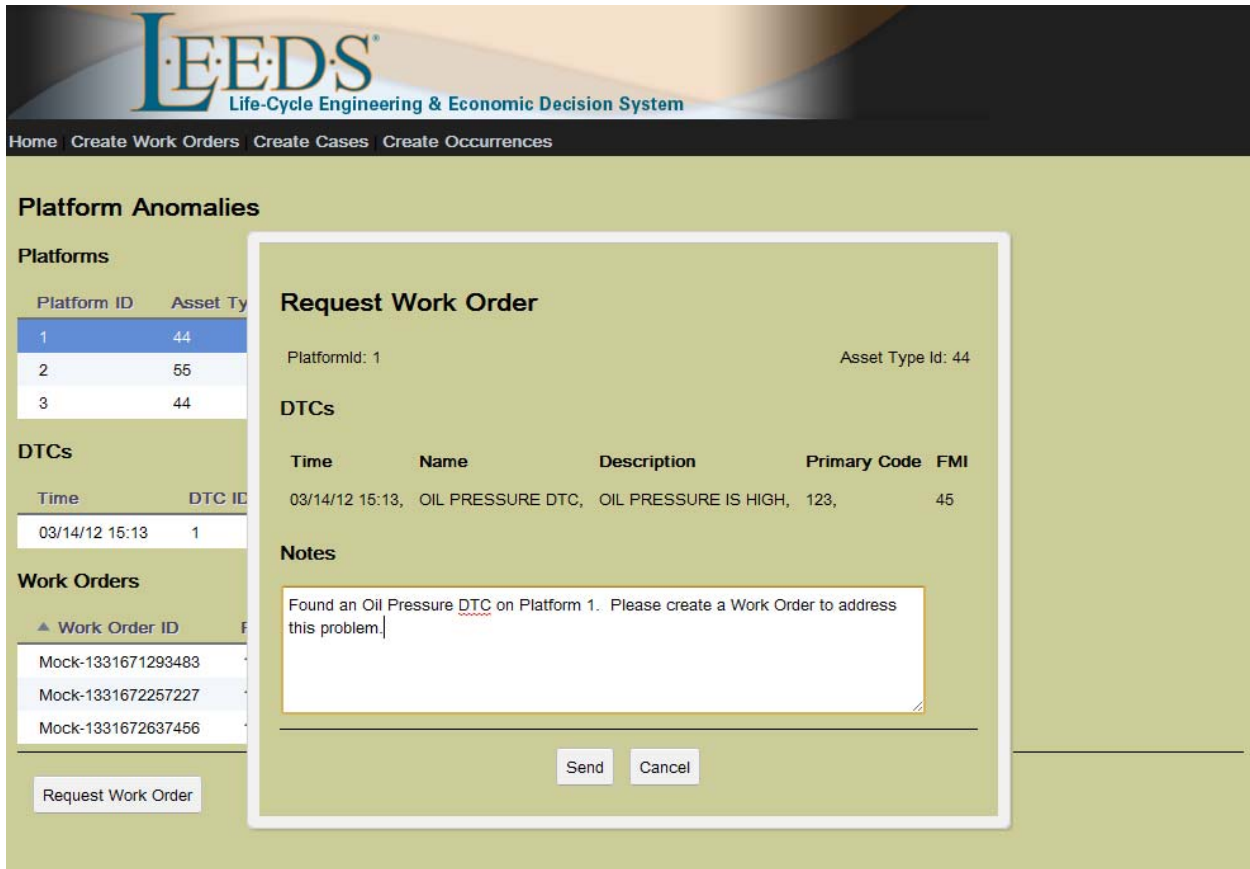
| ▲ Work Order ID    | Platform | Date           | Agent         | Status     |
|--------------------|----------|----------------|---------------|------------|
| Mock-1331671293483 | 1        | 03/13/12 16:41 | Chris Piggott | InProgress |
| Mock-1331672257227 | 1        | 03/13/12 16:57 | Chris Piggott | InProgress |
| Mock-1331672637456 | 1        | 03/13/12 17:04 | Chris Piggott | NotStarted |

Request Work Order

This screen shows a list of platforms, and a count of occurrences associated with each platform. It shows that platform 1 has one occurrence. When you select platform 1 in the table, the DTC (occurrence) is shown below, along with any open work orders associated with the platform. This allows the SME to review any other issues that may be pending on the platform.

This screen supports the scenario where an SME discovers an anomaly for which no work order has been created. Since the system only acts upon existing work orders, the SME must request that a maintainer create a work order in the CMMS.

Select the “Request Work Order” button to open a dialog that will allow the SME to send a request to maintenance. The request includes the platform, the occurrences and a notes section as can be seen below:



The screenshot shows the LEEDS Life-Cycle Engineering & Economic Decision System interface. A modal window titled "Request Work Order" is open, displaying the following information:

- Platform ID:** 1
- Asset Type Id:** 44
- DTCs Table:**

| Time           | Name             | Description          | Primary Code | FMI |
|----------------|------------------|----------------------|--------------|-----|
| 03/14/12 15:13 | OIL PRESSURE DTC | OIL PRESSURE IS HIGH | 123          | 45  |
- Notes:** Found an Oil Pressure DTC on Platform 1. Please create a Work Order to address this problem.
- Buttons:** Send, Cancel

In the background, the "Platform Anomalies" section is visible, showing a table of Platforms and a list of Work Orders.

After the maintainer creates a work order, the work order will enter the system, and one of the previously discussed work-flows will be supported.

### Notes

- This system is for demonstration purposes only.
- The system still has some minor bugs. If the screen appears to be non-responsive, simply click the refresh button for the page.

For further inquiries regarding LEEDS, please contact Sean McConky by email at [Sean.McConky@rit.edu](mailto:Sean.McConky@rit.edu) or by phone: (585) 475-5522, weekdays between the hours of 8-5 EST.