Weigh In Motion (WIM) With Rational Rose

Department of Energy
Research Alliance for Minorities (RAM) Program

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PROJECT DESCRIPTION

The primary objective of this project is to understand WIM and WIM Systems. The secondary objectives of this project are to:

1. Understand Rational Rose
2. UML and UML Diagrams
3. Understand Visual Modeling and Software Development
4. Develop Use Cases which developers can generate into the WIM system.

INTRODUCTION

Weigh-In-Motion

The Department of Energy, Oak Ridge Operations Office (DOE-ORO) oversees advanced research and development programs through its management and operating contractors. One of those contractors, UT-Battelle, LLC, manages and operates the Oak Ridge National Laboratory (ORNL) for DOE-ORO. ORNL has highly specialized, and often unique, scientific, and information technology challenges. ORNL's highly specialized multi-disciplinary and comprehensive approaches offer solutions that are not available elsewhere in the public or private sectors. Additionally, ORNL approaches are unbiased and independent of commercial considerations.

ORNL is providing WIM technical support to the United States Army Logistics Transformation Agency (USALTA), a Field Operating Agency of the Department of the Army Deputy Chief of Staff for Logistics, G-4. As part of ORNL's support to Logistics Transportation Agency Decision Support Package, ORNL is documenting the Weigh In Motion (WIM) interfacing with Automated Air Load Planning System II (TC-AIMS II). This support is centered on developing a comprehensive plan for the development of a data exchange capability between ORNL’s WIM system and an appropriate automated information system such as the USAF’s Automated Air Load Planning System (AALPS), and between WIM and DoD’s radio frequency identification devices (RFID), tags and readers. This data exchange capability is essential in maximizing the current utility of the WIM system and is seen as a critical element in rapid Army global power projection/distribution.

PORTABLE WIM BACKGROUND

Currently the Army manually identifies the vehicles and manually enters the data into TC-AIMS II and then manually calculates vehicle axle weights and balance data and manually records and transfers this data to AALPS personnel who manually enter it into the AALPS system. Each of these steps in the process is prone to human error. By establishing automated data exchange links between (1) WIM and the vehicle RFID tags and (2) WIM device and AALPS, vehicle ID and WIM data could be automatically transferred to AALPS, thus eliminating those human errors at the same time expediting the process. The first step in acquiring this data exchange capability is to establish a data exchange plan by the technical staff of WIM, DoD RFID tags and readers, and AALPS.

WIM PROTOTYPE BACKGROUND

As part of the Department of Defense mobility operations, a wide variety of cargo items must be weighed and their center of balance calculated prior to being loaded onto transport aircraft, and sea craft. These tasks are currently performed manually using portable individual wheel weight or in-ground static scales, calculators, and tape measures. This process is very time consuming and potential sources of error are numerous. To increase the efficiency, productivity, reliability, and safety of the personnel performing these tasks and generally enhance U.S. Armed Forces ability to out load supplies, the U.S. Air Force Productivity, Reliability, Availability, and Maintainability (PRAM) Office sponsored the successful development by ORNL of a first generation prototype weigh-in-motion system in 1993-1995.

During demonstrations in 1996, at Combined Arms Support Command (CASCOM) Fort Lee, VA and at Fort Bragg, NC, the PRAM Office sponsored WIM performed the required tasks described above approximately 5 to 10 times faster than conventional techniques and required less rigging by fewer personnel. The current WIMS shown in Fig. 1 is a first-generation prototype that has not been field-hardened. Several features have been identified that will require an additional development effort to product a field-ready WIMS.

Figure 1 Vehicle Traversing Across WIM[1]

The Army's forces must maintain the capability to rapidly project massive combat power anywhere in the world with minimum preparation time. Currently, as depicted in the next figures, the Army units use portable individual wheel weigh (Fig. 2-6) or fixed in-ground static scales (Fig. 7-9), tape measures, and calculators to determine vehicle axle weights, total vehicle weight and center of balance for vehicles to be transshipped via railcar, ship, or airlifted in support of military and humanitarian operations. The process of manually weighing and measuring all vehicles subject to these transshipment operations is time-consuming, labor-intensive, and most importantly is prone to human errors than can result in safety hazards and inaccurate data. (Errors result from inaccurate or incomplete identification of vehicles and equipment; misreading a scale or tape measure, manually recording data incorrectly; manually miscalculation the axle weight, total weight, and center balance; and transferring data from manually prepared work sheets into an electronic database via keyboard entry personnel. Many of these errors can greatly increase during stressful deployment times an adverse weather conditions.)

Figure 2 Preparing to Position Portable Weigh Scale[2]

Figure 3 Positioning Portable Weigh Scale under Front of Wheels[3]

Figure 4 Weighing Vehicles on Portable Weigh Scale[4]

Figure 5 Close Up of One Axle on Portable Weigh Scale[5]

Figure 6 Marking Measurements While on Portable Weighing Device[6]

Figure 7 Measurement of Front of Vehicle to 1st Axle on Static Scale[7]

Figure 8 Measurement of Front of Vehicle to 2nd Axle on Static Scale[8]

Figure 9 Marking of Weight of 2nd Axle on Static Scale[9]

WIM JUSTIFICATION AND URGENCY TO SOLVE PROBLEM

While a man-portable, lightweight Weigh-In-Motion System can expedite deployment from CONUS or other built-up area deployments or re-deployments, it is even more critical to support movement from those areas of operation that are austere in nature. As seen in the last decade, United States military and humanitarian operations have taken place in third world areas, which are characterized inferior transportation networks and support services. Units deploying from the CONUS base will have already access to accurate fixed scales for weighing wheeled and tracked vehicles, palletized and containerized loads. In an austere environment, where Air Force aircraft may be landing and taking off from unimproved (e.g., dirt) runways, no such infrastructure will exist. It will be up to the soldiers and Air Force Loadmasters to determine the safety of personnel and aircraft prior to take-off. The potential for disaster was recently highlighted in Afghanistan.[10]

> *The June 12, 2002 crash of an Air Force transport in Afghanistan that claimed the lives of a soldier and two airmen was caused by the plane being overloaded with cargo, an accident investigation board concluded in a report released Nov. 15.*
>
> *Air Force Brig. Gen. Frederick Van Valkenburg Jr., a fighter pilot and commander of the 37th Training at Lackland Air Force Base, Texas, presided over the board. He concluded that a combination of "imprecise information" about cargo weight and a "get the job done" attitude led to fatal mistakes.*
>
> *Valkenburg faulted the weight-estimating procedures used by the Army – and accepted by the Air Force – for allowing the plane to take off with a load heavier than estimated. He didn't fault any individual for the accident.*
>
> *As Air Force special-operations planners worked up the flights' fuel and cargo requirements, they figured the first payload weighed about 17, 500 pounds and that the maximum allowable load was 21,000 pounds. The Talon carried a High Mobility Multipurpose Wheeled Vehicle, a Special Forces gun-mounted vehicle, a trailer and three soldiers.*

The payload's weight was a critical factor for the night operation because the special operations-modified C-130 took off in the morning in thin air from a dirt airstrip at 7,200 feet above sea level. About 45 minutes before the crew members departed their Oman office for the plane, a mission coordinator got word the Army had upped cargo weight to 20,500 pounds, the report said.

The weight estimates came from Army Special Forces team member at Kandahar. And because there was no practical way to weigh cargo at such isolated airstrips, Air Force special-operations crews depended on Army weight estimates. This mission pilot, a major with 4,721 flight hours in G-130s, was given a verbal message about the change, but he misunderstood and thought the new weight was 19,000 pounds. But all those estimates were wrong, the accident investigation board concluded. When the investigators weighed similar gear plus other items in the Army trucks – such as six cases of MREs – the board concluded the cargo weighed between 23,000 and 25,800 pounds.

RATIONAL ROSE

Rational Rose is a powerful visual modeling tool to aid in the analysis and design of object oriented software. It is used to model systems before the code is written. With using this design tool, developers can catch any flaws before the model is put into production.

VISUAL MODELING

Visual modeling is the process of taking the information from the model and displays it graphically using a standard set of graphical elements. By producing visual models of a system, we can show how the system works on several levels. Individuals can also model the interaction between the users and a system. One can also model the interactions of objects within a system and the interactions between the systems if needed.

After the creation of the model, we can show them to needed individuals. Users can visualize the interactions they will make with the system from looking at the model. Developers can visualize the objects that need to be developed and what each one needs to be accomplished. Testers can visualize the interactions between objects and prepare test cases bases on these interactions. Project managers can see the whole system and how the parts interact. To conclude, visual models provide a powerful tool for showing the proposed system to all interested parties.

UML Diagram

UML allows people to develop several different types of visual diagrams that represent aspects of the system. Rational Rose supports the development of the majority of these models as follows: business use case, activity diagrams, sequence diagrams, and collaboration diagrams. Use case diagrams show the interaction between cases and actors. Use case also represents the requirements of the system from the user's perspective. It describes in detail what the system will include and how it will work, so developers can use the model as a blueprint for the system being built.

The following sections develop Use Cases for the data interfacing between the following systems WIM System data input and WIM System Data output to AALPS, and the AALPS Deployment Equipment List (DEL) functional module and reference Fig. 10.

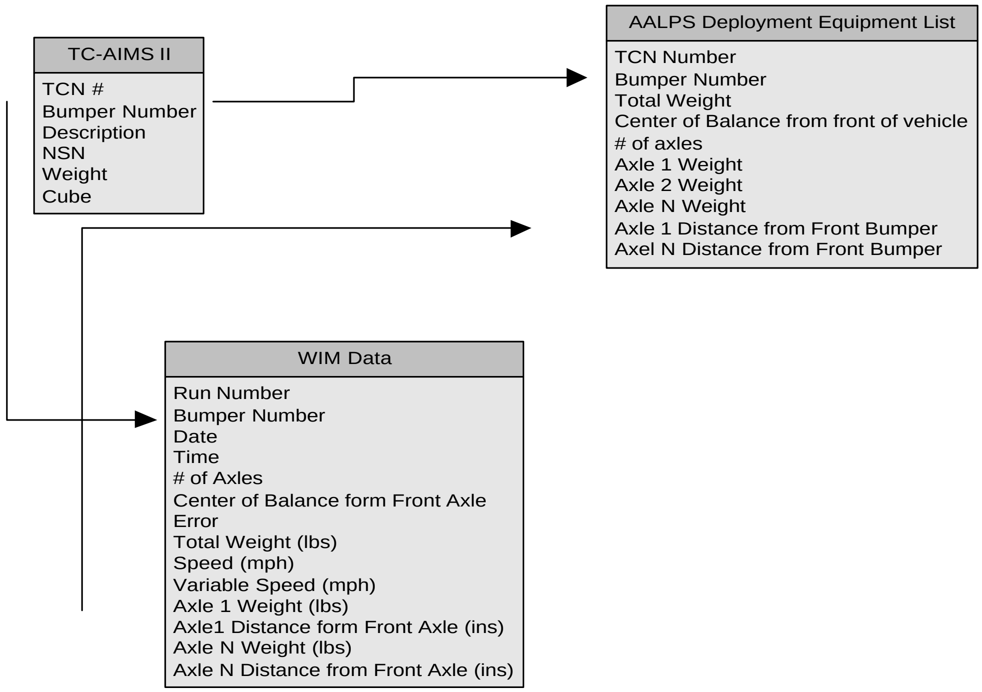


Figure 10 Subsystem Relationship of WIM Information Flow

USE CASE FOR VEHICLE DATA ENTRY SYSTEMS

Basic Use Case Template

Project Name:	Vehicle Data Entry System
Use Case Name:	Input data into database
Use Case Number:	UC-1
Platform:	WIM System
Use Case Author:	Sabrina A. Phillips
Actors:	Military Vehicle, Military Personnel

Abstract:
This use case documents the process the Military Personnel must perform in order to get the military vehicle weighed and the information entered into a database using the WIM system.

Goal:
The Military Personnel's goal is to get the vehicle weighed and receive notification that it was done from station attendants.

Special Requirement:
Special requirements associated with this use case are that a communication channel be established for the electronic transfer of data. This may be either wireless or wired.

Pre Conditions:
Data is process in WIM and that DEL exists in AALPS.

Post Conditions:
Normal archival of data on WIM with success or failure status noted.

Use Case:
Initialization:

1. This use case begins when the actor indicates they wish to get the vehicle weighed.
   [Exception: Vehicle has no information in database]

Process:

2. The system presents the actor with a list of vehicle accounts in the database, and asks the actor to select the vehicle's information.
   [Exception: Actor cancels the transaction]

3. The system displays current weight information.

4. The system weighs vehicle.

5. The system feeds new information into database.

6. Database authorizes the WIM of new information.
   [Exception: The weight is more than allowed]

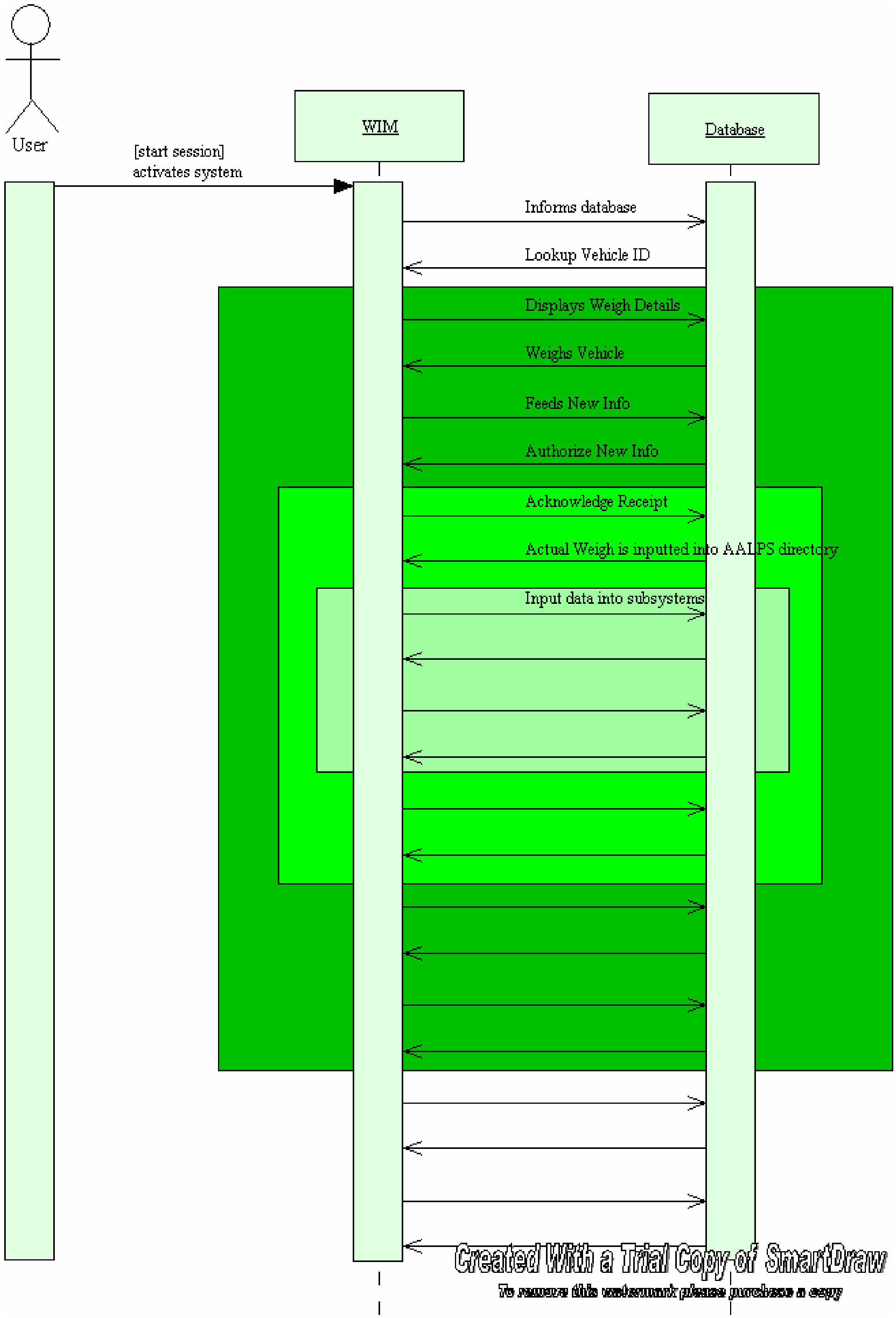
7. The system acknowledges receipt and actual weight is inputted into AALPS directory.

Termination:

8. This use case ends when the system has delivered the requested information to the actor and a receipt has been printed (if applicable) and new information has been updated into the database.

It is important to remember that the key here is to uniquely identify what is being weighed and measured and ensure that all weighing systems are accepting, processing and transmitting the same data in the same formats.

RESULTS



User
WIM
Database
[start session]
activates system
Informs database
Lookup Vehicle ID
Displays Weigh Details
Weighs Vehicle
Feeds New Info
Authorize New Info
Acknowledge Receipt
Actual Weigh is inputted into AALPS directory
Input data into subsystems

CONCLUSION

Once the WIM Interface Documents are approved by the Military and Business Use Case Diagrams and their variants are completed and approved by the Military, Rational Rose will be used to design and implement an emulator for the multiple interfaces. Upon completion of the actual WIM device, itself, the interface software will be integrated to produce a total WIM system.

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REFERENCES

[1] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-24, 2003

[2] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-14, 2003.

[3] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-14, 2003.

[4] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-14, 2003.

[5] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-14, 2003.

[6] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-14, 2003.

[7] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-14, 2003.

[8] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-14, 2003.

[9] Photograph from LTA/ORNL/XVIII Airborne Corps WIM Ft. Bragg Demo May 13-14, 2003.

[10] Army Times, Weight of cargo cited in crash of MC-130H. Three killed in June 12, 2002 accident in Afghanistan, Issue Date: December 9, 2002, by Bruce Rolfsen.