

## **Interactive Web-Based Training System at Tinker AFB: *Aircraft Part Maintenance and Assembly Process***

**Chaturaporn Nisagornsen, Zahed Siddique, and Kurt Gramoll**

**School of Aerospace and Mechanical Engineering  
The University of Oklahoma**

### **Abstract**

Three-dimensional visualization is an essential element in any web-based applications for engineering education and technical training. As concepts of virtual reality become possible, the use of three-dimensional elements can simplify the learning process. Effective information delivery is done by integrating a variety of multimedia components such as three-dimensional animations and simulations with the standard text and graphics. These electronic media are combined to match nicely with many of the aspects of technical training. Opportunity for the user to explore and learn effectively through an investigative process is provided using these technologies. This paper describes the incorporation of three-dimensional visualization as a main component with other media elements in the interactive web-based training project for Tinker Air Force Base (AFB) in Oklahoma City, Oklahoma. Three-dimensional visualization is implemented using the latest web-based, three-dimensional graphics supportive capability technology, namely Shockwave 3D technology.

The training system, called the Constant Speed Drive (CSD) System, was developed for Tinker AFB to provide a flexible and effective training system that is accessible as a resourceful, stimulating, attractive, and challenging training method to serve a large number of personnel simultaneously. It should be noted that CSD is the name given by Tinker AFB personnel to a demonstration part used in this system. However, the name of this part used in the official Technical Order is Constant Speed Mechanical Drive Mechanism. The fundamental objective of this environment is to help engineers, technicians, and professionals at Tinker AFB better understand the required operations through an Internet-based learning environment. These various technologies such as text, graphics, and three-dimensional visualization (e.g. animation and simulation), are integrated to develop and efficiently deliver content-rich learning material.

### **1. Introduction**

The rapid improvement of the Internet and web technology has provided new possibilities for various web-based applications including education and training. These technologies provide new and creative methods for presenting course material effectively. An advantage of web-based education is the flexibility in letting students, both in school and in industry, adapt to their own learning pace and different ways of understanding the concepts. A feature that allows immediate

feedback develops an interactive learning environment that can expand the students' ability to understand the subject.

In addition, to demonstrate engineering and technical concepts successfully, the best way to present information is to use three-dimensional models. As concepts of virtual reality become possible, the use of three-dimensional elements can simplify the learning process for engineering or technical concepts. Furthermore, integrating three-dimensional components and interactivity to create three-dimensional visualization provides users an opportunity to learn through experimentation and research.

Currently, several learning and training systems for both educational and industrial purposes incorporate a variety of electronic media over the Internet such as Virtual FlyLab, Virtual Earthquake [1], Virtual City [2, 3], and eCourses [4, 5]. Three-dimensional visualization has played a major role in existing technical learning environments. This paper describes the incorporation of three-dimensional visualization as a main component with other media elements in the interactive web-based training project for Tinker Air Force Base (AFB). Three-dimensional visualization is implemented using the latest web-based, three-dimensional graphics supportive capability technology, namely Shockwave 3D technology.

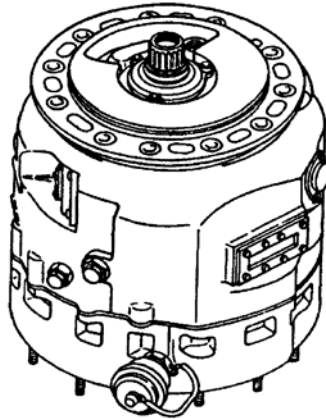
In order to understand the details about designing this training system, a brief overview of the training system is given. As the training system is categorized into sections, the structure of the learning system is explained. Next the details of each section are discussed. Finally, the concluding section provides the summary of the training system. In this section, an assessment of the effectiveness of the training system is presented in order to support the usefulness of this environment. Additionally, the final section discusses recommendations for future improvement in improving web-based training system.

## **2. Overview**

The fundamental objective of the CSD System is to train engineers, technicians, and professionals at Tinker AFB how to perform required operations on complex aircraft parts through an internet-based learning environment. Various technologies such as text, graphics, and three-dimensional visualization, including animation and simulation, are integrated to develop and efficiently deliver content-rich learning material. The environment is composed of three major elements including interactivity, three-dimensional visualization, and evaluation. These elements are considered essential elements for this particular web-based environment since they are the minimum elements required to achieve its objectives and to comply with Tinker AFB requirements as well.

The CSD System was developed for Tinker AFB to guide and train Tinker AFB personnel to correctly perform the specific Aircraft Part Maintenance and Assembly Process. The main reason for Tinker AFB to have this web-based environment developed is to provide a flexible and effective training system that is accessible as a practical, impressive, attractive, and challenging training method to serve numerous personnel simultaneously. This training system focuses on

the Constant Speed Mechanical Drive (CSMD) Mechanism as a specific component. The purpose of the CSMD Mechanism is to drive each generator used in an aircraft (Figure 1).



**Figure 1:** The CSMD Mechanism

### 3. Learning System Structure

In order to manage and effectively organize the materials, a linear structure is incorporated in designing the organization of the learning system. Three sections are organized in sequence to provide users an opportunity to gain the most information out of the learning materials. These sections include Part Breakdown, the Assembly Process Tutorial, and the Assembly Process Evaluation section. Figure 2 illustrates the learning structure of the CSD System.

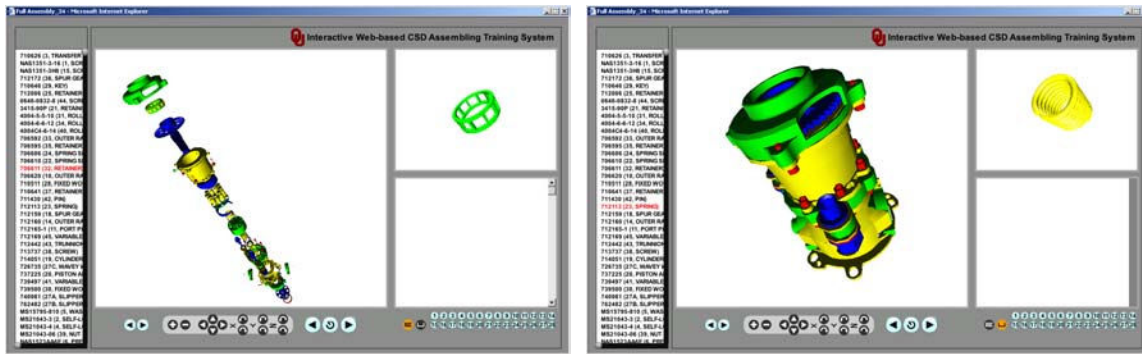


**Figure 2:** Learning structure of the CSD System

#### 3.1 Part Breakdown operation

The Part Breakdown operation provides users the basic information about the assembly part, such as physical appearance of the assembly part and subparts, subpart names, and subpart locations. This information is necessary for users to proceed to subsequent sections and to

successfully understand the concepts presented. This information helps extend users' ability to properly complete the training and assembly process itself. Users can obtain the information through the presentation of three-dimensional models. Using three-dimensional models is beneficial for users because users can actually observe the information in three dimensions and then obtain necessary information directly from what they perceive. A complete assembly part, represented by a three-dimensional model, is displayed in both exploded and unexploded views in order for users to explore and obtain information of subparts located inside the assembly part. Users have two options to explore the information in details, first, when users select an individual subpart of the assembly, and second, when users select an individual subpart name. Example screens of Part Breakdown are illustrated in Figures 3a and 3b.

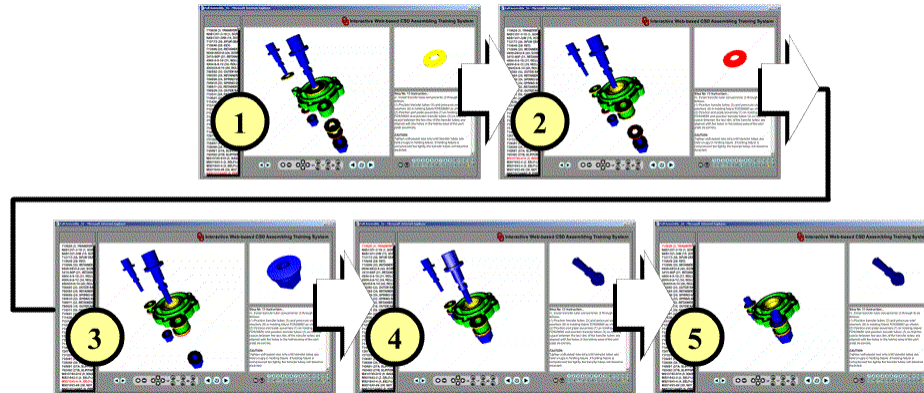


**Figure 3a and 3b:** Example of a screen in the *Part Breakdown* section

In this operation, users can highlight and rotate the selected part at will. Users are then able to select any part in the assembly from an indented list and the component will be highlighted on the main screen. The selected part will appear solid while the non-selected parts will become more translucent. Users can then select a part from the view port screen and the selected part will be highlighted in the indented list.

### 3.2 Assembly Process Tutorial operation

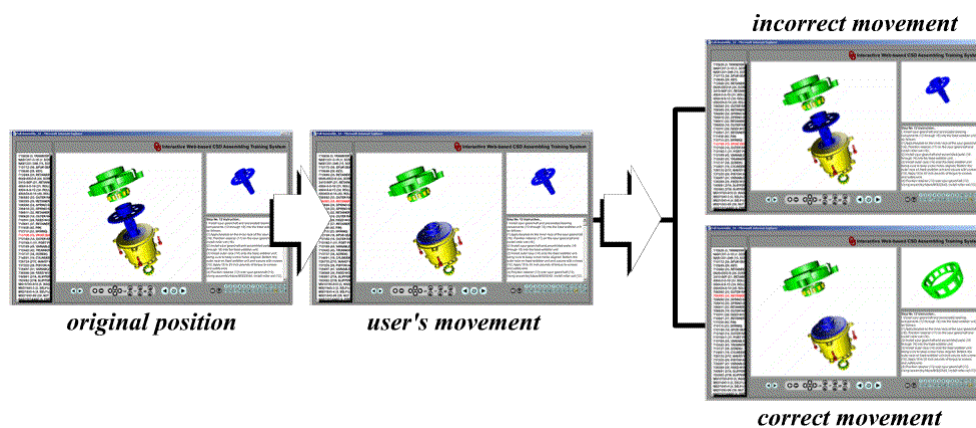
The goal of this operation is to teach users how to correctly perform the assembly process. Users learn how to perform the assembly process step-by-step from the beginning until the assembly is completed. It is important to present users an assembly process one step at a time in order to make sure that users are able to perform the assembly process in the right order that is necessary for the completion of the assembly part. Step-by-step assembly process is presented through the use of three-dimensional animations along with text instruction. Using three-dimensional animations that closely imitates the real assembly process can help users understand the concepts clearly. Text instruction gives users written explanations of the actions required for each step. Using animation and text instruction together allows users to clearly understand how to complete the assembly process. Figure 4 illustrates sample animation snapshots from the beginning to the end.



**Figure 4:** Samples of an animation process from the beginning to the end

### 3.3 Assembly Process Evaluation operation

The Assembly Process Evaluation operation is designed to evaluate users' performance in assembly process step-by-step to ensure that users clearly understand the assembly procedure and they are ready to correctly perform the assembly process using the actual assembly part. Users have to perform exactly a step-by-step assembly procedure as demonstrated in the previous operation through the use of three-dimensional simulations. Three-dimensional simulations are employed in order to make users feel like they are performing the assembly process using actual assembly parts. Users have to move the models involved in a particular step to their correct position in the assembly and in the right order of assembly to be able to move on to the next step and so on, until the completion of the assembly. A user has to perform as though he or she was completing a real assembly using real models. Figure 5 illustrates samples of models in a simulation process when the position is correct and incorrect.



**Figure 5:** Samples of a simulation process in both correct and incorrect situations

#### **4. Assessment**

Assessment was conducted over a period of the development. The progress of the system has been reported to Tinker AFB on a frequent basis in order to comply with the requirements. Reviews, comments, feedback, and suggestions from Tinker AFB on system's performance, are received and reviewed after each section is developed. The feedbacks were extremely positive as to the way the system can contribute to employees' work and responsibility. Although, all the positive feedbacks received from Tinker AFB personnel are verbal only. Since Tinker AFB decided to continue the project to the second phase, the CSD System can be considered success in its performance and effectiveness.

One issue for the improvement of the CSD System is the creation of three-dimensional models using only Lingo. At this time, three-dimensional models used in the system were created using another application (Pro/ENGINEER) and then imported into Shockwave 3D. This results in large file sizes that required long download times. This is a significant concern in term of memory usage as well. Using Lingo to create three-dimensional models would help solve this problem; however, creating such complex three-dimensional models is a challenging task since the structure of Lingo does not provide sufficient flexibility and convenience for 3D technical models. Also developers have to clearly understand the mathematical representation of three-dimensional models.

#### **5. Summary**

An interactive web-based training system was developed for Tinker AFB for convenient, flexible, effective, easily accessible, and low-cost training of its personnel. However, it is still capable of supporting an intensive learning style similar to traditional training methods. The system is intentionally used to train and guide Tinker AFB personnel to properly perform procedures for the specific Aircraft Part Maintenance and Assembly Process. Once training is completed, the user has the ability to accurately operate the specific Aircraft Part Maintenance and Assembly Process as a result expected by Tinker AFB. This demonstration environment focuses on the CSMD Mechanism. The system consists of three major sections: the Part Breakdown operation, the Assembly Process Tutorial operation, and the Assembly Process Evaluation operation.

The environment is composed of three major elements, including interactivity, three-dimensional visualization, and evaluation. These elements are considered essential elements for a web-based environment to achieve the objectives and to comply with Tinker AFB requirements as well. Interactivity is maintained throughout the learning process to make the system participative intensive so that the concentration of the user is focused on the subject. This element is mainly represented by a variety of simulations that are designed and implemented to enable students to learn through exploration and investigation along with the learning material. Three-dimensional visualization is integrated to develop and deliver content rich learning material efficiently. This element is used as the main component universally in the system, which means it is also the principal piece of work used to build the other two essential elements, including interactivity and evaluation.

Evaluation, which developed based on the other two essential elements, interactivity and three-dimensional visualization, is represented through various high level interactive simulations. These high level interactive simulations are designed to evaluate the effectiveness of the user's learning capability by allowing the user to perform the maintenance process as presented in the Assembly Process Tutorial section or animation section and to provide feedback to the user. Finally, considering the system in an implementation aspect, this entire system is developed inside Shockwave 3D and is implemented using only Lingo scripting language to control simulation, animation, three-dimensional model movements, navigation system, and other interactivities that appear during the operation of the system.

## **Acknowledgment**

The authors gratefully acknowledge the support of this work from Tinker AFB in Oklahoma City through the project "Phase I: CSD Part Assembly Training Demo Using Interactive CAD", number F34650-01-D-D703 D.O 0008.

## **Bibliography**

1. Robert Desharnais and Gary Novak, "Virtual Courseware for Science Education", Syllabus, Vol. 12, No.1, August 1998
2. Qiuli Sun, Kurt Gramoll, and Michael Mooney, "Self-Paced Instruction to Introduce Traffic Engineering in Virtual City (Sooner City)", 1999 ASEE Annual Conference & Exposition, Charlotte, North Carolina, June 20-23, 1999
3. Qiuli Sun and Kurt Gramoll, "Internet-based Simulation and Virtual City for Engineering Education", 2000 ASEE Annual Conference & Exposition, St Louis, Missouri, June 18-21, 2000
4. Kurt Gramoll, "Teaching Statics Online with only Electronic Media on Laptop Computers", 1999 ASEE Annual Conference & Exposition, Charlotte, North Carolina, June 20-23, 1999
5. Yellamraju Vikas, Tony Romanello, and Kurt Gramoll, "Teaching Dynamics Online with only Electronic Media on Laptop Computers," 2000 ASEE Annual Conference & Exposition, St Louis, Missouri, June 18-21, 2000
6. Chaturaporn Nisagornsen, "Implementation of Three-dimensional Visualization in Interactive Web-based Environment for Engineering Education and Technical Training", PhD Dissertation, The University of Oklahoma, 2003.
7. Chaturaporn Nisagornsen, Arun Arunachalam, Kurt Gramoll, and Hengzhong Wen, "Interactive Web-Based Training System at Tinker AFB: Environmental Engineering, and C-135 Aircraft Maintenance Instruction", 2002 ASEE Annual Conference & Exposition, Montréal, Quebec Canada, June 16-19, 2002.
8. Tinker Air Force Base, "Technical Manual – Overhaul Instructions: Constant Speed Mechanical Drive", Midwest City, Oklahoma 2002.
9. Tinker Air Force Base, "Technical Manual – Illustrated Parts Breakdown: Constant Speed Mechanical Drive", Midwest City, Oklahoma 1999.
10. Dean Utian, Sam Humphries, Charles Parcell, Jose R. Rodriguez, Chuck Wainman, II, and Luke Wigley, "Foundation Director 8.5", friends of ED, Chicago, Illinois 2001

11. Gary Rosenzweig, "Special Edition Using Director 8.5", Que, Indianapolis, Indiana 2002
12. Phil Gross and Mike Gross, "Macromedia Director 8.5 Shockwave Studio for 3D: Training from the Source", Macromedia Press, Berkeley, California 2002
13. Jay Armstrong, Barbara Herbert, and Stephanie Gowin, "Macromedia Director 8.5 Shockwave Studio Using Director 8.5 Shockwave Studio", 2<sup>nd</sup> edition, Macromedia, Inc., San Francisco, California 2001
14. Jay Armstrong, Barbara Herbert, Stephanie Gowin, Tom Higgins, Macelle Taylor, and Frank Welsch "Macromedia Director 8.5 Shockwave Studio What's New in Director Shockwave Studio", 1<sup>st</sup> edition, Macromedia, Inc., San Francisco, California 2001
15. <http://www.macromedia.com/software/director/>
16. <http://www.macromedia.com/software/director/3d>

## **Biography**

### **CHATURAPORN NISAGORNSEN**

Chaturaporn Nisagornsen recently graduated from the University of Oklahoma with a PhD in Mechanical Engineering. He received bachelor degree in Industrial Engineering from the Royal Thai Air Force Academy, Bangkok, Thailand, and master degrees in Mechanical Engineering and Industrial Engineering from the University of Oklahoma. His research dissertation focuses on the development of interactive applications utilizing various multimedia technologies to effectively demonstrate engineering and technical concepts. His research interest involves multimedia and online education technology for engineering and technology applications.

### **ZAHED SIDDIQUE**

Zahed Siddique is an Assistant Professor and Director of the Product and Process Design Laboratory at University of Oklahoma. His research focuses on product family design, CAD/CAM, design collaboration and engineering design education. Dr. Siddique received his B.Sc., M.S. and Ph.D. in Mechanical Engineering from Georgia Institute of Technology.

### **KURT GRAMOLL**

Kurt Gramoll is the Hughes Centennial Professor of Engineering and Director of the Engineering Media Lab at the University of Oklahoma. He has developed and published CDs and web-based sites for engineering education, K-12 instruction, and industrial training. Dr. Gramoll received his B.S. degree in Civil engineering and M.S. degree in Mechanical Engineering, both from the University of Utah. He received his Ph.D. in Engineering Science and Mechanics from Virginia Tech. Previously, he has taught at Univ. of Memphis and Georgia Tech.