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Disassembly Operations

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### **3-D Simulation for Assessment of Transparent Weapon Disassembly Operations**

#### **Abstract**

The Technology Modeling and Analysis group of the Los Alamos National Laboratory is using 3D-process simulation to evaluate options for transparent disassembly of nuclear weapons. Transparent warhead disposition is likely to be a major issue of future nuclear arms treaties.

Using Quest™, from Deneb Robotics, we have developed simulations to help visualize what treaty observers might see during facility inspections or while witnessing weapon disassembly operations. In addition, these models help assess the impact of observers being present in a working facility. Operational delays due to resource unavailability or rerouting traffic to bypass observer-occupied areas are a major concern.

Our Quest models not only simulate facility operations in detail, but they provide 3D views into the operations as they occur. Any number of camera positions can be represented including cameras mounted on equipment or parts as they move through the facility, or "flying" a camera through a facility to give the viewer a guided tour.

3D-facility and process simulation provides a mechanism to work out the logistics and procedures for monitored disassembly without disrupting existing operations. By modeling facilities such as Pantex and the Device Assembly Facility (DAF), we are demonstrating several capabilities useful for transparency analysis including:

- Modeling the movements of equipment and personnel using explicit speed, distance and paths facilitates analysis of various facility layout options.
- Using the explicit representation of facility walls and corridors demonstrates the impacts of rerouting operations around areas occupied by inspectors.
- Using doorway motion animation and explicit camera placement helps visualize the observables for both inspectors and automated monitoring equipment.
- Representing the availability and utilization of various labor categories provides information on certification requirements for facility operations.
- Explicitly modeling failure and repair times of equipment and processes helps assess the impacts of potential scheduling and throughput issues.

## 1. Background

Current arms control treaties place limits only on weapon delivery platforms. Arms control agencies can, at least periodically, observe and count delivery platforms, such as missiles, planes and submarines. By assigning, sometimes artificial, warhead counts to these vehicles START treaties can imply limits on nuclear warheads. This approach allows ready verification of treaty terms, i.e. the number of bombers is within treaty limits, but can do nothing if the payload of a bomber exceeds the value assumed by the treaty.

The next level in Strategic Arms Reduction would seem to be limits on the numbers and types of actual warheads. Counting warheads, however, implies levels of intrusiveness and inspection, referred to as "transparency", far beyond any previously attempted. Inspectors would need to distinguish real warheads from decoys but inspection techniques must not reveal internal details of weapon design. After verification that an object is a warhead, the inspectors would need nearly constant observation of the device to assure that an illegal switch does not occur. Disassembly operations would require observation to verify that warhead destruction. To assure that new warheads are not being manufactured and sent out to replace those removed requires observation of ALL weapon manufacturing activities, not just those covered by treaty limitations.

Observing assembly/disassembly operations without revealing weapon design requires careful arrangement and organization. Testing proposed observation systems in working facilities would cause unacceptable disruption of essential operations. LANL/TSA-7 has been developing 3-D process simulations of weapon facility operations as a tool for planning and evaluating proposed transparency measures before implementation in real facilities.<sup>1</sup>

## 2. Device Assembly Facility (DAF) Modeling

When evaluating proposed measurement and monitoring techniques, it is important to view the results. At a minimum, the user must be able to visualize what treaty inspectors might see while monitoring a weapon facility. Consequently, a modeling application that provides visual representations of the process is required.

The impact of having foreign nationals occupy positions within a classified working facility is also felt in the operational delays associated with waiting for resource availability. Rerouting traffic to bypass observable areas would affect facility operations. Properly representing these impacts requires a modeling environment that handles spatial relationships.

The search for an applicable modeling and simulation tool began with assessments of a variety of commercial applications. We examined Arena™, Taylor II™, Promodel™, Quest™ and several lesser packages that proved to be non-contenders. We selected Quest™ based on the impressive 3D graphics, intelligent movement representations, and extensibility.

By modeling the DAF facility in Quest™, we intended to demonstrate several useful capabilities for transparency analysis.

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- Modeling the movements of equipment and personnel using explicit speed, distance and paths facilitates analysis of various facility layout options.
- Explicit representation of facility walls and corridors demonstrates the impacts of rerouting operations around areas occupied by inspectors.
- Replicating door motion and camera placement helps predict what areas and operations would be observable by inspectors or automated monitoring equipment.
- Representing availability and utilization for the various labor categories provides a handle on certification requirements for facility operations.
- Explicit modeling of failures and repair times helps assess the impacts of restricted facility access.

The prototype model demonstrates the value of the above simulation capabilities. As illustrated in Figure 1, the prototype facility is a simplified layout providing three main work areas -- receiving, inspection and a disassembly cell. The layout also includes the corridors connecting the work areas. The yellow lines show the pathways used by forklifts and workers for movement between the workstations. Examination of Figure 1 shows the situation where a forklift and a worker are approaching each other in a hallway (lower right side of the picture).

The 3D representation provided by Quest™ allows perspective views from any desired vantagepoint. Figure 2 shows the view from the front of the forklift as it approaches the worker and illustrates how the pathways allow people and equipment to pass each other in the halls. Figure 2 also demonstrates the view from a camera mounted on a shipping container. Such a view would be common in scenarios using remotely operated monitoring equipment.

Figure 3 shows another view available to remote cameras. In this image, the camera is looking into the disassembly cell as the forklift enters, carrying a shipping container. Such a view would be commonly available to container-mounted monitoring equipment.

Wall-mounted cameras are a staple of security systems. It is possible that the views from these cameras would be available to inspectors as well as security guards. Due to the contradictory goals of showing security guards everything happening in the cell but not showing the inspectors any classified shapes or operations such views require careful examination. Figure 5 illustrates the view from a camera mounted in the receiving area. In the view, the forklift has just delivered a shipping container for processing into the facility. A worker is approaching the receiving station to begin the necessary processing as the forklift exits to perform another operation.

Figure 6 shows the view from a camera located in the disassembly cell during the forklift entry operation.

As illustrated in the above, Quest™ not only simulates the operation of the facility in fine detail, but it provides the user with 3D views into the operations as they occur. Any number of camera positions can be represented including cameras mounted on equipment or parts as they move through the facility. It is even possible to "fly" a camera through a facility to give the viewer a

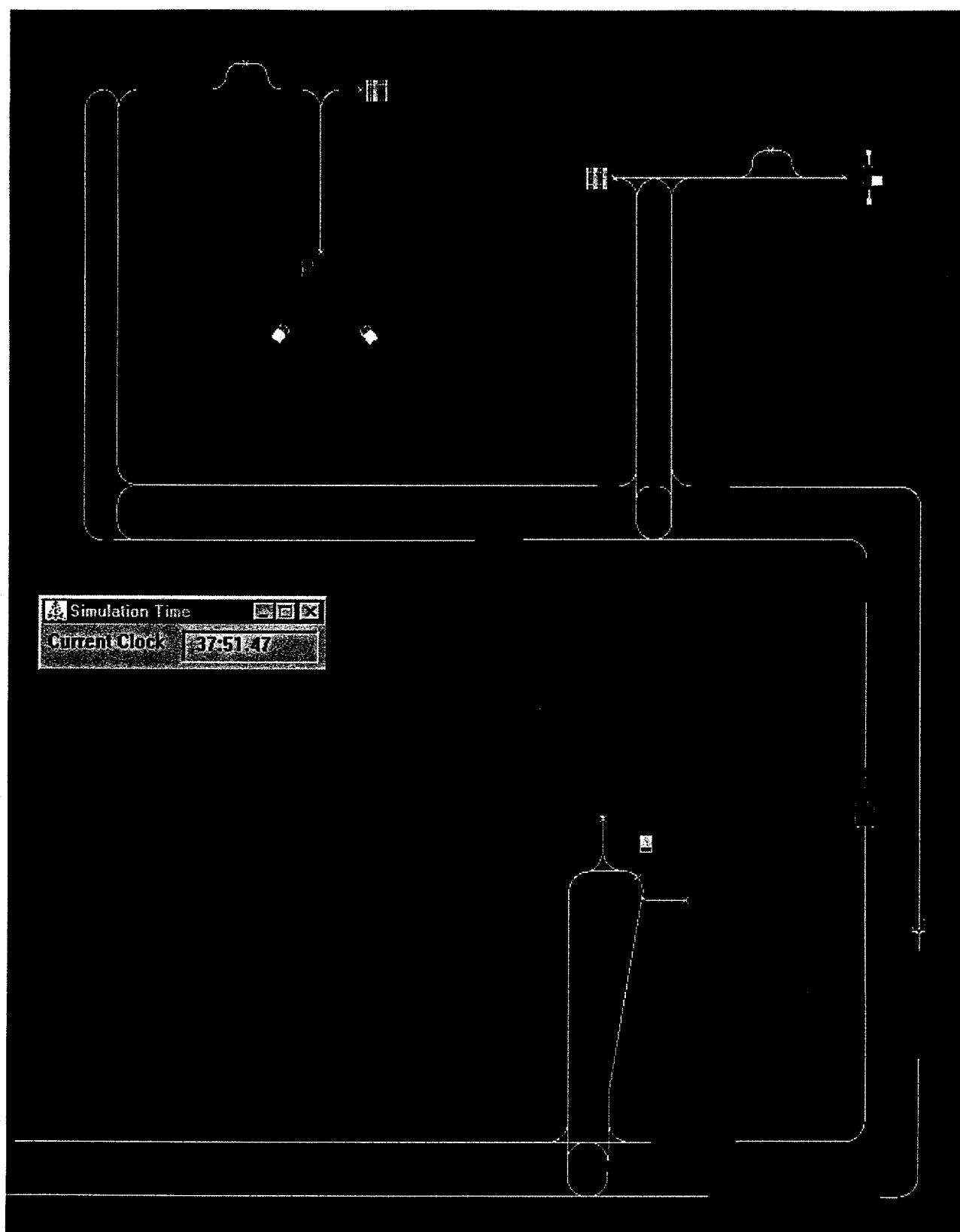


Figure 1. Top view of prototype simulation model.



guided tour. Quest™ also provides the capability to output the images from the cameras to digital-movie files or even to standard video equipment.

### 3. Conclusion

TSA-7 developed the prototype simulation discussed above as a proof-of-concept exercise. Quest modeling proved far more difficult and expensive than originally estimated. The required computer power and the trial and error approach used to learn Quest have both slowed developments significantly. However, the completion of the prototype, while slow, has demonstrated the utility of 3-D simulation for this kind of facility layout and operational analysis.

Development of fully detailed simulations of the DAF and Pantex facilities has begun at a rate paced by funding availability and treaty progress. These simulations will include all rooms and

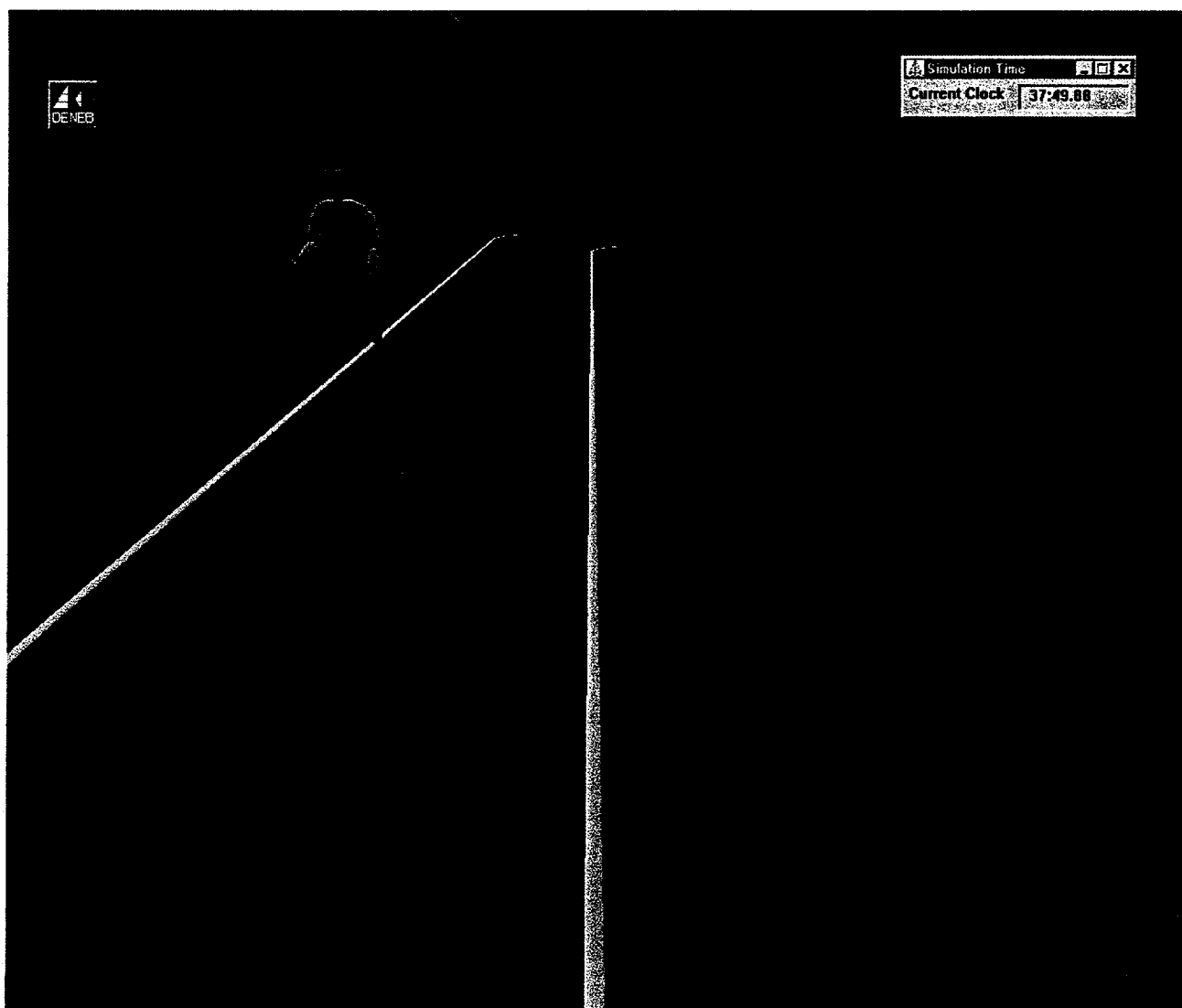


Figure 2. View from a forklift when passing a worker in the corridor.

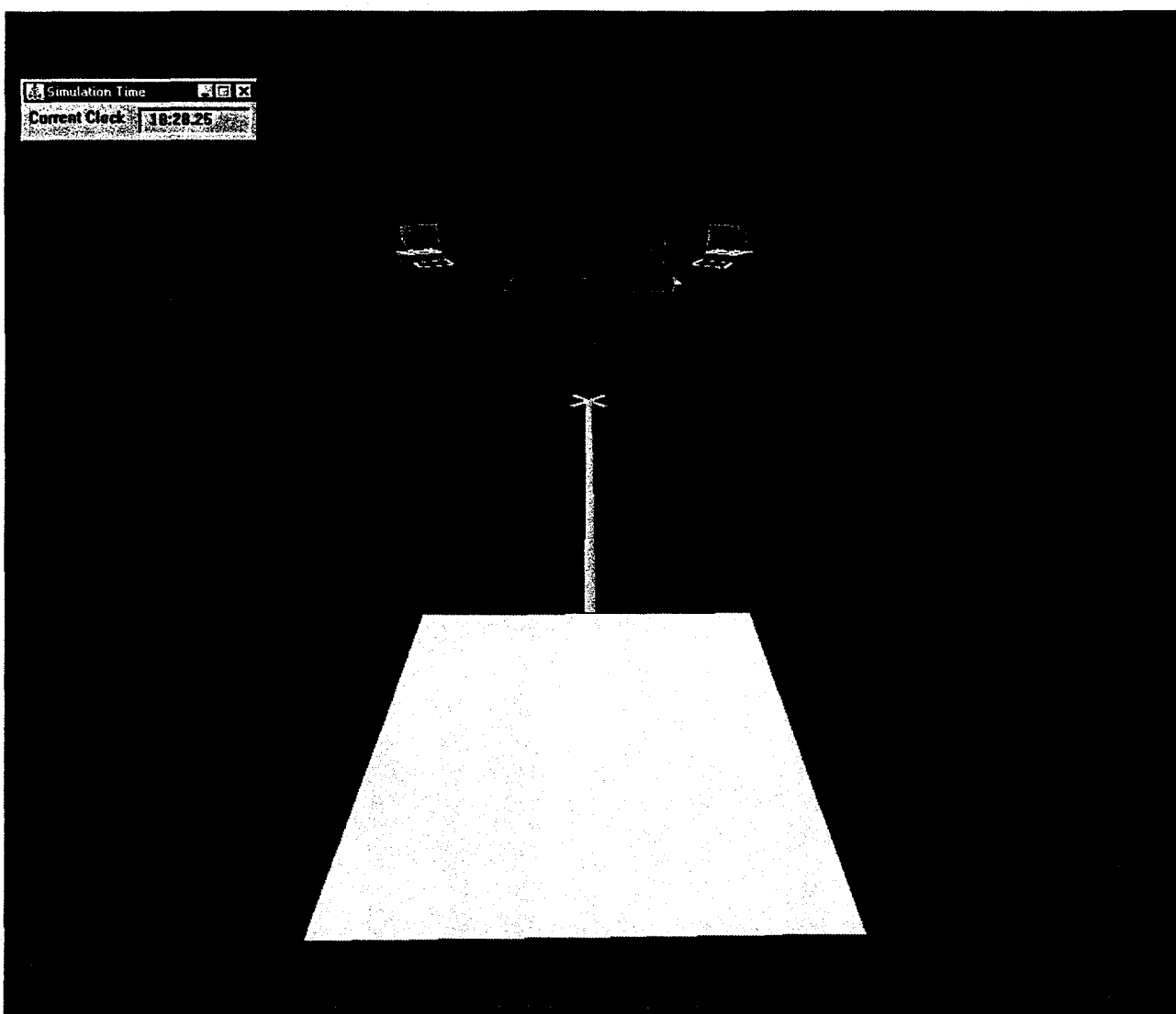


Figure 3. View from a forklift entering the disassembly cell.

operations proposed for inspector monitoring. In parallel with US model development, we have proposed modeling a Russian facility using data provided by the Russians and others. After completion, the entire suite of models will provide analysis of scenarios and the different measurement technologies proposed for transparency and their impact on the dismantlement process.

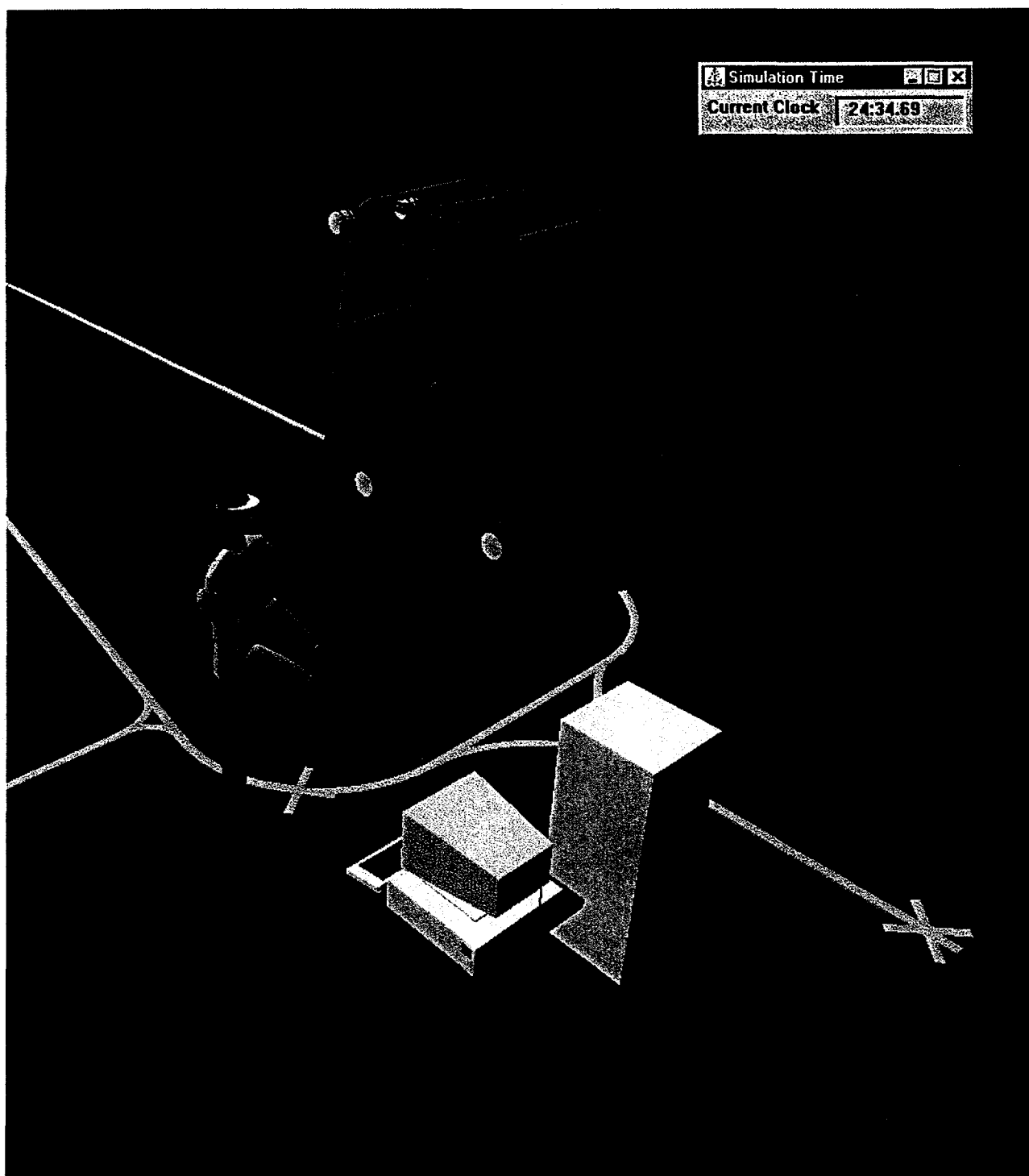


Figure 4. View from a wall-mounted camera in the receiving area during a receiving operation.



Figure 5. View from a wall-mounted camera in the disassembly cell during a container arrival event.

## 1. References

<sup>i</sup> Possible Options for Monitoring Russian Nuclear Warhead Dismantlement (u), Classified Document