Chapter 7

Web-Based Remote Access Modeling & Simulation Workbench for Transatlantic Student Team Projects in Transportation

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The Internet provides an opportunity for transatlantic students to access course materials and simulation models from outside the campus, outside the country and outside the continent. This can be achieved through a Web-based remote access learning protocol. Remote access pertains to the communication with a data processing facility from a remote location such as a computer lab or home computer through a data link. For remote access, individual authorization codes are usually required which give transatlantic student team members the flexibility to access and control their projects on the local computers from anywhere and study the learning objects independent of time and location. For this purpose transportation models are developed and installed to monitor and control the transportation process, depending on constraints for different real world transportation scenarios. Henceforth, transatlantic students can access and run transportation scenarios via the Internet. This is regarded as a distributed virtual teaching and learning environment in transportation that supports collaboration between transatlantic (distant) team members, such as students, instructors and researchers as they develop plans and procedures for classes, case studies and projects, perform measurements and data processing as part of their transportation projects. This approach allows collaborative work at an international level independently of location and time. The Web-based remote access architecture helps to improve student skills in international collaborative projects, a requirement for the workforce of tomorrow in the modern globalized industrial world.

INTRODUCTION

Transportation concentrates on issues involved with the design, planning, safe operation, performance and evaluation of transportation systems and infrastructure, including their economic and public policy aspects. Transportation in the next century will have to be much more ecological, effective and flexible in order to handle the volume of people and cargo that is projected worldwide. To achieve this goal the existing transportation chains must be improved in a cost effective way connecting the existing modalities in an innovative manner making each more efficient.

The debate about economic impacts of new transportation systems and infrastructure investments policy is concerned with balancing environmental and social costs of transportation. Hence, it is strongly argued that longer-term economic objectives of transportation policy have to be compatible with ecological and social objectives. But what are the major ecological objectives in transportation? One main goal is to decouple the significant increase in transport movements from the increasing amount of greenhouse gas emissions. Beside costs and a better efficiency the dependence on fossil fuels of transportation remains a crucial objective in an environmental perspective and is a common denominator for intermodal transportation.

Transportation planning has to incorporate considerably lowered greenhouse gas emissions in spite of the continuing growth of transportation needs on a national and on a worldwide scale. Due to high complexity, solutions to the problems cannot be found only by in one discipline but require the cooperation of different disciplines.

Transportation stresses the development of analytical and problem-oriented design and management skills suitable for public and private sectors professional work. Increase in global competitiveness requires that the next generation workforce receives innovative training and practice that prepares them to participate and compete in the global transportation market. Academic institutions must prepare students for tomorrow's global transportation job market. In theory, most administrators in higher education are well attuned to this urgent need; however, in practice, a response to this imminent problem has yet to trickle down to the academic and student levels.

In recent years there have been significant changes in education. With the advent of computer learning through computer-based environments like hypermedia tools, Web-based educational support through e-Learning, simulation environments, etc. has dramatically increased [1-7]. The Internet is now extensively used as a connectivity tool that opens a variety of new avenues and methodologies for enhancing the experience of learning, as well as expanding educational opportunities for a larger number of students.

Distance education and non-traditional classrooms have the capability to reach more students at a global level by using the Internet as a new and increasingly important medium for distributing information worldwide, free from constraints such as time and location, and for displaying information numerically, graphically, and textually on any client platform. In order to adapt education to global competitiveness, this research work described in the present paper aims to enhance transatlantic education collaboration of students on a broader range without the necessity for transatlantic relocation, comparing and fine-tuning learning outcomes and competencies to enhance comparability and transparency of educational structures and programs.

Special effort was made to combine transatlantic student projects and coursework to benchmark transatlantic education programs. This was achieved through international transportation study programs with integrated transatlantic student team projects which focus on global competitiveness. This capability will enhance Web-based education system approaches [1, 3, 8] by integrating Web-based remote access concepts that allow students to access for example real-time laboratory data and/or control instruments as shown in [8, 9, 10]. As reported in [10] several studies performed in recent years have investigated the implementation of Web-based laboratory experiments in different applications such as a coupled tank apparatus, which was presented in [11], an inverted pendulum, reported in [12], a power system developed in [13], and power electronics shown in [14]. Beside the foregoing mentioned applications there are more subjects published in the literature like robotics, automated systems, digital electronics design projects using VHDL, chemical reactions, etc. as cited in [8].

No result has yet been published showing the use of modeling and simulation (M&S) in a remote access system for education and training in the area of transportation, specifically, running models on a server via web remote access. Simulations are well-known educational tools in engineering and science programs because of portability, ease of use, and cost effectiveness. Moreover simulations are used in many industries such as aviation, chemical, mechatronic, nuclear, petroleum, and other engineering applications.

The term web remote access pertains to communicating with a data processing facility from a remote location or facility through a data link to remote desktops or any type of remote application (including remote browser). Individual authorization code usually is required which give the transatlantic student team members the flexibility to access and control their projects on local computers independent of time and location.

For this project, transportation systems and infrastructure models have been developed and implemented to monitor and control transportation systems depending on different constraints and scenarios. Suitability and efficiency of simulations on the part of the transatlantic project team students depends on criteria as discussed in [8, 15]. The most important are:

- Modularity, which allows for testing developed modules easily and for adopting developed modules to specific applications quickly.
- Executability, which avoids alteration, and hides the code or creates standalone applications.
- Performance, which ensures that the modules meet the required performance.
- Intuitive Graphical User Interface (GUI), which enables transatlantic student team members to look at it and see what needs to be done.

The availability of remote access laboratories is of utmost importance to allow distributing the specific expertise available at the different participating schools within an international education and research network, integrating theory and practice in a cost effective way at high quality standard level in education. This is essential to developing and improving students' hard- and soft kills to enable them to succeed in the highly competitive global job marketplace, as shown in part in the USE-eNET project (USE-eNET: US-Europe e-Learning NETwork) in Science and Engineering [16].

Hard skills encompass design and implementation knowledge of laboratory hardware and simulation models for supervision and control and their integration into a transportation M&S framework. Using simulation means supervision through the front end, namely, the computer.

ProModel was selected as the simulation package because it is available at the two universities. This allowed the inclusion of comparative studies, scenario planning and analysis, content integration through e-Learning, and modeling and simulation case studies. Because of the vast opportunity for application areas of M&S, the transportation study program should emphasize the utilization of the concepts in the student's area of specialization. This gives students the opportunity to enhance their problem-solving skills by conducting effective simulation modeling, analysis, and research projects using the simulation software.

Recognizing the importance of M&S, the 2006 NSF Blue Ribbon Panel [17] reported that continued advancement in the M&S field is critical for resolving a multitude of scientific and technological problems facing the United States public and private institutions. The White House American Competitive Initiative [18] report identified M&S as a key enabling technology of the 21st century. With pressure to cut costs while increasing technical development, researchers are turning more and more to M&S in order to increase the development and understanding of the systems and their respective interactions.

Simulation software for modeling and simulation can be divided, into software for:

- Continuous-time systems; and
- Discrete-time systems.

Simulation software systems for continuous-time systems are:

- Block oriented simulation software; and
- Equation-based simulation software.

Simulation software systems for discrete-time systems are:

- Transaction-based: time schedules are determined; elements of transaction-based simulation software are transactions, blocks, facilities, queues, logical switches, numerical and logical variables, functions, tables;
- Event-based: the time schedules of which depend on the time characteristics of the event;
- Activity based: the simulation run will be active if the previous specified conditions are realized; and
- Process oriented: the specified model element activates the next event.

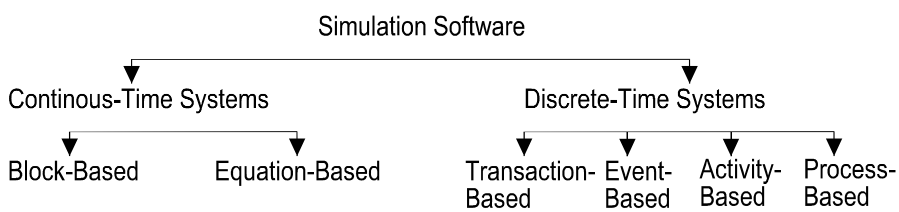


FIGURE 1
SIMULATION SOFTWARE FOR CONTINUOUS-TIME AND DISCRETE-TIME SYSTEMS

Soft skills involve cultural, social, and educational interactions and networking with students and instructors. With the advent of computers and learning through computer-based environments, e-Portfolio has become a very popular social e-room enhancing reflective feedback, allowing quality measurement, accountability, and assessment in higher education, as described in [19]. Specifically, the goals are:

1. establish an international program for students in interdisciplinary transatlantic projects that fosters cross-cultural interaction and networking;
2. expose students through this network to cultural, social, and communication issues in an intercultural transatlantic e-Portfolio environment;
3. reinforce fundamental scientific concepts, providing opportunities to put fundamental scientific concepts into practice through M&S;
4. establish e-learning education framework in transportation; and
5. provide students with experience in transatlantic team work through the web.

SIMULATION APPROACH AT THE TWO UNIVERSITIES

For future design and assessment of inter-modal transportation chains, simulation is used to analyze cost and benefit of the various transportation chains. Applying M&S, the transportation workflow are to be represented in a simplified manner, alongside technical, economical, and ecological benchmarks of the transportation mode for which the transportation chain should be accomplished. Hence several complementary simulation models have been developed for inter-modal transportation chain.

The challenge and innovation of this study lies in an integrated system approach that allows the entanglement of the several models, including methodological concepts and inter-modal transportation, with air plane, rail, ship, truck, and car as the common denominators. This conceptualization allows the user to develop models in a standalone manner as well as within a network. This architectural concept also affords to analyze the individual transportation chain elements as well as the intermodal transportation system as a whole.

Model building follows current programming languages and simulation systems to allow an independent use of the developed models. This research work approaches the problem by a top-down concept in order to integrate the complete transportation chain, permitting evaluations concerning travelling time, costs, environmental impact and the different views of the stakeholders. This intrinsic complexity asks for an educational approach that is more model-based and that benefits from knowledge represented by already existing models. The new approach offers a framework for easy experimentation with new developments given by variations of the corresponding model components.

The principal focus, however, is the ability to optimize intermodal transportation by easily switching between the given alternatives for every step in the transportation chain, even by variation in the means of transportation. Therefore, the following four topics are of specific relevance:

1. valid composition of transportation chains from sets of model components;
2. finding and evaluation of optimization criteria of different levels of abstraction and individual stakeholders;
3. specification of the intermodal nodes, where the means of transport is changed; and
4. provision of the physical characteristics of the various transport vehicles.

Graduate students at the Universities of Alabama in Huntsville (UAH), USA, and the University of Hamburg (UHH), Germany, participated as pilots in several transatlantic student team projects. Since M&S relies heavily on computer processing and analysis, it was highly recommended that participating students should at least have enrolled in one course in programming language, one course in numerical analysis, and one course in data structures.

The programming course included an introduction into programming language, problem solving, and problem analysis using computers, specification and development of algorithm, program design and implementation, data type, data representation, and processing of algorithms on computers. Moreover, an introductory course in continuous time and discrete time system simulation was highly recommended. The contents of the continuous time simulation course usually cover advanced numerical techniques for solving ordinary differential equations, stability including absolute stability, estimation and control of error, stiff problems, numerical methods solving partial differential equations, treatment of boundary conditions, nonlinear equations, coupled systems of equations, numerical dispersion, constructing difference formulas and other approximation methods, and solving the resulting system of equations.

The contents of discrete time simulation course usually cover discrete event M&S, discrete system model building, model verification and validation, data integration, modeling methodologies, advances and practices, and their applications to transportation problems. The students at both universities had already taken a programming language course, M&S courses, a course in probability theory and a multimodal transportation seminar. Initially, two interdisciplinary transportation projects on container handling facilities at sea ports were used for best-case, worst-case and real-case scenario planning and analysis, considering the multi-criteria method for bottleneck analysis.

E-learning is an important component, which allows transatlantic students to study independently of time and location. The interdisciplinary and international nature of student activities strongly encourages multicultural and multidisciplinary learning. It also provides an additional incentive for subsequent transatlantic student cooperation in education and training.

The novel environment is a Web-based transportation laboratory (workbench) where all transportation models used in the transatlantic student team projects are remotely accessed via the Internet with 24-hour access for remote control, interacting with dedicated application servers, which run the developed models and to manage concurrently among the transatlantic users. This allows each partner accessing:

- lecture material;
- models developed at both universities;
- appropriate laptops and/or PCs to run the transportation models;
- models to investigate solutions to the problem of expansion of container handling facilities at sea ports through adaptation of the models for the sea ports; and
- models to investigate infrastructure development in relation to specific needs.

As a result, the transatlantic students will improve their knowledge in:

- discrete event simulation of freight movement by truck, rail and waterborne;
- transportation networks that include inter-modal transfers between truck, rail and waterborne vehicles at specific transfer points; and
- modeling the impact-changing freight patterns to plan for future transportation infrastructure development.

TRANSATLANTIC REMOTE ACCESS STUDENTS PROJETCS

Remote access can refer to remote desktop, remote terminal or any type of remote application (including remote browser). For remote access, individual authorization codes are used like "LogMeIn" which gives users the flexibility to access and control their computers from anywhere. The Web-based system used show the following features:

- transportation models stored on laptops and/or PCs at both Universities;
- transatlantic student project members hook up at the remote laptop and/or PC:
  - select "all models"
  - select "all e-modules"
  - select "communications"
  - click "remote laptop or PC connection"
  - enter IP address of laptop and/or PC at UAH and/or UHH
  - click "connect"
  - enter transatlantic students user name and password
  - click "ok"
- transatlantic project team members now have access to laptops and/or PCs to select the transportation model to run their student team project via the Web; and
- transatlantic student team projects aresmall and simple to provide students with more time for their analysis, using real world models for being beneficial.

ALABAMA TRANSPORTATION MODEL

The experimental setup using the Alabama Transportation Infrastructure Model (ATIM) was developed in conjunction with the National Center for Intermodal Transportation and is shown in Figure 2. The components of the setup are:

1. major highway network of the entire state of Alabama and links with multiple metropolitan planning organizations;
2. alternatives for freight transport on waterways and rail and their impact on highway congestion;

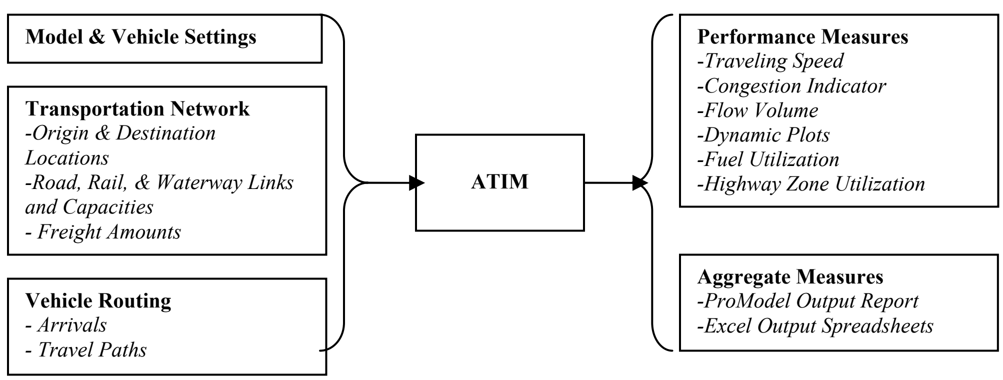


FIGURE 2
BLOCK DIAGRAM OF THE EXPERIMENTAL SETUP FOR TRANSATLANTIC STUDENT TEAM PROJECT WORK

3. statistical information such as travel times, vehicle speeds on average, number of vehicles, tonnage of freight moved, fuel usage and congestion levels; and
4. ProModel simulation software package, interfaced with Excel spreadsheets.

ATIM is a statewide freight transportation model to rapidly evaluate the impact of various decisions on the state's freight multimodal transportation system including highway, rail and water routes, as shown in Figure 2. The transportation network also includes intermodal transfers between truck, rail and water borne vehicles at the transfer points in Huntsville, Birmingham, Montgomery and Mobile. ATM contains four entities: trucks, barges, trains and a dummy entity, used for speed and congestion calculations. Truck, train and barge entities represent freight traffic.

The freight origin and destination points are hard-coded using ProModel Locations. Locations in the model include major cities, road and rail network intersections, ports, locks and dams, and boundary points for the states surrounding Alabama. The roadway and railway system, and navigable waterways are also hard-coded using ProModel Path Networks. Each network represents a section of a road, river, or railway and links two locations in the model [20].

To run a transatlantic student team project, students, called clients, access the web page, as described above, which activates the web server application of the respective transportation infrastructure model, as shown in Figure 3.

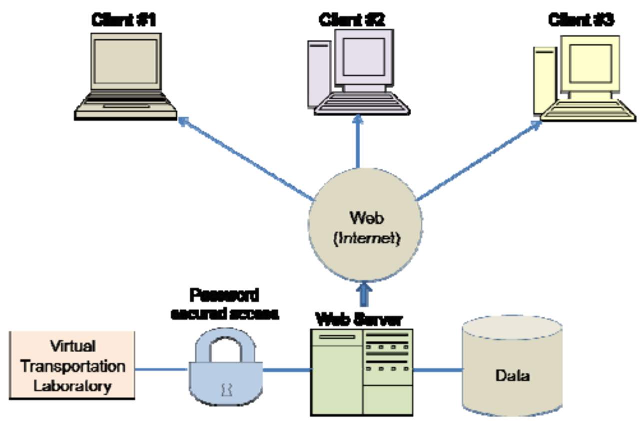


FIGURE 3
WEB-BASED REMOTE ACCESS TRANSPORTATION LABORATORY SCHEME FOR TRANSATLANTIC STUDENT TEAM PROJECT WORK, MODIFIED AFTER [10]

When transatlantic students are logged in, the web server redirects students to either the Alabama ATIM or the modified Hamburg ATIM transportation models. Data exchange occurs according to the simple request-response method. The HTTP client of the student project team member sends a request to the HTTP server that processes it and returns the response. Transatlantic student project team members and the server establish a connection via the Ethernet interface for data exchange. Students can access to the ATIM and are allowed to change parameters and/or the transportation chain model itself. All experimental data can be exported for further studies.

Instructors and student project team members at Huntsville and Hamburg can access all experimental data for discussing pros and cons. Students also can download the e-learning material. Since the participating student teams at both sites have enrolled in a multi-model transportation seminar, the theoretical knowledge necessary to the experiments are known. After selecting the respective transportation model, the students can start with their case studies, which can be scenario examples or infrastructure planning and solutions. Students can download the Alabama VITS model to run a simulation as shown in Figure 4.

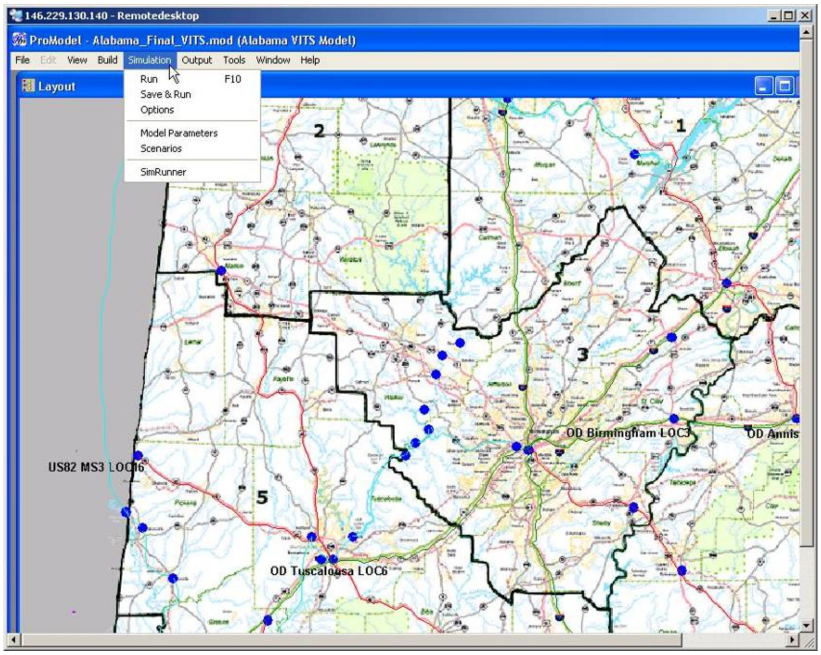
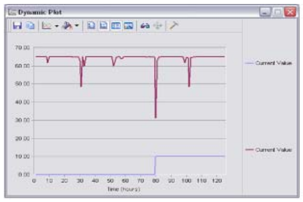


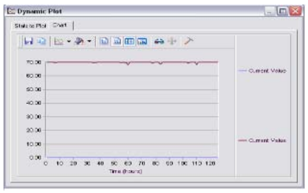
FIGURE 4
ATIM FOR ALABAMA

Truck Traffic to Mobile Along I-65	3839
Truck Traffic from Mobile Along I-65	3838
Truck Traffic to Mobile Along US-43	1467
Truck Traffic from Mobile Along US-43	1466
Truck Traffic Passing Through Mobile Along I-65	2197
Truck Traffic Passing Through Mobile Along US-43	499
Truck Resolution Factor	15
Warmup Period (Hrs)	6
Run Time (Hrs)	120

TABLE 1
EXPERIMENTAL DATA STORED ON THE DATABASE FOR A DEFAULT SIMULATION RUN



US 43



I 65

Road Link	Truck Entities Traveling Out of Mobile	Truck Entities Traveling Into Mobile	Total Truck Entities On Road Link	Simulation "Daily" Average
I 65_Net 6	4454	4073	8527	25581
US 43_Net 28	1602	1515	3117	9351

FIGURE 5
VIEW ON THE DEFAULT SIMULATION RUN

When students select a specific objective like traffic moving to/from Mobile along Interstate 65 and US Highway 43, they find experimental data stored on the database to run a default simulation as shown in Table 1. The outputs of the simulation allow interpretation of the chosen scenario through dynamic plots, Excel outputs and graphs shown in Figure 5.

Based on the simulation results the transatlantic student team has to answer the question as to what happens if truck traffic moving to/from Mobile along Interstate 65 and US Highway 43 triples, changing the data stored on the database as shown in Table 2.

Truck Traffic to Mobile Along I-65	11517
Truck Traffic from Mobile Along I-65	11514
Truck Traffic to Mobile Along US-43	4401
Truck Traffic from Mobile Along US-43	4398
Truck Traffic Passing Through Mobile Along I-65	2197
Truck Traffic Passing Through Mobile Along US-43	499
Truck Resolution Factor	15
Warmup Period (Hrs)	6
Run Time (Hrs)	120

TABLE 2
EXPERIMENTAL DATA STORED ON THE DATABASE FOR A TRIPLE TRAFFIC SIMULATION RUN

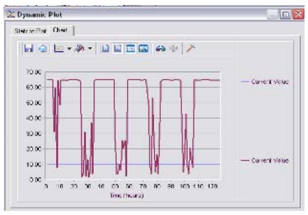
The results of this student project are shown in Figure 6.

Comparing the results from Figures 5 and 6 the transatlantic students are able to discuss whether or not another lane will solve the congestion problem for the planned scenario.

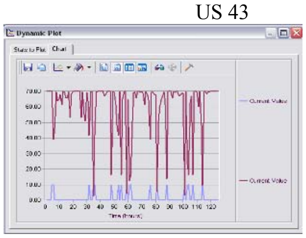
HAMBURG TRANSPORTATION MODEL

The traffic M&S environment of metropolitan Hamburg is based on the following criteria [21], and shown in Figure 7:

- simulation and performance evaluation of traffic flows;
- customization of traffic network in terms of topology (i.e. nodes/ links) flow offered per origin-destination-route, link speed, lane numbers, and capacity;



US 43



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Road Link	Truck Entities Traveling Out of Mobile	Truck Entities Traveling Into Mobile	Total Truck Entities On Road Link	Simulation "Daily" Average
I 65_Net 6	4454	4073	8527	25581
US43_Net28	1602	1515	3117	9351

FIGURE 6
SIMULATION RUN ASSUMING TRIPLE TRAFFIC

- customized parameters for scenario planning and evaluation (e.g. increasing number of lanes, speed limit, etc.);
- multi-modal support; and
- traffic flow visualization.

The discrete event traffic simulation for metropolitan Hamburg includes road, rail, and waterway modality, combining the aspects of microscopic and macroscopic traffic simulation. Microscopic traffic simulation deals with:

- traffic situations;
- road conditions;
- inter-modal following behavior;
- inter-modal velocity profiles;
- interaction profiles of inter-model traffic participants;
- lane changing; and
- dangerous traffic situations, etc.

Macroscopic traffic simulation deals with:

- level of abstraction of the traffic control flow, modeled based on network theory;
- higher efficiency due to simple analysis of existing meshes and nodes;

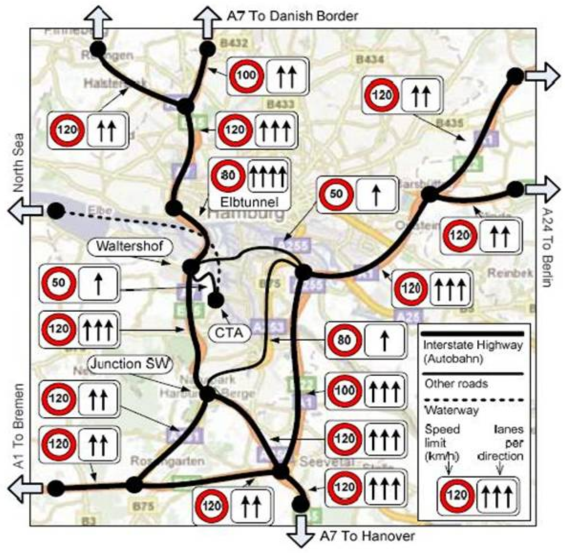

FIGURE 7
MODIFIED ATIM MODEL FOR HAMBURG WITH THE CONTAINER TERMINAL ALTENWERDER (CTA)

- simple models, with detailed resolution not considered; and
- results obtained from these models showing traffic control flows with no consideration on detailed individual transportation units.

The Hamburg traffic network is interpreted as graph, consisting of nodes with a short description and their geographical position (e.g. interstate highway junctions and exits as well as plants and ports and other locations important for freight traffic) and links (road, rail, or waterway segments each of which connect two nodes), as shown in Figure 6. Trucks are modeled individually, i.e. attributes including current location, destination, and speed are assigned. Trucks stochastically appear at any node, their interarrival time is exponentially distributed with a higher mean during daytime than at night. Each truck traverses a fixed route, i.e. a sequence of road links that depends on the origin-destination node pair assigned to the vehicle. A truck that reaches its destination node is removed from the system.

The calculation of the speed of a truck along a road segment derived from microscopic vehicle interaction which was first described by the Bureau of Public Roads [22], where speed depends on the (macroscopic) parameters road capacity and utilization. The speed assigned to a link (from which truck speeds are derived by sampling a normal distribution) during the next period (e.g. one hour) is set such that the expected travel time $\hat{t}_i$ required for traversing the link amounts to

$$\hat{t}_i = t_i \left[1 + \alpha \left(\frac{x_i}{C_i} \right)^{\beta} \right]$$

subject to free flow travel time t_i (constrained e.g. only by the relevant speed limits), link capacity C_i, and flow during the last period x_i. Parameters α and β are set as suggested in [23]. The flow x_i is measured in terms of passenger cars and estimated by counting trucks entering the link since the last speed update, applying an equivalence factor of 2.5 passenger cars per truck. Non-freight passenger car traffic is not modeled explicitly; the flow x_i is chosen such that trucks account for 25% of the overall traffic.

The truck travel time is dominated by the traffic conditions on the link (e.g. traffic density, speed limit, etc.) and not by the nodes. Hence link speeds are updated every 7.5 minutes instead of every hour as done in [24], reflecting that link lengths in metropolitan Hamburg model are shorter than in the original Alabama transportation model, so that the probability of an update conducted while a vehicle passed a link are approximately the same as in VITS/ATIM.

Link capacity depends on the type of road, speed limit and the number of lanes and varies between 2200 and 2400 passenger car units per hour per lane as suggested in [25]. In contrast to road traffic, rail, and water modes are derived from traffic density influencing travel times. Trains and vessels always traverse links on their route at desired (maximum) speed; i. e. rail tracks and rivers capacities are assumed to suffice for any rail and barge traffic offered.

Application to the metropolitan Hamburg area is a complex approach for M&S evaluated traffic scenarios. Because the Alabama state-wide models based on VITS are considered still valid in a smaller scale metropolitan area as long as trucks travel time is dominated by the traffic conditions on the link (e.g. traffic density, and speed limit) and not by the nodes: A vehicle at a node is always assumed being able to immediately switch to the subsequent link. This is typically valid for Interstate Highway junctions yet not necessarily true e.g. for downtown urban areas with nodes (i.e. traffic lights) restricting trucks ability to leave a link. Hence, making use of the state-wide models based on VITS for metropolitan Hamburg necessitate to include the existing road, rail, and waterway infrastructure on the one hand and to expand this infrastructure in conjunction with the traffic expected in the future. This is based on the specific situation that the port's container terminals are located close to the centre of the city, which requires interweaving lanes for freight and individual traffic flows, was constraints for the transatlantic student team projects. Hamburg faces significant freight traffic passing through the city, e.g. from Scandinavia to Western and Central Europe. The river Elbe tunnel (connecting Interstate highway A7 that links the Danish border to Central Germany) provides the westernmost crossing of river Elbe through the river Elbe tunnels.

Student projects provided the ability to investigate such scenarios of planned future network configurations and expected load through simulation. Evaluation typically includes performance measures like vehicle travel times, link speeds or throughput, yielding a valuable decision support tool in urban planning by offering judgment whether intended extensions to the traffic network are sufficient with respect to given target performance measures or further enhancement are necessary. This helps to develop hard- and soft-skills of the transatlantic student team project members while working and deciding on real world problems.

Figure 7 depicts the Hamburg network, consisting of 16 nodes (of which seven are network boundaries) and 18 links. Most of the nodes denote interstate highway junctions or exits. In this coarse topology (that does not claim to reflect a level of detail sufficient to produce valid results), the port is represented by the Container Terminal Altenwerder

(CTA) only to keep the project simple. Moreover, any sea-borne container arriving or departing the CTA is assumed to be fetched or delivered by a truck, requiring intermodal transfers at the CTA.

Table 3 shows the simulation results for a 24-h run based on the transportation infrastructure network shown in Figure 7 for two fundamentally opposed transfer situations. Assuming a default value of traffic (case study 1) results is in the expected average speed close to the speed limit of 120 km/h. For maintenance reasons lanes per direction are reduced from 3 to 2 lanes on link Waltershof-Junction SW on interstate highway A7 for river Elbe tunnels (case study 2) results are in the expected average speed below to the speed limit of 80 km/h. Table 3 entries are mean ± standard deviation of the measured variables

Scenario	Av. travel time all vehicles (hours)	Av. travel time CTA-A7 south vehicles (hours)	Av. speed Waltershof-Junc SW (km/h)	Av. Trucks on Waltershof-Junc SW (number)
Default	0.41 ± 0.09	0.36 ± 0.07	117.3 ± 11.0	48 ± 22
A7 lane closure	0.45 ± 0.11	0.43 ± 0.09	68.5 ± 15.7	90 ± 54

TABLE 3
SIMULATION DATA FOR RIVER ELBE TUNNEL TRAFFIC SCENARIO STORED ON THE DATABASE

From Table 3 it can be seen that the A7 link Waltershof-Junction SW is highly congested (average speed dropping by almost a half), the mean travel time of vehicles passing this link, e.g. from CTA onto A7 southbound, is increased, which yields more trucks on the link at the same time. Likewise, standard deviations of link speed and affected vehicle travel times have increased, indicating a higher sensitivity to perturbations in traffic demand, A24 to Berlin and A1 to Bremen North Sea, which form the base for ongoing student project work on different scenario planning and analysis to optimize the transportation infrastructure.

Scenario analysis is a methodology that breaks down possible future events by considering alternative possible outcomes, or scenarios. Hence scenario analysis enables improved decision-making by allowing consideration of outcomes and their implications. In so far as pace of change and increased level of uncertainty is concerned, as it is reality on future needs of transportation infrastructure, an enormous interest in scenario analysis and planning can be discovered. This is because scenario analysis is seen as capable of transforming scenarios into perceptions due to the identification of driving forces, predetermined factors, critical uncertainties, implications of different scenarios and indicators to monitor.

Scenario analysis in general is no substitute for a complete and factual exposure of survey error in the respective studies under test. In common prediction, the data given are used to model the problem under test, with a reasoned specification and technique. The analyst in-charge with the respective analysis is duty bound, within a certain percentage of statistical error, to state the likelihood of previously specified coefficients being within a certain numerical bound. It should be noted that the exactitude need not come at the expense of highly disaggregated statements of hypotheses of a real scenario analysis, i.e. it has to be considered causal inference, as well as the evaluation of the counterfactuals.

Against this background the scenario analysis in the students' simulation runs for transportation for the river Elbe tunnels contemplates the possible outcomes in metropolitan Hamburg while river Elbe tunnel tubes are closed for maintenance, reconstruction work or demolition through an assumed terrorist attack that may destroy all tunnel tubes. Therefore, thinking about how to respond to the consequences of the hypothesis results in simulating the different scenarios and different responses, in order to consider the likelihood of each scenario. This is the essential issue for real scenario analysis.

Based on what is perceived would be the outcome of each and the basis to plan the next step, which finally require testing to perceive a good scenario that is:

- plausible to decision-makers/stakeholders;
- internally consistent;
- relevant to topics or issues of interest;
- recognisable from data/signals;
- challenging; and
- surprising or novel.

Scenario planning is necessary to understand likely future trends to make strategic decisions based on an analysis of the consequences of the most likely scenario. Such contemplation at least results in the following topics that have to be taken into account in the transatlantic student team projects:

- key questions;
- time and scope;
- stakeholders;
- uncertainties;
- extremes of possible outcomes; and
- disaggregated statements.

A traffic network model was developed by the transatlantic students, based on a modified version of VITS (Virtual Intermodal Transportation System), that supports multi-modal traffic and provides reasonable tradeoff between macroscopic computational efficiency and microscopic/agent-oriented accuracy, but requires data sometimes nearly impossible to obtain or unknown [26]. This requires embedding the parameter identification approach for initial parameter estimation [27].

Parameter estimation of immeasurable or unknown system parameters was done using a transportation model, and adapting its parameters. In fact only the model structure has to be known to build the adaptive model. Initial parameter values themselves are guessed, for instance, on some a-priori knowledge on the transportation system under test. The type of model structure and the parameter estimation method chosen for identification purposes are of essential importance for the accuracy of the estimates, as shown in Figure 8.

From Figure 8, the parameter-identification methodology can be considered synonymous for statistical and numerical procedures to obtain reasonable values for model parameters or data. The classical method is the linear regression technique, because it's easy to handle; hence, linear regression has long been established as a convenient tool for analyzing data of dynamic systems. The diversion of using linear regression methods has led to an overemphasis on linear relationships. The relationships of real-world systems – or data – are nonlinear and linearization is nothing more than an approximation with a limited scope. Statistical program packages are available with routines for solving nonlinear regression problems. Parameter estimation provides the link between data and models, in other words, between statistics and simulation and is used for getting deeper insight into the physical structure of real-world dynamic system under test.

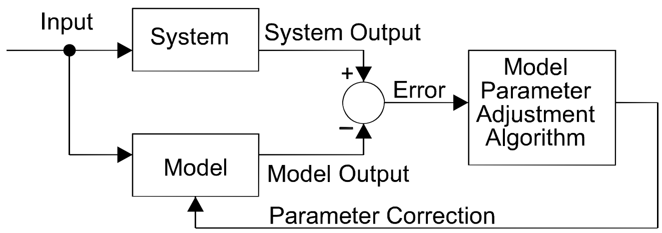

FIGURE 8
PARAMETER ESTIMATION USING AN ADAPTIVE MODEL

WEB-BASED REMOTE ACCESS

The Web-based remote access workbench for transatlantic student teams consisted of client users, transatlantic student team members, a Web server with the developed transportation models and an Internet connection. The transatlantic student team members as client users access the transportation model workbench via a Web server. The architecture is shown in Figure 3. Transatlantic students can simultaneously access the Web server as clients and use the embedded e-Learning transportation learning objects on the web.

The transportation workbench consists of real transportation models. The transatlantic students can access the models using a password protection feature, as described above in the Introduction. Time zone differences put Hamburg six hours ahead of Huntsville; hence, transatlantic student team project work had to be scheduled for students at Hamburg between 2 PM and 5 PM and for Huntsville students between 8 AM and 11 AM. Project work typically started with a project team meeting discussing the actual scenario planning and analysis for the day. The team members adapted the transportation model to the decided problem and run simulations to find an optimal solution that had to be interpreted and discussed as part of the common student project work.

EVALUATION

The distance education workbench on transportation offers a complementary e-room for real transportation infrastructure measures. Such a workbench is of importance in today's inter- and multi-disciplinary online education and training opportunities at schools and in industry because of the embedded lab work. Transatlantic student project team members have enrolled in a multi-model transportation seminar at their home campus to gain the knowledge necessary to perform student team projects via the Internet. Each student team must perform M&S of transportation systems and must interpret and discuss the results obtained by simulation. This real learning occurs only because student team project members are familiar with scenarios. Scenarios come to life. The student team interacts with the conceptual information built into the scenarios to broaden their skills. Besides this different conceptual skills of student project team work, culture, accountability, etc. are woven into the design of student team projects. So student project team members make decisions, solve problems, make mistakes, and finally have access to an expert as required to answer questions and to give them advice. Moreover, using the remote access transportation laboratory has a significant impact on student team project work efficiency and efficacy because access is possible independently of regular office hours.

CONCLUSION

This paper presents an M&S based distributed education and training workbench on transportation for inter- and multi-disciplinary online learning opportunities embedding project based lab work via a Web-based remote access. Such a workbench is of interest for vocational education at the academic and industrial sites. Besides this group of students, handicapped students are another target group because mostly labs are not endowed handicapped accessible. Both groups, handicapped and non-handicapped, are able to access lab experiments online without any need to adjourn to the lab.

In addition to the spatial flexibility, temporal flexibility is another advantageous feature. This is an important consequence owing to the essential concept of today's needs for life-long education. This is achievable only if the study platforms offer flexibility which means independence from location (space) and time. Henceforth, learning opportunities must be integrated within existing daily workload without any major difficulty; therefore, in the foregoing described research work, a model workbench for transportation case studies was developed based on the VITS system. The VITS system has been adapted for the state of Alabama and the metropolitan Hamburg transportation infrastructure. The main advantages of the transatlantic student team project work are:

- transatlantic students use real transportation infrastructure networks for M&S;
- access to the transportation workbench was not restricted by time; students can access the virtual transportation laboratory on or off the home university campus;
- username and password protection were added to permit access to the virtual transportation laboratory only for authorized users; and
- remotely accessed virtual laboratories can be offered to students on a global scale, allowing the establishment of a borderless and complete education curriculum in several specific domains.

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