Game Engines: Tools for Landscape Visualization and Planning?

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Summary

The fast growing market of computer games forces the development of constantly improved software and increasingly powerful hardware. Meanwhile many of the computer games can simulate virtual environments, e.g. synthetic landscapes, extremely close-to-reality in real-time on PCs or game consoles. This rapid development in computer game technology is almost unnoticed by the users of professional CAD-, GIS-, and illustration software. While many of these games are objectionable because they glorify mindless violence, landscape planners should have an eye on these developments because some components of the software may be useful for their purposes. Can these low-priced tools be applied for landscape architects and planners, e.g. to support collaborative landscape planning?

The authors discuss options and limitations of game technology for landscape visualization, and present a preliminary example within a collaborative landscape planning process.

1 Introduction

Planning landscapes takes place somewhere between fixed rules, the freedom of choice and random. *Fortuna*, the goddess of fortune and destiny, exerts her sphere of influence in the realm of the gamblers, and beyond. Successful landscape planning (while possibly *engaging* even more *Deities*) is relying upon the team play of the actors: stakeholders and the public. More playful elements within the participation process could attract them and last but not least the so-called "computer kids", could boost the acceptance of the planning.

Since the earliest civilizations games involve landscape metaphors, figures and signs, especially map metaphors, e.g. go, chess[1]. Others like golf and even marble game use landscape as a (play-)ground and stage. Planning can be interpreted as a complex strategic game which borrows from parlor games, games of chance, role-playing and storytelling. While there are a lot of computer game genres inspired by traditional games, today's 3D computer games offer scenarios from possible and fantastic worlds, or stage reality as a game (BAUMUNK & KAMPMEYER-KÄDING, 2000). *Discreet*, the maker of *3D Studio*, proclaims in spring 2001: "Like Survivor and Temptation Island on TV, next-generation games are all about reality. Real characters, real physics, real materials, real fun". The entertainment industry and especially the computer game branch have become the "draught horse" in developing technological solutions to landscape visualization. Meanwhile state-of-the-art 3D games already meet very high standards of visualizing landscapes.

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[1] interestingly a pawn in German is called "farmer" ("Bauer")

3D game design and landscape planning share the interdisciplinary approach and the need of visualization. The question comes up how landscape planners and the planning process could benefit from this technical progress, and how can game technology be implemented in computer-assisted collaborative landscape planning?
The starting point was a "Feasibility Study of a Visualization Tool"[2] conducted by the ZALF (Centre for Agricultural Landscape and Land Use Research). Aims of the research project were:

- to get an overview about available software for 3D landscape visualization,
- to assess and determine the requirements and the potential demand of 3D landscape visualization tools by interviewing planning offices, planning authorities and visualization service providers in Germany,
- to outline a collaborative landscape planning process assisted by interactive visualizations, e.g. by testing game technology.

This paper considers possibilities of 3D landscape visualization, gives some backgrounds of 3D game technologies, and discusses their use with the example of a collaborative landscape planning process.

2 Material & Methods

2.1 Approach: Computer graphics-assisted collaborative landscape planning

In the field of architecture, drafting in a 3D CAD environment and visual simulations are already widely used. High-quality visualizations are persuasive means of advertising, and they might be used to optimize the design. It is well known that it often is not easy for a layman to read maps, but what is the surplus of 3D visualization in landscape planning?
The cost-benefit analysis is different, because it is not about "selling houses or gardens", and the costs and expenses are normally strictly limited. It is questioned that non-interactive of pre-rendered walk- or fly-throughs with a predefined route are worthwhile in landscape planning. BERGEN et al. (1998, p. 289) state that "data-driven models have been too abstract to serve as the basis for visual quality decision making". The pros and cons of image manipulation have been already discussed (e.g. BERGEN et al., 1998). All these methods prevent one from understanding the context of an image, "grasping the spatial characteristics of a scene" and the ability of "looking around and moving about" (DANAHY, 2001). Stakeholders are no more than spectators.
Professional landscape visualization software does not seem to take full advantage of the rapid developments in computer graphics. If e.g. stakeholders and planners could walk in a virtual 3D landscape metaphor they could get a much better idea of what it looks like. Bird's eye-views offer a good overview, but do not come up with the common landscape perceptions. A visualization from a pedestrian's eye-view (stroller's or driver's eye-view etc.) is close to the everyday landscape experience. This technology is available through game software, but has not been implemented into landscape visualization software.

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[2] "Machbarkeitsstudie für ein Visualisierungstool", visit: http://www.zalf.de/dbu-vis/

Immediacy in the medium, 3D and continuous real-time movement (navigation) are essential to mediate the experience by computer graphical visualization.

Other significant qualities are the near-immediate visual feedback to design and conceptional suggestions or iterations, and the ability to change the compositional characteristics (DANAHY, 2001).

Fig. 1 and 2 sketch a concept of interactive 3D visualization systems for collaborative landscape planning and decision support. The system enables stakeholders and the public to visually explore plans, debate solutions, choose between options or suggest alternatives and add annotations in 3D views. Virtual measures can be selected or modified within the available decision space. The first scheme shows individual users who can meet with others virtually via Internet PC. The model is derived from multi-player games. With such a kind of a system the landscape planner has the possibility to evaluate responses to the users' input.

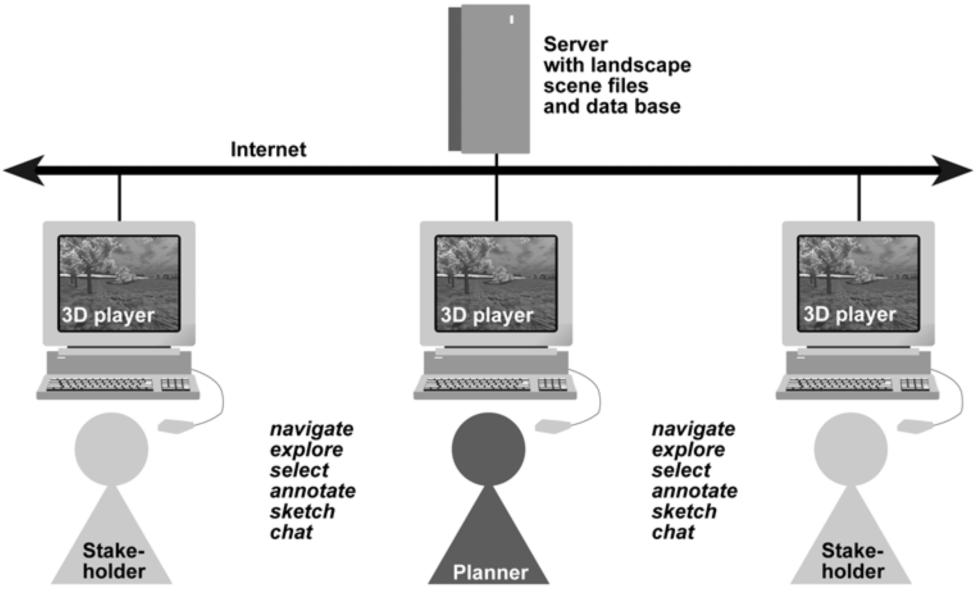

Fig. 1: Scheme of networked stakeholders using an interactive 3D landscape visualization player

Fig. 2 outlines a public planning forum conducted by a moderator or mediator. The "Chauffeur" navigates a group through projected 3D landscape metaphors, selects objects and sketches onto maps or terrain. The landscape planner ("Operator") chooses a visualization and controls the ongoing process. Landscape elements, maps or meta data can fade in or out and the operator can highlight or modify image components. Most importantly, the operator can communicate with the group and give explanations.

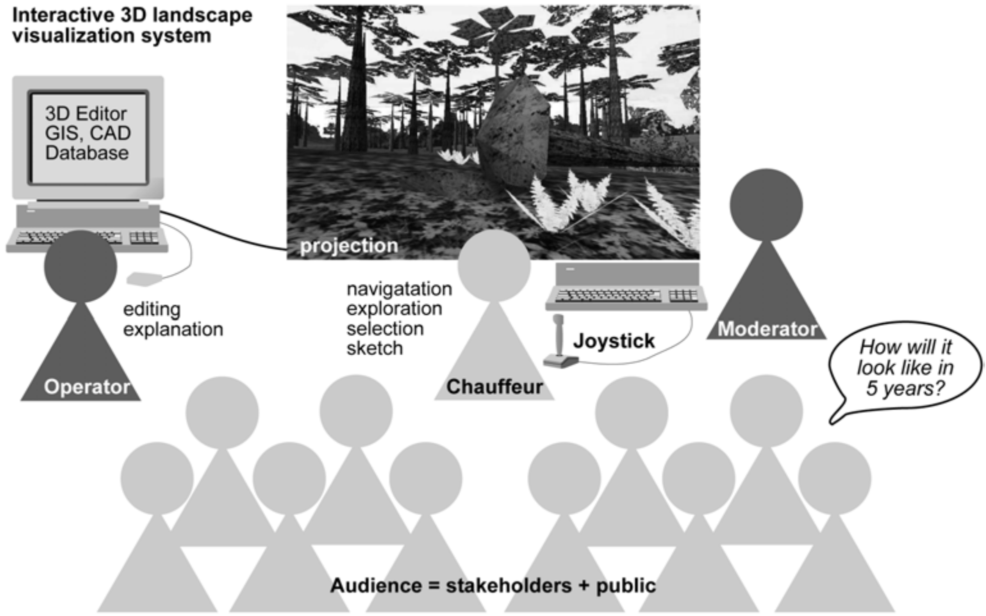

Fig. 2: Scheme of a computer graphics-assisted planning workshop

In this regard there is an interesting quotation from ORLAND et al. (1997), who are calling for an "interactive game-like visualization" to represent ecosystems.

Taking as examples 3D accelerators like the *NVidia GeForce* or *ATI Radeon* series, which focus on 3D games, it is promising to explore game-based landscape visualizations. Game technology and game titles are optimized to support emerging features, e.g. hardware accelerated visual effects and transformations, of these graphics processing units (GPU). These developments turn out to be interesting for architects and landscape planners due to the simplicity to create convincing virtual environments. And it is low-budget, considering that not more than $10 are needed for a game which runs on a today's consumer PC.

There are examples of game technology-based visual simulations in e.g. military, architecture, real estate, archeology and exhibitions. For example, in the project "Virtual Florida Everglades" an interactive visualization and presentation system was developed using *Unreal* game technology (see below) to educate the public and promote ecological awareness of the Florida wetlands[3].

2.2 Excursion: A brief history of 3D gaming

To introduce some basic terminology of 3D games and to outline the technical progress made in the last years, it seems to be useful to sketch the history of 3D games (i.e. TAGGLIAFERRI, 1997[4]). A "game engine" contains the core algorithms controlling a game. It reads controller input from the user, drives characters through game levels, fabricates behavior, generates sound at specified times, and generates real-time display. Meanwhile,

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[3] visit: http://digitalo.com/deleon/vrglades

[4] see also: http://www.gamedev.net/dict

hundreds of 3D game engines have been developed with a lot of them being used in more than one game title[5].

Early computer games like *Pong*, *Space Invaders*, *PacMan* or *Donkey Kong* showed a flat virtual 2D environment. The view was from above or from the side.

While computer graphics have improved over the years a new game genre was created, the “3D Shooter”, “Ego Shooter”, or “First Person Shooter” (FPS). Some of theses ground games have 3rd person display modes, but allow the full navigational freedom of a 1st-person point of view. The player is represented by a virtual figure, an “avatar”. The avatar’s movements are restricted by “physics” (e.g. “terrain following”, “collision detection”).

Some of the first FPS were *Wolfenstein 3D* and *Catacomb Abyss* in 1992. Although the player’s view was 3D-like, the virtual environment was not. For example, all the walls had the same height and were orthogonal to each other. There were no stairs, no ramps and no pits. Also the lighting was the same everywhere in this virtual world. Objects and enemies were represented by flat bitmapped graphics, so-called “billboards”, which always turn their front to the player.

At the end of 1993 a FPS was released to become the most popular game of that genre: *Doom*. Until then no other game could pretend a virtual interactive environment to that quality, which gave the player a feeling of immersion. The technical improvements were non-orthogonal walls with different heights, vertical movable areas (like elevators) and different lighting, which conveyed a much more realistic atmosphere. Other main innovations were the ability to play the game with multiple players by networked computers and to extend the game with “level” editing tools. Levels are the 3D environments in which game are played and include the geometry and textures, static or moving elements and terrain. A “level editor” is a 3D CAD-like tool for game level design and tuning. Almost instantly a user community established itself on the Internet to interchange self-made game levels as well as its know-how in level editing. *Doom* had some limitations relating to the 3D representation: Mainly no part of the level could be built directly under or over any other part, which meant that no bridges or catwalks could be constructed. Also no inclined floors or ceilings were possible.

In early 1996 further improvements were seen when *Duke Nukem 3D* was released: The ability of representing sloped floors and ceilings made it possible to construct various architectural elements. Other limitations remained until late 1996, when *Quake* was released. In *Quake* there were no more limitations in geometrical constructions except the maximum size of a level. Bridges could be build as well as rooms above other rooms. Every object could appear in an individual three-dimensional shape, whereas virtual creatures could be animated. Dynamic lighting performed realistic shadows and various light effects. With the successor, *Quake 2*, released in late 1997 these features were improved furthermore. One of the new features that the player could interactively move or destroy objects like boxes. *Quake 2* was the first FPS which made consistent use of 3D graphics application interfaces (API).

Unreal featured stunning graphics when it was released (1997/1998). The game used a different technique to process level geometry, which made it possible to build larger outdoor areas. Also the color depth, i.e. the number of the usable colors was significantly raised, so the representation of the virtual environment became more natural. *Unreal* was

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[5] see e.g.: http://cg.cs.tu-berlin.de/~ki/engines.html (not up-to-date)

one of the first FPS which was shipped with a level editor. Along with the *Unreal* engine's extensible C++ core, a scripting language was implemented to control and manipulate internal parameter within the game or add new ones to it.

Today almost every month a new FPS game is being released. Game engines and level editors are distributed with games or sold separately. Many game engines offer Intranet- and Internet-server-based multi-player support including chat features. There are increasing interactions and movement capabilities, which let avatars move, take, leave or change objects within the virtual environments, or which allow avatars e.g. to climb, crouch, swim, dive and fly within the virtual environments. Objects can be with behavior via “artificial intelligence” (AI). AI allows intelligent behavior of characters or other game entities that are not directly controlled by a person playing the game.

Recent technical improvements include large-scale terrain support, procedural character animations, and particle systems to realistically model fire, smoke, cloth, hair, weather effects, and e.g. breaking glass.

2.3 Study site: The *stage* and the *players*

In a case study, the suitability of game engines for computer graphics-assisted collaborative landscape planning was tested within the scope of the “Feasibility Study”. Therefore, an ongoing planning process for the rural areas of Strausberg, a city east of Berlin, was selected. Much of the area is considered of high quality for nature, and the Centre for Agricultural and Land Use Research (ZALF) had already been involved in scientific consultation within this planning. The city of Strausberg is searching for ecological measures to compensate the loss of habitats due to construction. A landscape planner was commissioned to conduct the participation with stakeholders, suggest adequate measures and following procedures like e.g. the reallocation of farmland. The main stakeholders were the administration of the community, the landscape planner, local farmers, landowners and the inhabitants of Hohenstein, a small village in the rural area, the administration for nature conservation, nature conservation activists and researchers from ZALF. The involvement of the landowners and the tenants is essential because most of the potential compensative measures rely on their consent.

The study site for the visualizations with an extent of 6 ha is located in a small valley (depression) at the outskirts of the village of Hohenstein. The main ecological problems are soil erosion on the arable land at the slopes and nutrient accumulation in small ponds (pot holes) which are important for amphibians.

Three land-use planning scenarios were built: “1 – low-input agriculture”, “2 – recreational and agricultural landscape” and “3 – natural succession to forest”. Five levels were built: the status quo (“0”), the three scenarios and finally, as a result of the collaborative planning process, one 3D plan.

The existing landscape plan featured few statements concerning the study site. Biotopes had to be mapped so that enough detailed data were available for the visualizations. Photographs were taken to document the status quo and build a texture library for the level design.

2.4 Techniques: Creating levels

The *Unreal* engine (1) was used to create the landscape visualizations for the study site. At first terrain data was prepared using *ESRI ArcView* with the *3D Analyst* extension.

The resolution of the digital elevation model (*GRID* file) had to be reduced from 2 m to 5 m in order to reach the required real-time display subsequently. The terrain grid was exported to *AutoDesk's DXF* file format and could then - after some modifications - be imported to *Unreal*'s level editor. Photo-based textures were mapped on the terrain to represent the ground and the lower vegetation layer. Cattail, fern and shrubs and hedges were modeled using simple polygons and textures to enhance the three-dimensional impression. Trees were 3D modeled and imported.

Each level starts at a virtual board with some background information. The pot holes were covered with a water sphere, which had an animated surface and could produce a splash sound when an avatar jumps in. Virtual midges, dragonflies and a flying raptor at the firmament were added and animated.

A "sky-box" was created with a virtual sun, moon and moving clouds as well as a horizon metaphor. The horizon was taken from a *Quicktime VR* panorama taken at the site. Also fog or haze effects may be defined as well as rain or snowfall. Finally the virtual scene has to be lightened up when representing a daylight environment.

Generally every virtual scene to be visualized is preprocessed, in other words the files that contain all scene information run through a compiling procedure. First the level geometry is split off i.e. every surface is divided in squares and triangles as well as the empty space is divided into so-called "leafs". Then a "binary tree" is built to arrange all the elements. Next a light map respectively a shadow map is generated which contains all implemented lighting information. Finally a "potential visibility set" (PVS) is computed to help the engine to decide what element to draw or to skip in the view. Complex scene objects as well as terrain can be set with different levels of detail (LOD) which decreases with increasing the view distance. Most important is a careful level design considering the technical limits of displaying a complex geometry with a high number of polygons in the view. When the number of polygons is rising, e.g. in complex sceneries, the "frame-rate" decreases. If the frame rate falls below 25 frames per second the display gets *jerky* and the impression of continuos movement is lost. For example, the *Unreal* engine and the hardware could not sufficiently display the complete forest scenario (3); thus the number of trees had to be reduced.

Compiled levels can be explored in the game engine's stand-alone 3D player in real-time.

Beside the *Unreal* engine *Conitec's A5* engine[6] was tested for landscape visualization later on. It can theoretically handle outdoor areas up to 15600 ha (*A5*) unlike the *Unreal* engine which can display 270 ha (*Unreal* 2 will display up to 1070 ha). With the *A5* level editor terrain can be generated via "greyscale height-fields" – thus *USGS DEMs* can be used. The *A5* engine's main advantage is the possibility to build executable programs from the finished level map, which can be freely distributed; *Unreal* engine-based levels need the game to be installed.

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[6] visit: http://www.conitec.net

3 Results

The city of Strausberg invited the stakeholders and the inhabitants of Hohenstein for a planning workshop concerning their environment. The workshop character was emphasized by the number of participants (20). First the status of the whole landscape planning for the rural areas of Strausberg was described by the landscape planner in a conventional manner (maps etc.). Then the ZALF presented the study site, the idea of a computer graphics-assisted planning workshop (cp. fig. 2) and the procedure.

The status quo was shown by *Quicktime VR* Panoramas, a digital aerial photo, a digital map and the *Unreal* engine-based visualization. Then the three scenarios were presented, each with a digital map, the underlying suppositions and the *Unreal* engine-based visualization.

After a first visual exploration of the levels the participants were requested to give individual incitements and to discuss the consequences of the supposed land use changes.

The concerned farmers agreed in principle to a low-input agriculture like it is pointed out in scenario 1. Especially scenario 2 got common consent because of its scenic and recreational qualities within a still agricultural landscape. Some inhabitants did not understand the difference between a scenario and a plan. Particularly the forest scenario (3) was understood as a “horror scenario”.

Older participants were remembered by the visualizations of historical conditions and occurrences, e.g. liquid manure, which had been dumped into the pot holes. Some measures were accepted in principle, e.g. the distribution of the set-aside land around pot holes as buffers and habitats. The participants proposed locations for trees and tree rows and discussed cultivation issues. One part-time farmer would like to acquire pastures for livestock husbandry of deer or horses.

In the end of the workshop, the participants were asked about their individual opinion concerning the quality of the visualization and workshop in general. The experiment was acclaimed by the participants. The limited interactivity and immediacy was criticized to visualize spontaneous ideas of the forum, while the improvable image quality of landscape representation was not discussed. The ZALF was invited by the stakeholder and inhabitants to repeat these kind of workshops, and the head of the planning administration asked for a presentation of the visualization at the city hall.

After the workshop, the landscape planner and the ZALF evaluated the discussed ideas concerning the development of study site in the context of the ongoing planning process for the rural areas of Strausberg. Finally a 3D plan level for the study site was built.

4 Discussion

The computer graphics-assisted planning workshop has contributed significantly to increased public interest in the ongoing planning process. Local knowledge was contributed to the planning. Ideas and memories of the landscape were triggered by the visualizations.

Collaborative landscape planning could become more attractive and persuasive to people by using these kinds of landscape visualizations. Young citizens, to whom computer technology belongs to every day life, seem to appreciate this approach. This might not be a temporary phenomena while it is new and unusual in landscape planing. People are already becoming familiar with computer graphics. The demands for visualizations and presentations are rising. Landscape visualization has often been done for spectacular sceneries or visual (environmental) impact assessments. In general, visualization should be used as a planning tool that facilitates understanding, conceptualization and implementation of planning targets like protection of species. The involvement of the stakeholders and the public could lead to a better accepted planning and their translation into action. Further studies are necessary to analyze and assess these advancing technological developments and procedures.

Using 3D game engines for landscape visualization requires a fundamental knowledge in 3D designing. Also a working strategy in level design is necessary due to the game engines restrictions and performance issues. Trial-and-error methods are often necessary to import terrain, 3D objects, and other external data from CAD or GIS software. On the other hand 3D game engines are versatile and low-cost tools, and a worldwide user community provides help and resources via Internet[7].

The close and 3D views imply the need of more detailed data than in a common 2D plan or new techniques for abstract 3D representations. Further research and programming are necessary to add missing features, to simplify, and to extend a professional use of game engines in landscape planning. These features include:

- GIS interface (*ESRI Shapefile, GRID, TIN*),
- geo-reference,
- interactive orientation functions like a compass metaphor or an indirect navigation via overview map,
- *ODBC* data base interface,
- interactive selection functions like 3D picking of objects,
- interactive analysis functions like length measurement,
- interactive editing functions like user controlled addition or removal of plants and other objects within the decision space in 3D view,
- interactive configuration functions like the ability to change the virtual environment conditions in 3D view to simulate different daytimes, seasons or weather conditions,
- improved plant and vegetation representation (biotopes, vegetation layers, dominant plants),
- data-driven plant distribution on the terrain to arrange plants automatically in an assigned area at correct altitude.

5 Conclusions & Outlook

3D game engines are interesting and low-budget alternatives to professional 3D landscape visualization software. They are optimized for real-time navigation in a virtual environment and are suited to generate views of the scenery likewise a pedestrian's eye-view in "real reality". Features like artificial intelligence and multi-user support are essential to build an interactive system for collaborative landscape planning. However professional features like a GIS- or a database interface are still missing, and the realistic representation of the vegetation is lacking. There are signs of further improvements. The entertainment industry

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[7] e.g. http://www.planetunreal.com/unrealed

is interested in the landscape theme (terrain, vegetation etc.). Both landscape planning and the entertainment industry could benefit from this concern to produce realistic games and tools for professional landscape visualization. For that purpose landscape planners (among others) should offer their professional knowledge of real landscapes and the specific needs for interactive landscape visualizations.

The feasibility study is setting up an interdisciplinary research project: The development and implementation of a user oriented communication tool for data-driven 3D landscape visualization. Special features of this interactive tool consist e.g. in generating views of the scenery with persuasive representations of the vegetation on a scale of local landscape planning as seen by a pedestrian in real-time running on PC hardware.

It is promising to further explore and test impacts and possibilities of computer graphical assisted landscape planning while the technology is further advancing.

Acknowledgement

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[8] visit: http://www.dbu.de