Person/Object Recognition, Warning in Danger Areas

Camera and Sensor Systems, Intelligent Software for Mobile Machinery

Safety and efficiency in the use of Non Road Mobile Machinery (NRMM) and commercial vehicles – Guideline for operators, manufacturers and supervisors
Netzwerk Baumaschinen | NRMM

The Network for Non Road Mobile Machinery supports the quality of processes increasing economic efficiency and safety in the field of application of mobile machines (NRMM – Non Road Mobile Machinery). For tasks of common interest, the network discusses information and creates guidelines in cooperation with involved stakeholders.

Essentially, information and proposed solutions presented in this guideline are applicable for mobile construction machinery, commercial vehicles, machinery utilized in quarries, the ceramic and glass industry. Due to similar technology and comparable hazard potential, vehicles for gardening, landscaping as well as agriculture and forestry are also addressed. Following this introduction, the aforementioned machinery and vehicles are summarized under the term "mobile machinery".

Offensive Gutes Bauen

Offensive Gutes Bauen is a national initiative of the construction industry, which is committed to building quality in Germany. Partners are federal and state governments, business associations and chambers, trade unions, employers’ liability insurance associations, guilds, consumer protection associations of the clients – more than 150 in total. The Federal Ministry of Labour and Social Affairs (BMAS) initiated and supports Offensive Gutes Bauen.

Support Programmes

The institution for statutory accident insurance and prevention, such as BG BAU and VBG, responsible for your business can inform you about funding options for systems mentioned in this guide – see page 39.

The present guide, developed within the network “Person/Object Recognition, Warning in Danger Areas” provides an overview of:

- Camera Technologies,
- Warning and Sensor Systems,
- Software for Terrain and Object Detection,

which, in restricted visibility conditions, can support drivers/operators in a useful way.

Entrepreneurs, executives, works committees, health and security coordinators, operators/drivers of mobile machines – especially of earth-moving machines, manufacturers and builders receive valuable information for a safe and efficient use of mobile machinery.

VISION ZERO.

Occupational safety is teamwork. Since 2018 the network has been a cooperation partner of the BG RCI prevention strategy "VISION ZERO". VISION ZERO pursues a working environment in which nobody will be seriously injured or killed and nobody gets so sick that he’ll suffer lifelong damage.

www.bgrci.de/vision-zero/vision-zero
Content

1 Detecting dangerous situations safely 4
   Vision and attention 4
   Performing a Visibility Risk Assessment 5

2 Vision and visual auxiliary devices –
   Camera-Monitor-Systems (CMS) 8
   2.1 Standard Camera-Monitor-Systems 8
   2.2 Bird/Surround View Camera-Monitor-Systems 10
   2.3 Front Attachment Camera-Monitor-Systems 13
   2.4 Wireless Image transmission 14

3 Person and object recognition –
   Warning and Sensor Systems 15
   3.1 Ultrasonic Systems 16
   3.2 Radar Systems 18
   3.3 Transponder Systems/Wireless Radio Systems/RFID 20
   3.4 3D Camera Sensors 22
   3.5 3D Time-of-Flight Sensors (3D ToF) 26
   3.6 Lidar Systems 27

4 Acoustic warning signals for people in the surrounding area 28
   4.1 Broadband SoundWarner (White Sound) 28

5 Intelligent software for terrain and object recognition –
   5.1 3D Terrain-Mapping 30
   5.2 Robust 3D camera data and intelligent software in mobile automation 32

6 General principles for procurement and operation 34
   Potentials and limits of technical assistive 34
   Determining the mounting site, mounting and adjusting 34
   Signaller 34
   Inspections by the person qualified for the inspection 34
   Vision and functionality check by the operator/driver 35
   Instructions 35
   6.1 Visibility field analysis of mobile machinery 36

7 Rules and Standards 37
   for operators and employers, manufacturers, builders

8 Support Programmes 39
   Retrofitting – support from the employers’ liability insurance association

Legal information 40
Detecting dangerous situations safely

Visibility and attention

During the operation of mobile machinery, deadly accidents and property damage occur repeatedly due to persons and objects in the danger area not being detected in time.

Poor or missing vision cause:
- disturbance of workflow
- stress in affected persons
- increased risk of accidents

First requirement: Provide clear visibility conditions!

Even though visibility conditions of mobile machinery has been improved in the past, design-related blind zones (“blind spots”) remain:
these danger areas can’t be seen directly from the driver’s position!

If the driver does not have direct vision on his working area to spot persons and objects safely, it is a priority to use technical auxiliaries, such as Camera-Monitor-Systems (CMS).

In that sense, even before ordering and after delivery of a new mobile machine, as well as when renting and purchasing an existing machine, it is essential to check whether clear visibility conditions are given.
In case of insufficient visibility, technical measures must be taken first!

Prevention - the best way to avoid accidents

Prevention is the safest method to avoid accidents. Therefore, always conduct a risk assessment regarding visibility before use – see the comprehensive information in the guide "Profis nehmen Rücksicht" at www.safety-machinery.com.
Detecting Dangers Safely

First, optimize seat adjustments for the driver. Then check:

Is direct vision given to the machine’s danger zones?

> Are all necessary mirrors mounted on the machine?
> Are all mirrors adjusted correctly?
> Is there sufficient sight?

If not, use the following technical measures and solutions:

> Camera-Monitor-Systems
> Surround/Bird View Camera Systems
> Warning/Sensor Systems
> Intelligent, active solutions

Always identify possible hazards in the operating area of the mobile machine, implement and document appropriate protective measures according to the “TOP principle”:

> Technical measures always have precedence over
> Organizational measures
> Personal measures

Be careful!
Instruct and use signallers only in specific cases, e.g. confusing situations like loading and unloading or heavy moving traffic.

CHECK:
Examining the given view to the mobile machine’s danger area.

The risk assessment already has to be started before selection and procurement of work equipment. The requirements and criteria for planned areas of application are to be described in detail:

➤ Take into account operational requirements, experience of involved employees and safety technology.

➤ Document results in a comprehensible way.

More useful information in the guide „Profis nehmen Rücksicht“. Download on: www.safety-machinery.com

Performing a Visibility Risk Assessment*

1. Technical measures
Utilize means to improve vision, for example Camera-Monitor-Systems. Check whether and which additional warning/sensor systems for person and object recognition are useful and necessary.

2. Organizational measures
Define and mark hazardous areas, establish rules of conduct (e.g. prohibitions of entry, signallers, security guards or barriers) and their observance and enforce it. Instruct on hazards regularly and observe protective measures.

3. Personal measures
Provide personal protective equipment (PPE), e.g. warning vests - as a supplementary measure – and ensure their use.
Second requirement: Enable the driver staying concentrated

However, nobody can constantly and fully concentrate on monitoring all operating procedures of a mobile machine or a vehicle. The best visibility conditions and additional measures to improve visibility can only be useful that time the driver has a simultaneous and attentive view to all danger areas. Decreasing concentration can drastically worsen the ability to react – possibly with severe consequences.

Identify the causes for fatigue and decreasing responsiveness which include:

- high work intensity, time/deadline pressure
- complex tasks
- completely missing or insufficient hazard assessments
- unfavorable weather and visibility conditions
- ergonomic influences
- fatigue
- high noise levels, dense traffic situations
- monotonous processes
- psychic stress factors*

And prevent in time to enable the driver to stay concentrated.

Additionally use Sensory Warning Systems that support Camera-Monitor-Systems.

The sensory system warns the driver in case of imminent danger. For example, it sharpens the driver’s attention with a clearly audible signal. When looking at the monitor of the Camera-Monitor-System, the driver receives the precise information about who or what has appeared in his operating/danger area.

In most cases a camera is already factory-installed on the mobile machine. Then it is recommended to add a sensory system for counteracting the loss of attention.

Third requirement: Make machines more “intelligent”

Even if clear visibility is guaranteed and active warning systems ensure the best possible attention, many other tasks remain for the operator/driver, reaching far beyond assistance in driving or maneuvering.

Examples of assistance tasks that make mobile machines more “intelligent”:

- Container filling level in the construction sector
- Lane keeping for agricultural machinery
- Intelligent collision warning
- Optimizing machine performance
- Minimizing downtime
- Positioning of pallets
- Warning signal transmission from machine fleets for preventive maintenance
- Supporting safety regulations compliance

These and other automation tasks can be solved with a combination of robust hardware and intelligent software. Vision technologies and robust 3D camera data play a key role here. The evaluated data directly communicates with the machine and on demand up to a central monitoring system, relieving the driver and reducing the risk of danger.
Digitization provides the basis for making machines more intelligent

Whereas camera/sensor systems worked on the same tasks independently of each other previously, (e.g. detection of persons and objects in danger areas) digitalized processes enable new solutions.

Digital processes combine information from several integrated sensors. The simultaneously acquired measurement data of e.g. a Camera*, an Ultrasonic sensor and a Lidar system are also evaluated simultaneously. This superposition of the sensor signals increases reliability in the detection of hazardous situations across a multitude of possible surrounding terrain scenarios. The measurement result then triggers a predefined system intervention:

When danger is detected, the behavior of a system is actively intervened in to protect detected persons and bring the system back to a safe state: for example, by an autonomous braking or evasive maneuver.

Digitization provides the basis to at the same time making machines more intelligent and to increasing automation of business and work processes.

Digitization supports value-adding effects by optimizing business processes. Digitization requires and leads to permanent changes, up to “new forms of cooperation”.

Meaning: Functional Safety

Functional safety is assessed by taking into account generally accepted rules of technology. The primary objective of functional safety is to reduce the risk of personal injury. Functional safety concerns the control system of mobile machines on which a safety-relevant function depends. This is particularly relevant for autonomous accident prevention systems. If the behaviour of a system is actively intervened in the event of danger, this must in any case be evaluated and implemented according to the criteria of functional safety.

Meaning: Industrial Security

With the increasing degree of networking in mobile machines and above all the increasing “openness” of previously internal data/communication networks and components, “Industrial Security” is also gaining in importance. The danger of an external attack and possibility of manipulating software and data is increasing. This can have serious consequences for safety. Industrial security thus becomes the focus of attention at all levels and phases of development and operation. The main objectives of Industrial Security are confidentiality, integrity and availability of data and software functions.

For more information, see supplementary sheet: “Challenges on Functional Safety”, see www.safety-machinery.com

▶ Functional Safety: Protecting people from the machine (occupational safety), constructive measures to make machines safer: When safety-related controls reliably perform their safety functions

▶ Industrial Security: Protection of the machine against third-party attacks; protection of informational technology in industrial plants, machines and systems (see VDMA: “Leitfaden Industrie 4.0 Security”)
2 Vision and Visual Auxiliary Devices

Camera-Monitor-Systems (CMS)

2.1 Standard Camera-Monitor-Systems

Camera-Monitor-Systems (CMS) are auxiliary devices for vision improvement and provide better safety in the work and movement area of mobile machines. They support monitoring of the danger area in front of, behind and around a mobile machine – in the case of machine movement as well as attached component movement.

Please note:

- CMS are not intended to be used for carrying out longer movements (shunting operation “by sight”!)
- CMS are to be used exclusively for monitoring the close range working area around the machine!
**Systems for improving vision and hazard identification**

Anyone operating a vehicle in poor visibility conditions is exposed to significant stress.

For improved vision and faster hazard detection, camera-monitor-systems have been proven effective in the field of mobile and construction machinery.

In addition to rear-view cameras, side-area cameras (see pictures above) can be used to monitor not yet visible danger areas - such as the (right) side of a mobile machine facing away from the driver.

**Avoiding accidents and hazards caused by obstructed vision**

Get qualified advice by a specialist company about the area of application and advantages of the mentioned systems for improved visibility and additional hazard detection.

Receive comprehensive information about important technical and optical requirements for Camera-Monitor-Systems in the guide "Kamera-Monitor-Systeme – sinnvoll und sicher nachrüsten" created by the Network NRMM, containing the following:

- opening angle of the camera
- color fastness of the monitor
- transfer time of the image data
- external influences
- alignment of camera and monitor

The guide can be found here: www.safety-machinery.com

In addition to rear-view cameras, side-area cameras (see pictures above) can be used to monitor not yet visible danger areas - such as the (right) side of a mobile machine facing away from the driver.

Set an end to blind driving when reversing, unloading, swivelling, turning and shunting. A controllable field of view for monitoring the danger area allows a faster, more precise and safer work.

More important information and tips on retrofitting CMS for entrepreneurs, specialist dealers and assembly workshops can be found here: www.safety-machinery.com

In the case of retrofitting, it is crucial to take manufacturer’s specifications for the mobile machine as well as the Camera-Monitor-System into account.
2.2 Bird/Surround View Camera-Monitor-Systems

No more dead angles

Advanced camera-monitor-systems make 270°-360° surround views possible. Their use tremendously optimizes workflow and processes.

Customized systems: quality of camera and monitor play an important role in perfect operation and usage.

In addition, CMS can be enhanced with extra sensors (see chapter 3: Person and Object Recognition, starting page 15).

Operating principle
Surround/Bird View CMS

Real-time display of the entire surroundings can be done in two ways:

1. SurroundView, here, images from four standard cameras are arranged to a panoramic view in the monitor using a certain logic.
2. BirdView, here, simultaneously generated digital images of the cameras are further processed by video stitching and combined into a single 360° image. On the monitor, the operator/driver can see a clear real-time image from bird’s-eye-perspective or several views in split screen mode.

From rear view to surround view

The decisive advantage is the simultaneous display of all relevant areas around the mobile vehicle: the driver is able to see all danger areas surrounding the vehicle with one look at the monitor.

Modern standard components make it possible to create a 360° surround view and to display it on a single monitor in an individual and work-specific way. The whole monitor will be used to display all camera images. The individual camera images show the entire required area to detect dangers, therefore increasing safety.

Retrofit:
based on a rear view camera, the system can be expanded to a Surround View system with up to four cameras.

Depending on the action of the vehicle, single pictures can be displayed in full picture mode or in split screen mode (see picture on the right), which makes it possible to see the close vicinity around the vehicle in Surround View or selected individual areas.
Four cameras for displaying a bird’s eye view (BirdView)

The application example illustrates what Bird View mode displays on the monitor. The ultra-wide angle cameras mounted on the front, side and rear of the vehicle cover the entire vehicle environment.

This photo shows the monitor view in the driver cabin. The Camera-Monitor-System provides the operator/driver with a realistic surround view of his vehicle. In addition, the operator/driver can also select specific individual areas at the same time.

Another practical example, showing a system with three wide-angle cameras, allowing 270° monitoring of the entire rear area of a mobile machine.

Real-time optimized images provide better overview for even safer maneuvering at low speeds. The software removes distortions and "fisheye" effects from Surround View and produces clear, uninterrupted images.

Panoramic view with Camera-Monitor-Systems for vehicles with front attachements

360°-CMS can be configured flexibly for a wide range of mobile machinery and many applications, such as three-camera-display for machines with front attachements.
Four cameras for displaying a Surround View

With flexible camera arrangement, it is possible to react to the specific vehicle/machine situation. Monitors with split screen mode support optimal view when operating wheel loaders, excavators, construction site and dump trucks, agricultural and forestry vehicles, especially with large attached components.

- no calibration or control unit needed
- flexible choice of opening angle and mounting location, so the entire surrounding and especially edges become visible
- overlays for better orientation and additional guidance can be added
- automatic, application-specific display of the cameras, i.e. camera on right when making a right turn
- retrofit for different uses is an possible
- 3 to 4 wide angle cameras to cover the whole area of the vehicle and its surroundings (aperture angle range from 100° to 130° – can be chosen depending on the specific camera position and the size of the vehicle)
- integrated pre-programmed monitors to perfectly fit your camera pictures in the order you prefer; play mode equals real-time and is interruption free
- Adjustable view area and distance of the vehicle and application
- individual adjustable triggers for different perspectives

Controlling which camera view is displayed on the monitor can either be done manually or by setting triggers (indicator, shifting to reverse) for certain camera displays.

Adaptable for various applications and danger areas

The images below show examples of possible camera locations of mounted cameras on different vehicles and machines when installing a complete Surround View system.
2.3 Front Attachment Camera-Monitor-Systems

- Technical measure when turning onto high-traffic roads and intersection areas that are difficult to overlook (“cross traffic observation”)

Turning from construction sites or depots into heavily trafficked roads or intersections that are difficult to see poses a considerable risk and stress potential – especially for vehicles equipped with front attachments. In addition to tractors, municipal vehicles used for winter road maintenance or landscape maintenance (e.g. mowing work) are also affected. If the StVZO prescribes that a guide is required when visibility is lacking, a camera monitor system (CMS) can be used to remedy the situation. They facilitate control in confusing traffic areas and minimize the risk of accidents.

Front attachment CMS must meet strict requirements, for example in regards to:
- object representation
- backlight properties (blooming)
- signal transmission and failure safety
- electromagnetic compatibility
- robustness to vibrations
- display of malfunctions/system faults

- Approved front attachment CMS must have an expert’s report, e.g. DEKRA, TÜV etc., or DLG certificate. It is imperative that you ask your specialist company whether these are available!

Tests may only be carried out by technical services recognised by the Federal Motor Transport Authority for tests according to UNECE regulations no. 46, no. 71 or no. 125 as well as by officially recognised experts for motor vehicle traffic who have been nominated for such tests by the technical testing authority to which they belong!

- Attention, cross traffic:

The driver’s field of vision is restricted by the presence of an attachment, there is no direct view! By using a certified front attachment CMS, the cyclist can be detected in time.

Please note: In most cases, movement speed of lateral traffic cannot be determined via CMS!

Legal situation according to § 32 StVZO (Straßenverkehrs-Zulassungs-Ordnung):
- The distance between the front end of the vehicle including the front attachment and the centre of the steering wheel must not exceed 3.5 m (photo bottom left).
- If this length is exceeded, the visual impairment must be compensated by suitable measures:
  - by an instructor who gives necessary instructions to the driver.
  - by means of suitable Camera-Monitor-Systems which offer more safety with long front attachment dimensions.

This measure is permitted since 2017* and can replace an instructor.

Front attachment CMS instead of instructors* are legitimized by the “Empfehlungen für Kamera-Monitor-Systeme für Fahrzeuge mit einer Sichtfeldeinschränkung insbesondere auch durch Vorbaumaßüberschreitungen von mehr als 3,5m” (“Recommendations for CMS for vehicles with a restricted field of vision, in particular due to front attachments exceedances of more than 3.5m”) published by the German Federal Ministry of Transport (15.12.2016).

Warning:
Other constructions and systems without type testing are dangerous and not permitted. They do not replace an instructor!
2.4 Wireless Image Transmission in battery mode

- **Alternative Camera-Monitor-Connection for long connection distances**

If cameras have to be connected to monitors at remote mounting points, long distances and fragile deflection points hinder the use of cable connections. Digital radio systems for wireless transmission of image data offer a practical and reliable solution using robust transmitter/receiver units. Compact radio units are used to quickly and without delay transmit digital signals from a camera to a monitor over short and long distances. Depending on the system, up to ten device pairs can be operated in parallel to achieve high flexibility when adapting to a wide variety of machinery and visual issues.

The use of digital radio systems for wireless image transmission is characterized by, e.g.:

- no cables directly on the machine
- operating time of up to 23 hours
- insensitive to interference due to frequency skip method
- applicable for all types of construction machinery
- simple, flexible assembly
- shock and vibration resistance of the complete system unit including integrated battery operation
- low power consumption
- robust M12 industrial connector
- weather- and environment-resistant system components (IP 67K)

Radio camera mounted on articulated arm to directly monitor the working area in the application field of a trench clearing spoon.

Wheel loader with large special bucket – thus harshly limited front view – and mounted camera with radio connection.
**Person and Object Recognition**

**Warning systems for operators**

**Fields of application, listed by function**

Warning/Sensor systems support person and object recognition in hardly visible and non-visible areas, improving the prevention of accidents. In order to increase safety, detection systems can be configured for a wide range of work tasks and hazards. Depending on the requirements profile, different sensor systems can be used, classified according to functional principle, e.g.:

- Ultrasonic systems
- Radar systems
- Radio systems/RFID
- 3D camera sensors
- Lidar systems

In addition, further technical solutions can be utilized for special tasks such as infrared/laser systems or infrared camera systems with night vision properties. However, the most important thing is application-oriented selection and quality of the system in use.

**Recognize hazards at all times!**

As continuous, concentrated work is not possible with CMS, object recognition systems provide additional security. At all times, prevention is the most effective method to prevent accidents. Therefore always conduct a risk assessment regarding view - see page 5!
3.1 Ultrasonic Systems

**Acting safely in confined zones**

Limited space conditions call for special attention of the operator/driver. Here, wide area obstacle detection in mobile applications is a typical task for ultrasonic sensors. If persons or objects enter the detection area of the sensors, the driver is warned by, for example, an acoustic signal making an immediate stop possible!

**Detecting objects with high precision at low speed**

Ultrasonic sensors detect persons and objects with a very high degree of accuracy to approximately 10 cm* in the near field: and to distances of up to 3 m (in individual cases even at distances up to 9 m) from the vehicle. The detection zone can be be adjusted according to requirements.

* Depending the manoeuvring speed

**Proven in a wide range of vehicles in many industries**

The precise object detection of ultrasonic systems enables the continuous monitoring of the approach of, for example, vehicles or forklift trucks to loading points of materials handling conveyors. They can also be used for vehicles in areas with a high density of trees (to avoid damage from hanging branches), for mobile machines in inner-city traffic or narrow conditions (where caution must be exercised for cyclists and pedestrians) and for construction site delivery vehicles.

Given consideration for the working area and particular hazards, ultrasound-based distance warning devices are available in different configurations. Depending on the requirements
- rear,
- lateral and/or
- front
sensor systems can be utilized.

**ATTENTION:** It is really important to examine deployment location, terrain and range of tasks required of the vehicle and to conduct a risk assessment on the impact to direct vision. In doing so,
- high risk of soiling,
- poor visibility conditions (dust, fog, smoke, snow) and
- impassable terrain

These factors can lead to false alarms. Continued false alarms can affect the willingness to respond to the warnings.

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**Operating principle Ultrasonic (ultrasonic waves)**

The distance to the object is calculated from the time difference in a sound pulse* between sending and receiving.

* at sound velocity with frequency > 20.000 kHz

Ultrasonic systems can detect multiple objects at the same time. In this way, for example, the object standing closest to the machine would be identified via the display.

As soon as an object leaves the danger area, the display will indicate that there are still other potential hazards in a warning zone.

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Example of an ultrasonic system:

In preparation: Guide to the requirement "Turning assistant – the blind spot next to and behind vehicles".
Features of Ultrasonic Systems

- detection independent of material color, transparency, glass and ambient light (also glass, liquids, foils)
- high accuracy due to transit time measurement
- insensitive to dirt, dust, moisture and fog
- multi-level, auditory distance warning system
- sensitivity adjustable in a flexible way
- environmental learning mode to avoid false alarms
- synchronization and multiplex operation, self-diagnosis, visual distance display

Ultrasonic systems can monitor the working areas of mobile machinery and vehicles. Ultrasonic sensors operate in all weather conditions (system-dependent). Their ability to detect objects is independent of color, surface and environmental influences. They are resistant to gravel and sand as well as fog, frost and moisture – and thanks to their long service life, they provide a high return on investment.

The area covered by the ultrasonic system can be divided across several adjustable hazardous zones. The warning signals, which can be distinguished between the respective zones, inform the operator/driver of the distance to the object or person in the danger area. Once alerted, a supplementary Camera-Monitor-System allows the driver to identify the obstacle and to locate it.
3.2 Radar Systems

▶ Reliable warning even in poor visibility conditions

Even in the harshest environments, radar systems detect people and objects reliably. Their high resistance to dirt, mud, dust, heavy rain, humidity, heat, cold (optionally equipped with heatable sensors), UV rays, vibration and storms ensures reliable operation even in poor visibility conditions such as fog, darkness and smoke. The mentioned characteristics make radar systems vital in harshest conditions, whether on construction sites, in mining, agriculture and forestry.

▶ Detecting objects in a 20m radius at high speed

Detection and location methods based on electromagnetic waves reliably provide detection over large areas, up to a distance of 20m from the vehicle, even at speeds of up to 20km/h.

▶ Warning with very short time delay

Warning systems with radar sensors support the driver with very short time delay (50ms) during object detection. They help to prevent accidents in the danger area of a vehicle and ease maneuvering and reversing. This applies to construction machinery (civil engineering, quarries, track construction, mining) as well as mobile cranes, agricultural and forestry vehicles and industrial trucks.

Radar sensor systems are usually comprised of one or two sensors. These sensors can be installed specifically where the respective danger area of the machine/vehicle has to be monitored.

The detection area is divided into several zones so that the operator/driver is informed of the distance to the object or person using appropriate signals.

▶ Especially perceptive if supplemented by a CMS

Radar warning systems enable additional safety in monitoring the field of vision of heavy machinery and commercial vehicles. Depending on the system, they can be coupled directly to a CMS or be used independently.

ATTENTION: It is essential to check the locations and areas of operation of the vehicle and to conduct a risk assessment. Please note: rough terrain can lead to frequent, unnecessary false alarms.*

* In order to suppress unwanted false alarms, Radar Systems can be combined with 3D Terrain Mapping (see page 30).

Intelligent software algorithms evaluate detected signals.

The alarm is only triggered if a hazardous or endangered object or person is detected.

Operating principle Radar Systems (electromagnetic waves)

Electromagnetic waves transmitted by the radar as a primary signal are reflected by the object at the speed of light and then received again as a secondary signal. The measured time between transmission and reception is used to determine the distance to the object.

Radar sensor in combination with a rear view camera
Features of Radar Systems

When purchasing, you should pay increased attention to the following equipment features and create a requirement specification including the specific demands beforehand:

- multi-level distance warning system
- adjustable detection zones
- short time delay for object detection (50 ms)
- acoustic and/or visual warning signal
- expandable for additional applications (e.g. reversing alarms)
- surround monitoring using additional sensors

The radar sensor detects and recognizes fixed and moving obstacles with the help of electromagnetic impulses. An active warning is given to the operator/driver as an acoustic and/or optical signal.

The driver can see the changes in distance between machine and object:

- A tone sequence increasing in speed signals that person at risk or an object in the danger area is approaching.
- In addition, the hazard situation is shown on the display in the driver’s cab.
3.3 Transponder/Wireless Radio Systems/RFID

► Warning the operator as well as persons in the danger zone

Enclosed work premises with guarded access control – for instance fenced-in stone quarry or mining business – is a requirement for the use of radio-based person recognition systems.

Proactive systems* "persons to vehicle" and "vehicle to vehicle" send a warning to the driver/operator of the vehicle and the persons approaching the danger zone through visual or acoustic signals. All persons involved can react in a timely manner: the machine can stop and leave the danger area immediately; an imminent collision can be avoided.

► Detection even during poor visibility

Depending on the distance within the circle shaped safety zone, there will be a warning to the operator and to the person in the danger zone automatically, after determining the warning criteria.

Radiobased surround detection works even in poor visibility, during wet roads and in dirt – without blind spots.

► Detecting persons even in blocked areas

Radiowarning systems/RFID can cover danger zones up to 25 meters, even at a higher speed from and up to 25km/h. As the whole danger zone is captured, with the warning signal the exact location of a person can be detected and pinpointed. The full coverage radio waves makes it possible to detect persons hidden behind obstacles.

► Requirements for a two-way warning:

► enclosed work premises with controlled access (i.e. fence and guard gate)
► each vehicle has to be equipped with the item unit "vehicle"
► each person has to wear an item unit "person" such as a transponder or tag

Several item units for people to chose from: like for instance head lamp, bracelet and belt element

*proactive systems can optionally interact with the vehicle (see next page) – important here: requirements for functional security measures! (see download at www.safety-machinery.com)
**Characteristics of the radio based systems/RFID**

When ordering your system, please keep in mind to pay attention to the following important criteria – also be sure to make a must-have-list with your special requirements:

- multi-level person recognition system
- configurable safety zones
- vehicle to vehicle recognition up to 100 m
- vehicle to people detection range 15 to 25 m
- two-way alarms to the operator/driver visual or acoustic signal and a person in the danger zone visual or acoustic signal
- possibility to retro-fit or to modify system

The diagram shown on the left shows the PDS system which can be used as a warning system as well as a system interfering with the vehicle technology. Where people and vehicles work together the system can be used to eliminate blind spots and to prevent accidents.

**Up to 4 configurable areas/security zones**

The areas of the safety zones and the display or output of the warnings to be issued can be configured application-oriented.

*Optional there can be operation restrictions when the alarm sounds, for instance:
Warning area 3: slow-down-mode, the vehicle slows down! Warning area 4: the vehicle stops automatically!*

**Additonal features**

- Particularly mining businesses can exempt the side fields of the vehicle to avoid disruption in production and false alarms in tunnels below ground
- Vehicle to vehicle detection (VTV), non-stop function to warn and/or to stop an approaching vehicle
- Self-monitoring of single vehicle components
- Data logger interface to record incidents in real time

*RFID = „Radio Frequency Identification“ technology for sender-receiver-systems for automatic and touchless identification and detection of objects and persons by using radio waves.

For information about funding opportunities, please contact the company responsible professional cooperative, e.g. BG BAU or VBG – page 39.

Further information about
- Radio Systems/RFID
- manufacturer index
at: www.safety-machinery.com
3.4 3D Camera Sensors

Avoid false alarms by using object-specific detection

3D camera sensors warn the operator/driver in critical situations using acoustic and optical signals. In addition, the situation is visualized on the integrated monitor, so the operator/driver can fully concentrate on the main task. 3D camera technology is already widely used for environment detection and object recognition in port logistics, robotics and automotive assistance systems for passenger cars and commercial vehicles. They are regarded as one of the key technologies in the development of autonomous vehicles.

Intelligent detection of people and further relevant objects

Thanks to object-specific detection, the false alarm rate is significantly reduced, since irrelevant objects are not classified as hazard. Utilizing intelligent ground detection suited for tilted positions in rough terrain, warnings are given reliably while the efficient data processing enables fast object recognition. A 3D camera sensor offers decisive advantages: Due to intelligent evaluation, the warning system works even in case of poor visibility and weather conditions, such as direct sunlight, rain, whirled up dust or fog. 3D Camera sensors are also suited for use in harsh environments.

Active 3D warning sensor – optimal for "blind zones"

Mobile machines due to their large size have blind zones directly around the machine. Due to the large opening angle of 3D cameras (about 120° x 75°), the system is able to warn of objects which for example are located immediately behind the vehicle right.

The combination of configurable detection zones and intelligent object recognition also enables maneuvering of narrow passages without false alarms triggered by walls or containers.

The 3D sensor visualizes potentially endangered objects on the monitor so the operator/driver can better understand the situation. In essence, 3D Camera sensors are "2-in-1 systems" consisting of an active 3D sensor and an integrated CMS. Especially the combination of live image with visual and audible warning signals provides improved hazard recognition.
Features of 3D Camera Sensors (3D snapshot systems)

In procurement, you should pay attention to the following equipment characteristics and create a list with your specific requirements beforehand:

- designed for use in harsh environments
- outdoor environments
- distance-specific warning system
- configurable detection zones for avoidance of false alarms
- acoustic and visual warning signal
- recording function of the image data
- standalone 3D sensor system: intelligent object recognition with integrated CMS

3D technology has the advantage of capturing a scene three-dimensionally by means of recording. This allows obstacles to be classified object-specifically and their position to be determined. This enables for example reliable detection and distinction of a kerbstone, a pedestrian or a container.

“Two-eyes principle”

The vehicle environment is recorded from two slightly different perspectives. From this, the third dimension and distance information can be calculated. Similar to spatial vision by human eyes, the sensor head records 3D raw data. The evaluation unit is – comparable to a a brain – programmed to analyze the vehicle’s environment and to warn the driver in critical situations.

Step 1:
Two pictures from slightly different perspectives.

Step 2:
Both images are matched.

Step 3:
The result is an image with depth information.
Can be used in a wide variety of vehicle types

3D camera sensors are ideal for driver assistance in heavy, all-terrain mobile machines used outdoors, for example on construction sites, at ports, in mining and in forestry and agriculture.

Due to the large number of different mobile machines existing in these fields, the requirements for collision warning systems are also different. The 3D camera sensors are therefore available in different versions:

- two 3D sensors can be coupled for very wide vehicles.
- vehicles that require a collision warning in different directions can be equipped with two 3D sensors and only activate the appropriate one in a certain scenario.

Further information on 3D Camera Systems at https://www.safety-machinery.com

Construction

- excavator
- wheel loader
- hopper dumper
- rolls

Agriculture and forestry

- telescopic stackers
- forage harvesters
- combine harvesters
- wood harvesters

Mining

- vehicles for tunnels and underground workings
- heavy duty vehicles
- excavators

Ports and cranes

- reach stackers (container stackers)
- heavy-duty forklift trucks
3.5 3D Time-of-Flight Sensors (3D ToF)

- **Choose the suitable technology for your outdoor conditions**

In dirty and dusty environments like construction sites, agriculture or mining, sensors face the harshest outdoor conditions. Robust 3D stereo camera technology (see chapter 3.4) suits these requirements the best. However, there are numerous outdoor situations, as for example outdoor logistics areas, where the conditions are not so harsh. For such “semi-outdoor” conditions, IP67 housing for example is often sufficient and other features play a key role. Then, 3D snapshot technology based on 3D Time-of-Flight (3D ToF) can fulfill collision warning and further assistance tasks for mobile machines and forklift trucks very precisely.

- **Powerful illumination, high precision, long detection distance**

  - 2-in-1: active 3D sensor having integrated 2D live IR camera
  - High depth precision over a long detection distance of up to 60 m
  - Powerful illumination for enhanced detection in poor light conditions
  - Over 10 configuration zones and various assistance tasks can be controlled via digital in-/outputs

### Operating principle

**3D Camera Sensors (snapshot – 3D ToF)**

3D ToF cameras send out an infrared light signal which is reflected by the object. For each pixel, it calculates the distance between the camera and the measuring object from the different light phase shifts. The thousands of pixels captured in a single shot thereby deliver a detailed three-dimensional distance image – a 3D snapshot – of the entire image area, virtually regardless of the surface characteristics of the object.
3.6 Lidar Systems

▶ Laser scanning for precise detection

Lidar or Ladar ("Light/Laser Detection and Ranging"), a method for optical distance measurement provides accurate results by using a laser beam. Detection is robust under all environmental light conditions and can even be used in complete darkness. Notable features include:

▶ large measuring range,
▶ large horizontal opening angle and
▶ high resolution.

Depending on the quality of the measuring method, the system is insusceptible against dust and precipitation.

▶ Data fusion

Based on object measurement and classification by laser pulses, the signals of the lidar system can be used directly for person and object recognition.
A large number of parameters can be directly processed and visualized by means of a software interface.

▶ Key technology for assistance systems

Lidar systems have also been used for a long time in environment detection and object recognition in port logistics, robotics and automotive assistance systems for passenger cars and commercial vehicles.

The permanent development also leads to the increased use of lidar systems in mobile working machines such as construction, mining, forestry and agricultural machines. Decisive factor for the off-road sector is a robust sensor in which external factors – such as vibration – do not cause any impairment of measurement result.

For off-road application, the sensors are mounted in robust IP67 housings.
4 Acoustic Warning Signals for persons in surrounding area

Warning of endangered persons

In many applications of mobile machinery it makes sense that not only the operator/driver is warned of hazardous situations, but also persons in close vicinity (such as work colleagues or pedestrians), who enter the hazardous area and who can get into danger if not warned in time.

Draw attention effectively

To improve perceptibility of mobile machines, various acoustic alarms are available:

- alarms permanently activated during movement (e.g. when reversing) or
- alarms activated depending on the situation, e.g. if a sensor system with intelligent software detects people/objects (see page 30).

The alarm tone emitted is perceived as a “hiss” or “beep” and can optionally be adjusted to the ambient volume. While a “Hisser” (broadband alarm) warns persons approaching or already in the danger area with a directional alarm tone, beepers are heard in the entire environment. Caution is therefore advised! “Beepers” cause noise nuisance, which leads to annoyance and stress for employees and residents.

Possible consequence: Desensitization against continuous beeping – an actual imminent danger is no longer considered as such. Also, since it is difficult to locate the beep, endangered persons must first determine the direction of the approaching danger.

Advantages of the “Hisser”

- only perceptible in the danger area (wide frequency spectrum)
- no noise nuisance for uninvolved persons
- no stress for employees/residents
- no desensitization
- fast localization
- optionally activatable by sensor

Broadband sound alarms issue strong and clear warnings to endangered persons. The system switches on as soon as the vehicle starts moving and can be configured individually.
4.1 Broadband Sound Warner

► Warning environment specifically – avoiding unnecessary noise nuisance

Broadband sound warners are a new generation of warning systems. They cause less noise nuisance – the strong, alarming hissing signals are heard only where it matters: in the danger area of the mobile machine.

There is no (permanent) stress for employees, residents and passersby due to shrill beeps and the operator/driver is not tempted to switch off the warning system to spare their nerves. There is less risk of desensitization to warning signals.

► Quickly detect the direction of approaching danger

Broadband sound frequencies provide directional information to the ear and allow the listener to better localize the sound. This gives the persons in the danger area time to avoid the danger.

► Can be used in many areas

Useful applications for broadband sound alarms include construction site vehicles and mobile construction machinery, baggage vehicles at airports, trucks, heavy vehicles used in quarries or recycling plants, agricultural and forestry vehicles, road rollers and road pavers.

Various models of broadband sound alarms have been designed according to a wide range of applications. A vehicle for quarry environment has different requirements than a vehicle that is, for example, on route to a city center. The same applies to the requirements placed on telescopic handlers in closed warehouses/barns/production environments and on baggage handling vehicles at airports.

Operating principle

Broadband Sound system

Broadband noise - also known as "white" noise - is caused by the composition of several frequencies. It acts as a masking sound by covering up other sound impulses in the noise.

The hearing threshold is set to the required level by adjusting the sound levels accordingly.

Significant for human perception of the produced sound are

► spatial limitation and
► fast, flawless localization.

When used as a warning tone, broadband warning system can be configured to adjust the volume to ambient noise levels.

Technical options:

The noise level in the environment plays a role in selecting a suitable system.

For some applications, an automatic adjustment of the warning sound volume is therefore recommended: the warning intensity increases as soon as this is necessary.
5 Intelligent Software for Terrain and Object Recognition

3D Terrain-Mapping

3D Terrain-Mapping (three-dimensional mapping of surrounding environment) is an important component in supporting the driver and preventing accidents. This method provides an innovative aspect to terrain, person and object recognition and is already paving the way for active assistance systems in the off-road/NRMM sector.

- **Innovative image processing supports safe operation**

On the basis of precise digital camera data, people, objects, obstacles and even the most difficult terrain are reliably detected and classified so that driver and mobile machine receive unambiguous information. On the monitor, the driver is informed about the specific conditions by real-time display, conditions such as:

- Where is the area passable/not passable?
- What obstacles are there, where are they and at what distance from the mobile machine?
- In which direction do people and/or objects move?

**Exact terrain and object recognition**

Through the application of "deep learning methods", the system trains and learns, among other things, the reliable differentiation between persons and objects. Targeted training in the specific working environment of the mobile machine (e.g. quarry) enables a very precise interpretation of the data supplied and thus increases safety and efficiency.

Depending on the application, the supplied image data can be combined/configured with existing or new systems that are to be integrated and precise "actions" can be defined. If there is a risk of collision, for example:

- the driver is additionally alerted by e.g. an acoustic signal and/or in addition
- persons entering the danger zone are warned by a directional broadband sound.
- As soon as the legal framework permits it, active intervention in the machine control system can also be carried out.

**Retrofitting increases work safety!**

The detection system can be integrated into camera/sensor systems.
Digitizing to intelligent Camera Sensors

Application example: process description of 3D terrain-mapping in combination with deep learning methods

Step 1: Bildaufbereitung – Image Preprocessing (IPP)
Image enhancement measures, such as contrast adjustment and noise reduction, ensure the required image quality. The two images of the stereo camera are then aligned in such a way that they correspond exactly with each other, i.e. receive the same image information.

Step 2: from 2D to 3D – Stereo Vision (SV)
In this analysis step, depth information is obtained from the pre-processed image pair – similar to human vision. This process converts the existing 2D data into 3D data.

Step 3: recording the terrain – 3D Terrain-Mapping (3DTM)
To calculate the 3D terrain map, an elevation map based on a grid structure is generated at first. In successive calculation steps (spline approximation), the terrain is modelled so precisely that it represents reality. In addition to environmental information such as the presence of hills, slopes, etc., finer terrain details are also obtained.

Step 4: object detection – Generic Object Detection (GOD)
The passability of the modelled terrain is determined on the basis of the existing elevation information. In addition, the terrain map is used to identify obstacles. With the help of algorithms, objects are detected and their minimum distance to the mobile machine is calculated. Direction of movement and speed of those objects are also determined.

Step 5: Person Recognition – through deep learning methods
The objects identified are classified in more detail using so-called “deep learning methods”:
The system decides whether an object in the machine environment is a person or not. In addition, it recognizes a large number of object classes, such as signs, pallets and others.

Step 6: Assurance and System Integration
The described algorithms may have to be integrated and tested together with a variety of other software modules on a suitable hardware platform. The machine manufacturer placing the machine on the market is bound by several normative regulations and must guarantee the functional safety of the machine.

"Deep learning methods"
“Deep learning methods” are data analysis algorithms of the field of machine learning, which have established themselves as an important tool of machine vision, especially due to their accuracy of recognition.

In order for a “deep learning algorithm” to be able to differentiate between different object classes, it “trains” and “learns” the specific recognition patterns through different images. After completion of the training process, the algorithm automatically and reliably differentiates the defined object classes during operation of the mobile machine.

In addition to aspects of functional safety, in the age of digitalisation and networking of mobile machinery, industrial security is becoming increasingly important.

see guideline „Functional Safety“
5.1 Robust 3D Camera Data and Intelligent Software in Mobile Automation

For drivers of mobile machines, the evaluated data of 3D cameras for collision warning tasks is a crucial help. However, in most industrial work scenarios, the tasks of a driver go far beyond mere driving and maneuvering.

The raw data or intelligently pre-evaluated data of such 3D cameras can also enable a wide range of other assistance and automation tasks such as navigation support or automatic checks of the container filling level.

Data output:
- depth data (3D),
- greyscale (2D),
- object position and classes

This can be used for a wide range of assistance and automation tasks.

Applications of intelligent software on 3D stereo cameras
- Navigation support
- Collision warning
- Swath tracking
- Container level filling
- Further image processing related tasks for mobile machines

2D data, 3D data and intelligent object classification
- 3D stereo camera hardware for harsh outdoor applications
- Camera streams both depth (3D) and greyscale (2D) data in one snapshot
- Intelligent object positioning and classification software for guidance and navigation support

Flexible use for mobile machines software specialists
- Specialists’ self-developed software can be implemented on ready-to-use 3D camera hardware
- Data streaming and object detection is available via TCP/IP, Ethernet
- C++ programming interface for both Windows and Linux systems
Further publications on the topics of “Visibility and Hazard Detection” from the Netzwerk Baumaschinen NRMM:

**Personen und Objekterkennung in Gefahrenbereichen**
Safety and efficiency in the use of tractors and mobile machinery in agriculture and forestry
- Guide for operators, manufacturers and supervisors

**Abbiege-/Assistenzsysteme**
a) for commercial vehicles, buses and mobile machinery
b) trucks, municipal vehicles and agricultural/forestry vehicles
- Guide for operators, manufacturers and supervisors

**Profis nehmen Rücksicht**
Identify and avoid hazards due to visual impairments
- Practical help for employers, employees and interest groups

**Erdbaumaschinen wirtschaftlich und sicher einsetzen**
Know the measures - work productively - profit
- Practical help for operators, employers and managers

**Kamera-Monitor-Systeme**
Sinnvoll und sicher nachrüsten
Tips for installing camera monitor systems
- Guide for companies, specialist dealers and assembly workshops

**Functional Safety**
Safety and industrial security in the development and use of control systems
- Information for operators, manufacturers and supervisors
Person/Object Recognition, Warning in Danger Areas

6 General Principles for Procurement and Operation

Potential and limits of technical assistive

If the driver’s direct vision is not sufficient to ensure safety, technical means or measures (see TRBS 2111 Part 1, point 3.2.1 (3) and (4)) such as camera monitor systems must be used as a priority to improve visibility.

Camera technologies, warning and sensor systems are technical auxiliaries for recognition of persons and objects in danger areas of mobile machines and commercial vehicles. These systems support monitoring of the close range in front of, behind and around the respective machine during machine movement and if necessary also during movement of attached components. Extended systems can additionally warn persons in the danger area.

**ATTENTION:**

- Warning systems are not intended to perform movements without vision!
- The systems are intended in particular for monitoring the danger area around a machine.
- A combination with CMS makes it easier for the driver to see endangered persons when warning messages are issued by the system.

Determining the mounting site, mounting and adjusting

The determination of the optimal mounting location and the appropriate alignment of the camera, sensor and monitor/display depend on several factors, for example:

- the operation site, the environmental/operating conditions and the required detection range
- the characteristics of the vehicle/machine.

Please also refer to the guide „Kamera-Monitor-Systeme – Sinnvoll und sicher nachrüsten“ (www.safety-machinery.com).

Signaller

If no sufficient visibility is possible (neither directly, nor by means of technical measures such as mirrors, CMS, or sensors), signallers are required!

Only if the use of suitable equipment such as camera-monitor systems (CMS) or reversing assistance systems (RAS) guarantees unrestricted monitoring of the road, the signaller may be dispensed with. Therefore, pay attention to high quality when selecting and installing technical auxiliaries.

Inspections by the person qualified for the inspection*

The installation of a warning system is a modification of the mobile machine that is subject to inspection. The warning system must therefore be inspected by a “person qualified to inspect” after it has been installed. According to TRBS 1201 “Inspections and controls of work equipment ...”, a so-called order inspection as well as a technical inspection must be carried out.

Operational readiness

Sensory warning systems and Camera-Monitor Systems must function properly when the machine is started. A functional test is therefore required before starting work.
General Principles for Procurement and Operation

In the event of defects regarding the CMS or warning systems which endanger operational safety, operation of the machine must be stopped until the defects have been fixed.

Instructions

Instructions must be based on the different operating conditions and the systems used. The scope of application, the limits of the systems and how to handle it must be explained!

- When using technical auxiliaries, the driver/operator must be instructed on the intended use and the necessary measures for setting, checking functionality and maintenance.

- For radio systems/RFID, also note: set up rules of conduct for drivers/operators and everybody at the place of use**, check and enforce compliance.

**Closed and with access control

Employer’s responsibility

The employer must ensure that work equipment (including mobile machinery and vehicles) is inspected. The purpose of the test is to ensure that the work equipment is properly installed and functions safely. The test may only be carried out by a person qualified for the inspection*

Important:
Always make sure nobody is endangered, if necessary use signallers!
6.1 Visibility Field Analysis of Mobile Machinery

Before placing new machines on the market, manufacturers have to verify that a sufficient field of vision is provided, e.g.:
- according to ISO 5006 for earth-moving machinery (see also page 38)
- according to ISO 5721 for agricultural tractors
- according to ISO 13564 for industrial trucks

**Problem**
The field of view of a new machine is often only determinable with an existing prototype and thus shortly before the start of the (serial) production. For standard-compliant field of view analysis costly and expensive test setups in a suitable test environment are required. Changes and adaptations to the machine an analysis may reveal as necessary can subsequently cause high costs.

**Consequence**
The improvement of visibility conditions on vehicles/mobile machines can be achieved by construction measures, such as a changing the cabin position or swivel seats. However, remaining “blind zones” can only be minimized through the additional use of technical auxiliaries such as mirrors, camera-monitor-systems and sensors.

**Solution**
Prevention can be achieved by a field of view analysis accompanying the product development on the basis of the 3D design data according to the applicable standards. Software solutions calculate areas not visible to the operator/driver, areas made visible by mirrors, camera fields of view and lighting fields of worklights. Non-visible areas are visualized as field of view restrictions on standard-compliant levels (e.g. test circuit, close area around the vehicle etc.) according to national and international standards and regulations and are graphically documented. The determined mirror/camera fields of view can also be analyzed and brought into correlation with the existing field of view restrictions.

A combination of standard-compliant field of view analysis and subjective visual assessment (such as virtual reality technologies) enables manufacturers to bring vehicles that conform to visual requirements and possess optimal visibility conditions for the operator/driver to market.

For further requirements for manufacturers see supplementary sheet: “Requirements for functional safety” (www.safety-machinery.com)

Further information about:
- Software for field of view analysis
- manufacturer overview at: www.safety-machinery.com
Rules and Standards

**Operator and Employer**

- **ArbSchG** – Arbeitsschutzgesetz
- **BetrSichV** – Betriebssicherheitsverordnung
- **TRBS 1111** – Gefährdungsbeurteilung
- **TRBS 1112** – Instandhaltung
- **TRBS 1201** – Prüfungen und Kontrollen von Arbeitsmitteln und überwachungsbedürftigen Anlagen
- **TRBS 1203** – Befähigte Personen
- **TRBS 2111 Teil 1** – Mechanische Gefährdungen – Maßnahmen zum Schutz vor Gefährdungen durch mobile Arbeitsmittel
- **DGUV Regel 100-500, Kapitel 2.12** – Betreiben von Erdbaumaschinen
- **BekBS 1113** – Beschaffung von Arbeitsmitteln
- **EmpfBS 1114** – Anpassung an den Stand der Technik
- **StVO** – Straßenverkehrs-Ordnung

**Recommendations for improving visibility –**

As an operator/employer, stay informed about the latest state of the art technology.

- Direct view must always have priority.
- Attach visual auxiliaries in forward direction.
- Visual auxiliaries are not to be affected by moving parts.
- Do not impair visual auxiliaries through modifications or attachments.
- Do not use mirror-to-mirror systems.

**Check for practical use:**

Empfehlung Sicht beim Einsatz von Erdbaumaschinen und Walzen published by the DGUV-Sachgebiet Tiefbau and practical guide „Sicht an Erdbaumaschinen“ published by the VBG und the BG RCI.
**Person/Object Recognition, Warning in Danger Areas**

**Manufacturers**
- ProDSG – Produktsicherheitsgesetz
- MRL – EU-Machinery Directive 2006/42 EG
- DIN EN 474* – Earth-moving machinery – Safety
- ISO 5006* – Earth-moving machinery – Field of vision – Testing procedures and requirement criteria
- UN ECE R46 – Devices for indirect vision
- ISO 15008 – Requirements for display systems in vehicles
- ISO 14401 Part 1 and 2 – Earth-moving machinery – Mirrors
- ISO 16001 – Earth-moving machinery – Object recognition systems and visual auxiliaries - Performance requirements and testing procedures
- ISO 13766 – Earth-moving machinery – Electromagnetic compatibility of machines with internal electrical systems
- EN 300 328 – “Radio directive”

**ISO 15998** – Earth-moving machinery – Machine control systems (MCS) based on electronic components - Requirements and tests for functional safety

**ISO 13849** – Requirements regarding functional safety, e.g. EN ISO 13849

**ISO 14401** – Earth-moving machinery – Mirrors

**ISO 16001** – Earth-moving machinery – Object recognition systems and visual auxiliaries - Performance requirements and testing procedures

**ISO 13766** – Earth-moving machinery – Electromagnetic compatibility of machines with internal electrical systems

**EN 300 328** – “Radio directive”

**Builders**
- BaustellV – Baustellenverordnung
- RAB 30 – Regel zum Arbeitsschutz auf Baustellen: Geeigneter Koordinator – Konkretisierung zu § 3 BaustellV – beschreibt die für eine Tätigkeit als Koordinator erforderliche Qualifikation und dessen Aufgaben

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**Important information on road travel with construction machinery**

Earth-moving machines may only drive on public roads if

- they are equipped according to the requirements of the StVZO and the StVO,
- an operating license is present,
- The driver must prove necessary technical knowledge and an appropriate driving license

**Required driving licences:**
- bbH* < 6 km/h: no driver’s license
- bbH* ≤ 25 km/h: Euro driving licence L without weight limit
- bbH* > 25 km/h:
  a) earth-moving machinery, admissible total weight up to 3.5 t: Euro driving licence B
  b) earth-moving machinery, admissible total weight up to 7.5 t: Euro driving licence C1
  c) earth-moving machinery, admissible total weight up to 7.5 t: Euro driving licence C

*bbH: durch Bauart bestimmte Höchstgeschwindigkeit = max. speed determined by construction type*
Retrofitting of construction machinery and construction site trucks

The employers’ liability insurance associations promote measures to increase occupational safety and health protection. All important information on the requirements, premium amounts, registration forms, etc. can be obtained from the trade association responsible for your company. The BG BAU and the VBG financially support their members when retrofitting:

- **with Camera-Monitor-Systems**
  - in the case of the above-mentioned professional associations, these include the following:
  - rear-view cameras (CMS) for construction machinery and construction site trucks
  - a second camera in connection with split screen monitor for improved vision on the right side of excavators

- **with Transponder/Wireless Radio Systems/RFID**
  - the VBG offer member companies with access control to the operating area support for
  - transponder systems/radio-sensor-systems (see pages 20 and 21)

Take advantage of the current subsidy offers of your employers’ liability insurance association!

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**BG BAU**
Berufsgenossenschaft der Bauwirtschaft
https://www.bgbau.de/service/angebote/
arbeitsschutzpraemien/
Telefon: 04321/9692-502

**VBG**
ihre gesetzliche Umfallversicherung
Präventionsfeld Glas und Keramik
www.vbg.de/praemie
Telefon: 040/5146-7778

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Most institutions for statutory accident insurance and prevention offer further measures and additional support to their members, e.g. in the form of training.

BG BAU also promotes the retrofitting of construction site trucks with Blind Spot Information Systems (BSIS).

For more information on BSIS, see the guide „Abbiege-/Assistsysysteme“ at:
www.safety-machinery.com
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BG RCI – Berufsgenossenschaft Rohstoffe und chemische Industrie
BMAS – Bundesministerium für Arbeit und Soziales
IG BAU – Industriegewerkschaft Bauen-Agrar-Umwelt
KAN – Kommission Arbeitsschutz und Normung
BV MIRO – Bundesverband mineralische Rohstoffe e.V.
SVLFG – Sozialversicherung für Landwirtschaft, Forsten und Gartenbau
UK NRW – Unfallkasse Nordrhein-Westfalen
VBG – Verwaltungsberufsgenossenschaft
VDGAB – Verein Deutscher Gewerbeaufsichtsbeamter e.V.

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