AUTONOMIK
INDUSTRIE 4.0

Legal challenges facing digital value chains – structured solution paths for SMEs

Imprint

Published by
Begleitforschung AUTONOMIK für Industrie 4.0
iit-Institut für Innovation und Technik in der
VDI/VDE Innovation + Technik GmbH
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Picture credits
Autonomik/Małgorzata Pakuła (Titel, p. 16/17), Begleitforschung AUTONOMIK für Industrie 4.0 (p. 4, 9, 22), ZVEI (p. 8), Visual Facilitators/AUTONOMIK (p.19-21), Jungheinrich (p. 25), HYVE Innovation Community GmbH (p. 25), Jürgen Effner – Fotolia.com (p. 26), Janto Trappe (p. 26), Manuserv (p. 27), KD Busch/Hochschule Esslingen (p. 27), FESTO AG & Co. KG (p. 28), Fraunhofer (p.28), Rainer Bressel (p. 29), Ammann Schweiz AG (p. 29), adidas Group (p. 30)

Issued
April 2016

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

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AUTONOMICS for Industry 4.0

This study was prepared within the scope of scientific assistance for the AUTONOMICS for Industry 4.0 technology programme by the Federal Ministry for Economic Affairs and Energy (BMWi). As part of a technology competition, 14 teams from academia and industry have qualified for funding from BMWi.

The „AUTONOMICS for Industry 4.0" technology programme is designed to merge state-of-the-art IC technology with industrial production by exploiting the potential offered by innovation in order to accelerate the development of innovative products.

The aim is to strengthen Germany's leading position as a world-class production site and as a supplier of state-of-the-art production technologies. The Ministry's technology programme hence marks an important step towards the implementation of Industry 4.0, the Federal Government's project for the future.

In anticipation of „Autonomics for Industry 4.0", important spadework was carried out in 2010 under the predecessor programme titled „AUTONOMICS – autonomous and simulation-based systems for medium-sized businesses" by the Federal Ministry for Economic Affairs and Energy. The results and findings of the R&D projects in production, logistics and assembly backed by AUTONOMICS are the perfect fit for Industry 4.0.

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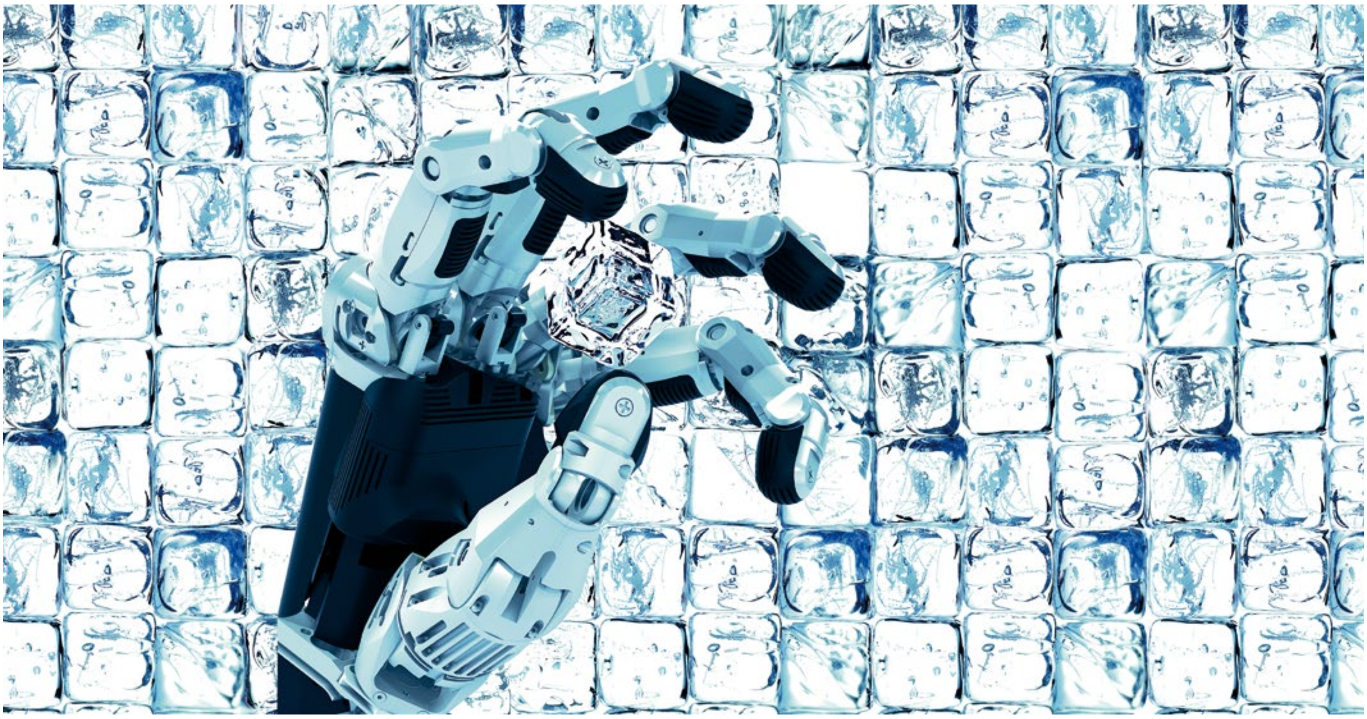


1 Visualisation of legal requirements

Laws can both hinder and promote innovation. It all depends on how good developers and technicians can communicate with lawyers and vice versa. Unfortunately, however, the technical and legal domains frequently appear to be divided by a deep gap of mutual misunderstanding. And all too often we see that these language barriers can lead to tension which has the potential to hinder or unnecessarily delay co-operation.

And this is where the „JuRAMI 4.0" legal reference architecture model presented here comes into play. The aim is to overcome the gap between the technical and legal domains by visualising the existing problems in their contexts. Visualisation is a means that is used on a daily basis in the context of technical sciences and in technical practice to structure problems and identify solutions to solve them. That being said, visualisation is also used in the world of law as we can see if we look at medieval legal texts like the „Sachsenspiegel" that dates back to the German Middle Ages. The images used for illustration there were more than just mere decoration. They explained the legal texts and, even more important for that time, formed a bridge providing viewers who had little or nothing to do with the law a point of access to their rights.

Starting with a reference architecture, similar to the ones frequently used in technical sciences, Ju-RAMI 4.0 aims to create a legal reference model that should help viewers to link the familiar with the unfamiliar and hence to gain new insights into previously foreign specialist fields. This specifically means refining a technical reference model in such a manner that it links legally relevant risk areas to certain areas of law. In this way, viewers will be able to

- recognise at a glance the dimensional diversity of the law that applies to them,
- identify the connection between the type of damage and the area of law that is „applicable", and
- easily find first information that can be used to discuss the issue and perhaps, looking to the future, solutions to the problems with legal experts.

The Ju-RAMI 4.0 legal model is hence to form an interface between the technical and legal domains in order to eliminate misunderstanding and pave the way for efficient problem solving. Therefore, Ju-RAMI 4.0 aims to make it easier, especially for stakeholders with a technical background, to enter the „unknown territory" of legal risk areas and to find solutions.

This is a pioneering project that brings with it both opportunities and risks. It goes without saying that visualisation of problems and their contexts is no substitute for a degree in law. The legal reference model should foster understanding and help to find a common language. On the other hand, it's not that easy to find solutions to complex legal cases.

Similar to comparable pioneering work, the further development of Ju-RAMI 4.0 depends on expert feedback from the stakeholders who use the method in their day-to-day work. The method described below should hence be seen as an invitation to contribute to the forthcoming process of specifying in more detail and expanding Ju-RAMI 4.0 for practical application and enriching the model with information and suggestions for improvement.

2 Legal framework conditions as challenges for Industry 4.0

Industry 4.0 – Networked value chains also mean new legal risks

The „Industry 4.0“ vision for the future is determined by the goal of smart and networked production, but also by global value chain networks that transgress the borders between sectors and where the work of individual players and machines is controlled by smart IT systems. Fast response times and optimum workflows are the key factors in the concept of digital production. In addition to new opportunities for greater productivity and improved performance offers, this brave new world of value chains poses a host of challenges which must be addressed if business models are to be successfully implemented.

In many areas, the smart factory with its technically controlled, autonomous workflows is leading to new requirements for the applicable legal framework. Completely new decisions now have to be made regarding causal relationships or legal safeguards. Just like in recent periods of innovation, case law has not kept pace with the speed of technical developments and their implications. The use of robots to support production workflows increasingly leads to new levels of human-machine interaction. Programmes can be set up to be more than just helpers; they can decide for themselves and select a suitable option from a number of possible alternatives. Smart production methods are ready for use, steered by sensor and actuator systems that enable maximum optimisation but which consider applicable technology law to an insufficient degree only. Completely new decisions will have to be made at times regarding the legal assessment of technical workflows and the possible hedging of liability risks. As in previous periods of innovation, case law is very important because it is through case law that the statute book is put to practice. Human-machine interaction, which takes place in Industry 4.0 in a new form and with a completely new level of intensity, raises many different legal questions that range from civil liability law to data protection and criminal law.

Layout of the study

This study is divided into two sections.

Section 1 describes the presentation method selected and how Ju-RAMI is structured. The individual evaluation levels of the reference architecture are clearly explained so that legal lay people can find their way round the selected structure and identify their own challenges. This makes it possible to take a first step towards considering the legal framework in the design of digital production.

In section 2, an attempt is made to assign the projects to the Ju-RAMI structure that are to be supported under the AUTONOMICS technology programme. In doing so, risk scenarios will be described which are conceivable but which have not yet actually occurred. This is so to speak a first practical test of the new reference model. The results should help in the further development of the model.

Support for legal/technical compliance

Industry and its decision-makers must always aim to gear their business activities to the applicable statutory provisions and legal evaluations. Compliance crash barriers can be used to set up measures to minimise the risk of penalty and liability for all the relevant stakeholders and also for Industry 4.0. The most important thing is compliance with laws and agreed rules in order to avoid liability risks under criminal and civil law for both companies and their bodies. Since the digital transformation of production and value chains is leading to completely new requirements for interaction between smart machines, systems and workers, which are only insufficiently covered by the existing legal framework, a very high degree of sensitivity is called for when assessing one's own risks. Data protection and IT security are just as important here as are issues of liability, e.g. in the case of accident scenarios. Vague concern regarding possible risks should not slow down innovation. Where international competition is concerned, it would be fatal to avoid possible improvements in production and value chains due to an unclear assessment of the legal implications. What's more important, especially for legal lay people, such as technical developers, is that they learn more about the existing legal framework conditions for their work and the later implementation of the results in order to minimise possible risks. This is why Industry 4.0 needs suitable compliance tools. Ju-RAMI 4.0 will provide support for the further development of Industry 4.0.

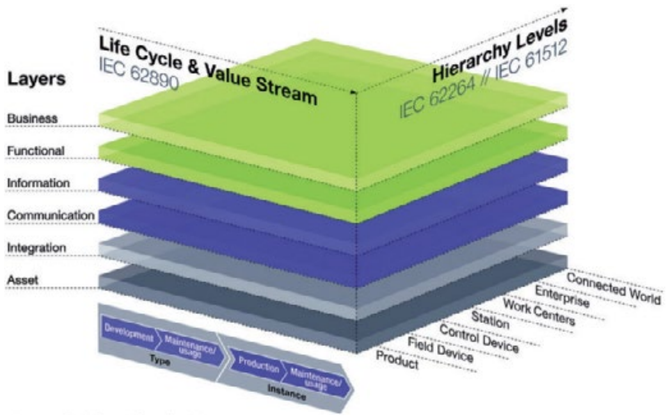
3 Ju-RAMI 4.0 – A detector of legal stumbling blocks

Starting point: Industry 4.0 reference architecture (RAMI 4.0)

If the Industry 4.0 Future Project is to be a success, standardisation will be essential, as too will be the mastering of the legal challenges specific to Industry 4.0. Industry 4.0 calls for unprecedented integration of physical and virtual systems across domain and hierarchy borders as well as lifecycle phases. This will only be possible through specifications and standards based on consensus and within the existing legal framework. The primary aim of a reference model is to clearly model the truly relevant circumstances. Any reference model that meets with these criteria can be used as a recognised standard. A second aim is to define a single reference model for circumstances that occur repeatedly and to update this as a globally valid standard.

In 2015, the Industry 4.0 platform (http://www.plattform-i40.de) already featured the Reference Architecture Model for Industry 4.0 (in short: RAMI 4.0), creating the foundation for a common understanding and a common language for the stakeholders of Industry 4.0. RAMI 4.0 compiles the main elements of Industry 4.0 in a 3D layer model that compares the main process steps and the lifecycle of products, factories and machines in digital production with the hierarchical levels of Industry 4.0. This makes it possible to describe and implement very flexible and cross-manufacturer Industry 4.0 concepts. The model shows where existing standards have to be used and where standards have yet to be developed. In this way, complex interaction can be broken down into clear-cut process steps. RAMI 4.0 serves as a basis for a joint understanding of the problem in expert circles. It describes the structure of application cases and is the starting point for the tools to be developed on this basis.

RAMI 4.0, which was presented at the 2015 Hanover Fair, is currently being transposed to DIN SPEC 91345 and included in international standardisation processes. Existing standards will be mapped in RAMI 4.0, so that the need to extend and revise them can be identified. It is also hoped that the interdisciplinary topic of Industry 4.0 can be clearly structured so that targeted discussions can be fostered.



The RAMI 4.0 reference architecture
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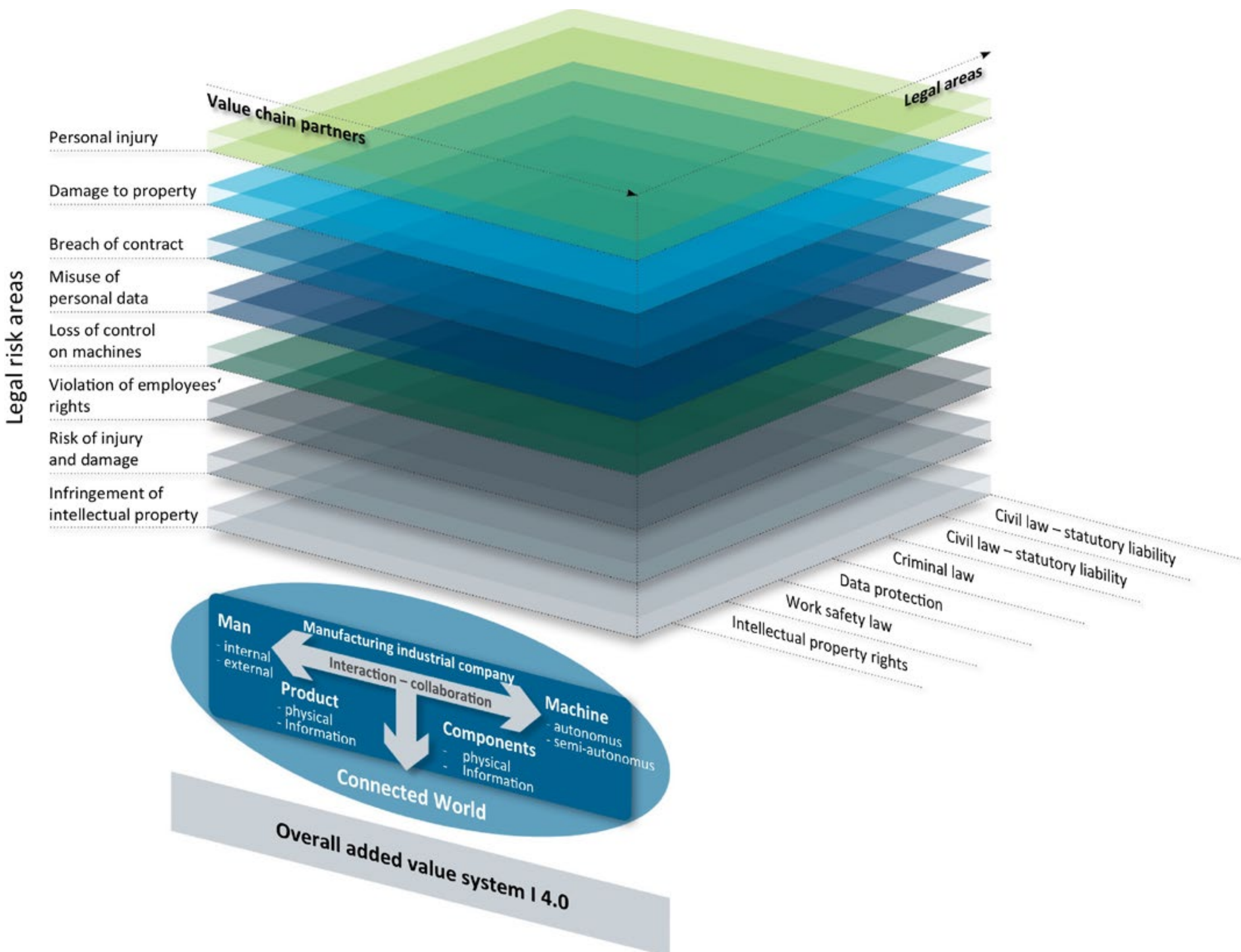
Structural classification of the legal challenges in AUTONOMICS for Industry 4.0

In order to make the legal risks involved in digital production as understandable as possible, research accompanying the technology programme has come up with the first version of a „legal" reference model for Industry 4.0 which is based on RAMI 4.0. Ju-RAMI 4.0 is designed to allow legal lay people to identify specific legal risk areas, damage and hazards across the entire networked value chain. The workshops and discussions related to the impacts of the legal framework conditions for the project partners of the AUTONOMICS for Industry 4.0 technology programme showed a desire for simplified, structured access to the topic that was unfamiliar to many stakeholders. Although the importance of the topic was recognised, approaching the „legal language world" was a frequently cited barrier. Since the RAMI 4.0 model and its structured presentation of complex dependencies has been highly praised and recognised by experts, a similarly designed presentation of legal and technical dependencies was requested. This is to be achieved by using the basic concept.

Just like the reference architecture model, Ju-RAMI 4.0 comprises a three-dimensional coordinates system that maps the key areas of law and legal risks along all of the value chain processes that are networked in Industry 4.0. It serves as a basis for analysing relevant legal issues and – as an easy-to-understand diagram – it should enable practical application without extensive legal knowledge. The aim here is to quickly present a first reference framework for Industry 4.0 project stakeholders that helps them to identify existing legal loopholes and offers first approaches to solving these problems. The individual legal layers are filled with practical examples and this makes orientation easier for legal lay people.



Ju-RAMI 4.0

Instead of referring to different technical views, the individual areas of law are mapped on the vertical axis. The unchanged axes of the product lifecycle with the value chain processes as well as the axis of the mapped functionalities and responsibilities in the Industry 4.0 ecosystem ensure that the Industry 4.0 reference architecture can be easily recognised. The applicable legal/technical compliance rules are described in this model on the basis of the individual areas of law, the contents of which and their relevance for business processes are not sufficiently known to the majority of stakeholders in industry. In order to boost practicality for a legal assessment, the basic structure of RAMI 4.0 was fundamentally adjusted in the second step. The layers are used to depict concrete legal risk areas, as well as the damage and hazards that can occur along the entire networked Industry 4.0 value chain process. On the second axis, the stakeholders are defined as socio-technical added-value levels. Axis three then presents the areas of law that form the legal framework for the individual risk areas.

Ju-RAMI 4.0 should offer the following key benefits to technically minded stakeholders in digitally based value chains:

- Structuring – Use of the first basic scaffold for a conceivable reference architecture for technology law.
- Orientation – Specific information regarding the legal risks that exist and the areas of law that are relevant.
- Options for action – Proposals for measures that should be taken in order to avoid legal problems for future marketing, if possible, even before performance.
- Solution paths – Specific legal paths can be derived from the architecture model which can be used by legal lay people.
- Understandability – The use of colloquial language makes it easier to adhere to the relevant legal rules.
- Loophole analysis – Ju-RAMI 4.0 makes it possible to identify topics in networked value chain processes where there is a need for legal action.

Ju-RAMI 4.0 was developed under the leadership of Prof. Dr. Dr. Eric Hilgendorf from the „RobotRecht" research unit at Würzburg University. Close co-operation with experts from the projects under the AUTONOMICS for Industry 4.0 technology programme and with Reinhold Pichler from the DKE German Commission for Electrical, Electronic and Information Technologies of DIN and VDE was important for the practical relevance.

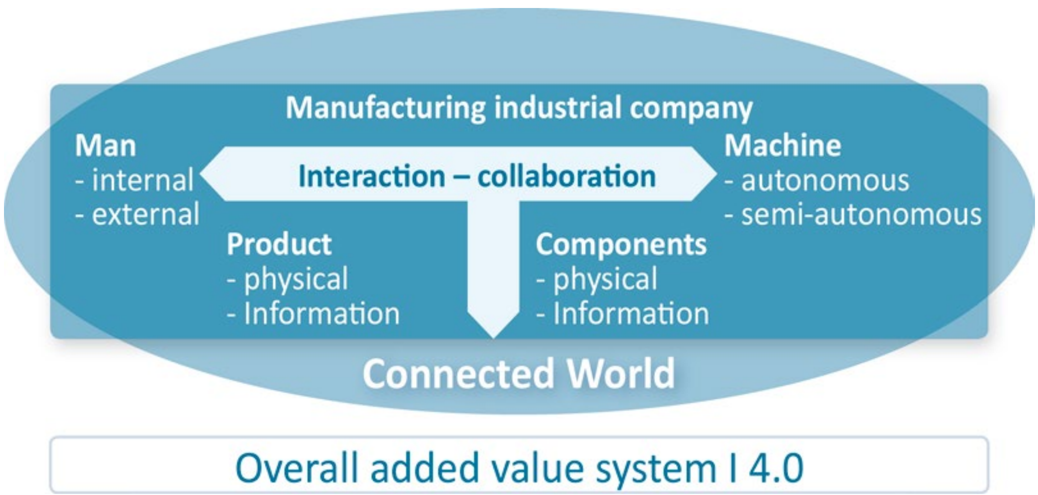
4 Overall value chain system in Industry 4.0

Value chains in Industry 4.0 follow the rules of communication in the ever-present Internet: they are rarely linear, often independent of clearly defined process steps and dependencies, but are always flexible and adaptable within the given context. Responsibilities, from the idea to the implementation of products ready for the market, are distributed in network structures that call for permanent informational and physical exchange across company borders. A host of sensors not only locate system components, they also detect the current performance and availability status. As soon as a company gets on board with organisational scenarios like these, hierarchical boundaries within the company and in co-operation with external partners become blurred in favour of needs-based collaboration that is not subject to any permanent rules and standards. The digital transformation integrates software commands and IT tools into complex industrial process chains, and both products, materials and individual production sites are sub-components of the digital factory 4.0.

Future business models will be determined by customers and their individual expectations regarding design, features and scope of performance. This will be made possible by combining basic technologies and processes which have in fact been around and available for years, but which combined with innovative networking technologies and ICT support lead to completely new options for optimisation. In order to describe the „overall value chain system in Industry 4.0" for Ju-RAMI 4.0, the following, extremely simplified image was chosen that identifies the individual stakeholder groups and their interaction, also in terms of cross-boundary and cross-sector co-operation. All of the stakeholder groups in this overall system operate in the existing legal framework and are hence part of the Ju-RAMI 4.0 assessment.

4.1.1 Manufacturing industrial companies – organisation of value chain processes

Companies that see themselves as being part of Industry 4.0 increasingly have to face complexities in internal and external value chain workflows. The company's own resources can always be organised to achieve greater performance and flexibility. Interaction with suppliers and processing customers is marked by just-in-time requirements and standardisation demands. Ultimately, end customers also expect a higher degree of individualisation and speed. All of this has to be organised across the board, posing new challenges for process management, but also calling for a weighing up of risks, not just from an economic perspective, but more frequently also from a



legal one. New value chain processes need to be integrated into existing legal frameworks and protected against legal risks.

4.1.2 Humans as part of the overall value chain system in Industry 4.0

Humans as stakeholders have an outstanding role to play in the overall system of Industry 4.0. The traditional form of work is increasingly changing to complex work design. The high level of automation and the growing degree of interaction between humans and machines are leading to new roles and responsibilities for employees. Humans and machines work closely together and not so much side by side. As part of a permanently monitored system, they have to face new requirements when it comes to securing employees' rights. The question as to whether humans as users of ICT-controlled production systems are operators or key influencers is also crucial when it comes to the legal evaluation of possible risks or damage.

4.1.3 Systems as part of the overall value chain system in Industry 4.0

In the digital factory, machines are increasingly performing tasks that are used to steer production workflows. As they become more and more „smart" (thanks to sensors, actuators and smart system components), they can recognise changes in production workflows and the need for adjustment, and they can interpret events and trigger options for action. They communicate with their environment and interact with humans in production and logistics. The optimisation of machines using new control algorithms and sensor/actuator systems should lead to „more secure" workflows in the medium term and hence to fewer legally relevant cases of damage. Many future scenarios, such as self-optimisation of learning production systems and the related autonomous decisions by machines or robots, have not yet been classified in existing legal frameworks and will continue to be discussed.

4.1.4 Products and components as part of the overall value chain system in Industry 4.0

Just like machines, products and semi-finished parts are increasingly acting autonomously in the value chain process – be it in production or logistics. Networking means that one communication language must be found and timing must be coordinated. But there are also enormous legal challenges that result from the integration of products and components into a higher-level, controlled process chain, especially when these products and components can directly influence individual process steps.

4.1.5 Connected world

Modern production is usually networked around the globe. Across national borders and sectors, value chain networks are connected and require coordinated workflows and responsibilities. When regional borders are crossed, this usually means a change in the applicable laws and rules of law. The future task of legal support will be to

design this with as few risks as possible and in an economically safe manner.

5 The Ju-RAMI axis of relevant areas of law

German law contains an almost unlimited number of laws that may be relevant in the context of Industry 4.0. The following section presents the most important legal areas only.

5.1 Statutory liability (civil law)

Civil law poses a series of questions, the answers to which could have a considerable impact on the legal evaluation of (semi-) autonomous systems. One important distinction is related first of all to liability due to unlawful acts under section 823 et seq. of the German Civil Code [§ 823 ff. BGB] as well as liability due to a breach of contract (contractual liability). In both cases liability means „[...] have to assume any liability“ for the damage caused, i.e. fault on the part of the potentially liable party is a precondition.

Anyone who intentionally or negligently causes damage to another party is generally liable. Anyone who recognises the risk of damage and accepts or even strives for such damage is deemed to act intentionally. This kind of behaviour is to be expected mostly in a criminal context. As part of „normal“ business activities, liability due to damage caused through negligence is more likely to be the case. According to section 276 of the German Civil Code [§ 276 BGB], a person is deemed to act negligently if such person fails to exercise reasonable care.

Since reasonable care for matters related to Industry 4.0 has seldom been identified under law, but has yet to be discussed and decided by case law or in legal literature, there are grey areas where legal questions cannot be answered with certainty. In cases like these, it is important for manufacturers and developers to find out about and to document possible risks and constellations that could trigger liability so that in the event of dispute they can prove that prior to any possible case of damage they had examined any risks and how they could be prevented to a reasonable extent, i.e. according to the state of the art.

The measure for negligence is persistently changing depending on technical developments and social perception of risks. Individual questions are not usually answered by laws but by case law or left to the stakeholders to determine for themselves (e.g. by setting standards, such as DIN or ISO). The German Product Safety Act also specifies general standards only.

This means that the level of care to be exercised must be decided by the interests of the individual case, which is a problem especially in non-regulated areas like Industry 4.0 which have to a large extent not yet been addressed by the courts. The result is a considerable degree of uncertainty regarding what to do because it is certainly possible that the considerations made by the user may be corrected at a later point in time in court. This is all the more true since critical situations that lead to damage are often easier to assess in hindsight rather than beforehand.

It must also be remembered that in technology law behaviour that was still considered to be careful in the past may be deemed to be negligent at a later point in time, for instance, if in the meantime technical progress enables new ways to prevent risks or if risks become known that were not previously discussed. In view of the fast pace of technical development, additional problems can arise when it comes to determining the level of care. Moreover, in the field of new technologies, the risks that threaten users may not even be foreseeable under certain circumstances due to a lack of practical experience.

It must be noted in this context that the scope of the obligation to exercise reasonable care depends on the prior knowledge of the users of the relevant product. If, for instance, an autonomous system is operated by skilled personnel only, a reduced level of care will apply.

In civil law, the measure for negligence is not geared to flexible, learning devices. It has yet to be clarified which „acts“ of a device can be traced back to the user, manufacturer or even developer. The only way producers can protect themselves against such cases of liability is to comprehensively document the development and manufacturing process so that they can prove that they examined all risk scenarios that can be reasonably examined. In this context, there is also the question of the monitoring obligations which must be fulfilled, for instance, by installing a black box.

Problems also exist when it comes to statutory product liability (product liability law). The term product generally refers to a thing and it is questionable whether the results of non-physical work are „products" within the meaning of product liability law. Moreover, it is also necessary to discuss restrictions for the term „defect" or product expectations in the case of software. It is also necessary to examine the defect categories in product and producer liability in order to determine whether or not they can be applied to automated systems.

There are also other issues under civil law that need to be explored: It is, for instance, disputed whether software is a thing in itself (and not just perhaps a carrier medium). This question becomes more important as distribution via the cloud or in any other online form increases, because this may under certain circumstances lead to differences in warranties for defects depending on how the question is answered.

Another issue arising in conjunction with autonomics is related to how the term „defect" can be defined if devices learn autonomously because in this case the very goal of the software is in fact to change.

5.2 Contractual liability (civil law)

Contractual liability means having to assume responsibility for damage that results from a breach of contract. The claim for compensation due to breach of a (contractual) duty is particularly important: The damaged party is entitled to demand compensation for the damage caused (section 280 (1) of the German Civil Code [§ 280 Abs. 1 BGB]). The obligation to compensate does not apply only if the obliger is not responsible for the breach of the duty, i.e. the obliger cannot be proven to be at fault in the form of intent or negligence. Liability without fault is relevant in exceptional cases only. Otherwise, see section 5.3.

Up to now, German civil law does not consider conclusion of a contract by (largely) autonomous devices or software agents. This problem is already relevant today within the scope of transactions on the financial market and it can be assumed that this will become increasingly important as the degree of automation increases (for instance, orders for spare parts by autonomous machines). Ultimately, the only way to solve this issue will be through the legislator.

5.3 Criminal law

Generally speaking, anyone who causes damage that is equivalent to an offence as described in the German Criminal Code can be held responsible under criminal law. Constellations of this kind are conceivable in Industry 4.0 because the manufacture, bringing into circulation and also the use of products can be used as a starting point for a criminal act, e.g. physical injury or (negligent) manslaughter.

Questions of causality, i.e. of whether a certain act led to a certain success, are often difficult to evaluate or prove.

There is also the question of whether the perpetrator acted intentionally („deliberately") or negligently („by accident") if a negligent act is punishable at all (e.g. sections 222, 229 of the German Criminal Code [§§ 222, 229 StGB]). The latter is particularly important when it comes to documentation and monitoring obligations which could rule out negligence. If everything that was possible on the basis of the state of the art was carried out in order to rule out defects that could lead to damage, this usually rules out any responsibility under criminal law.

Due to the extent of the term „cause" under criminal law, both the developer and the manufacturer of damage-prone autonomous systems as well as programmers and sellers may be liable under criminal law.

5.4 Data protection (use of personal data)

If personal data is to be handled by an autonomous system, the legal requirements which must be observed for data protection must be identified. There is no special provision for autonomous systems.

The core areas of German law regarding data protection are largely identical because Data Protection Directive 95/46/EC specifies a minimum standard for all areas of regulation. Work is currently underway on a new EU data protection regime which is due to come into effect in 2018.

The basic principle is that personal data may only be collected, processed or stored if the owner of such data consents to this or if this is permitted by law. If, for instance, the personal data of a worker is collected and used, the worker must consent to this beforehand. This can also be included as part of an employment contract.

In Industry 4.0, large quantities of precise worker data is collected and saved; simply think about direct human-machine co-operation which makes it necessary for the machine to be adjusted precisely to the worker using it. There are many legal issues that need to be clarified in this context.

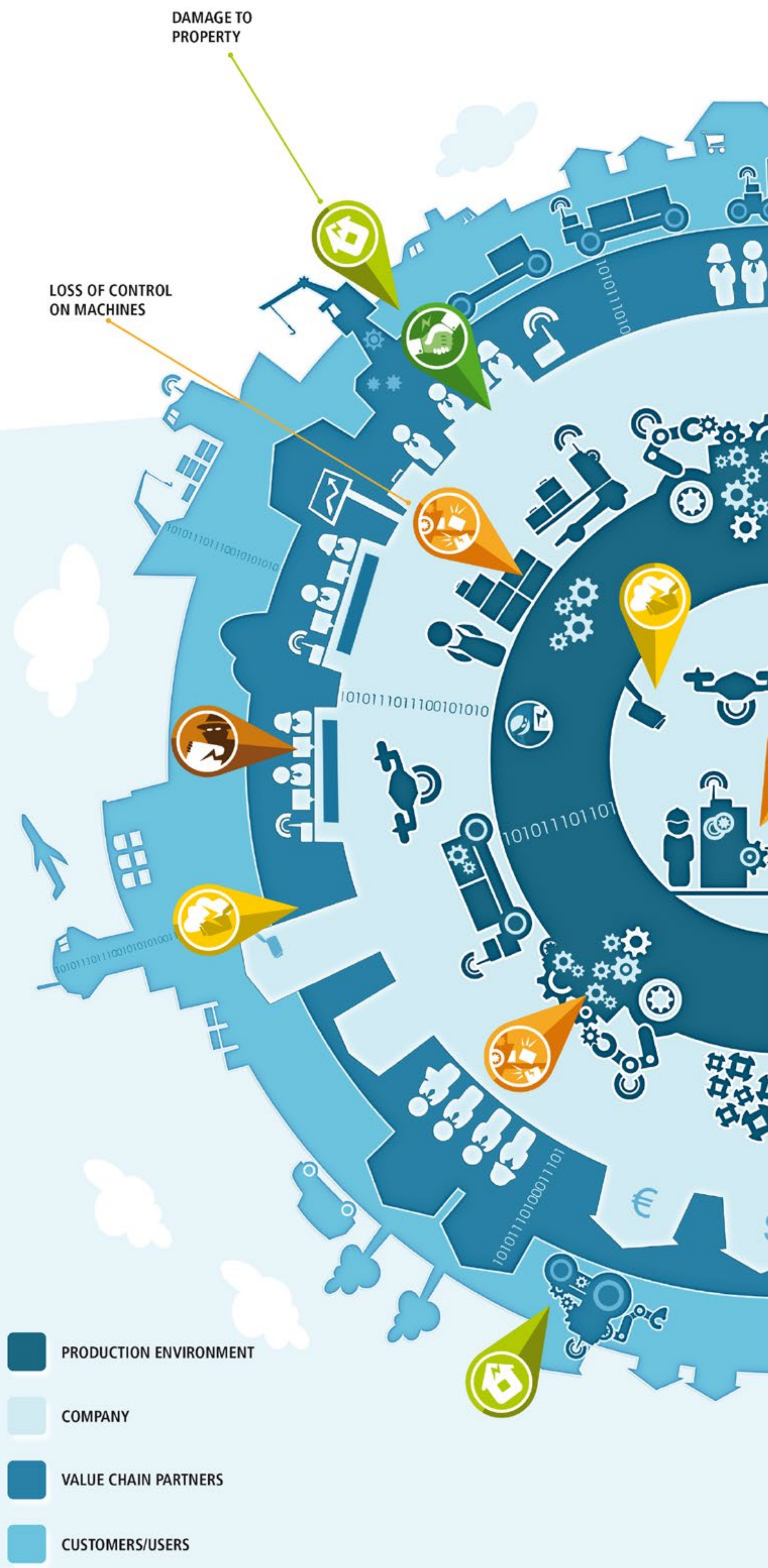
5.5 Occupational health and safety legislation (occupational health and safety)

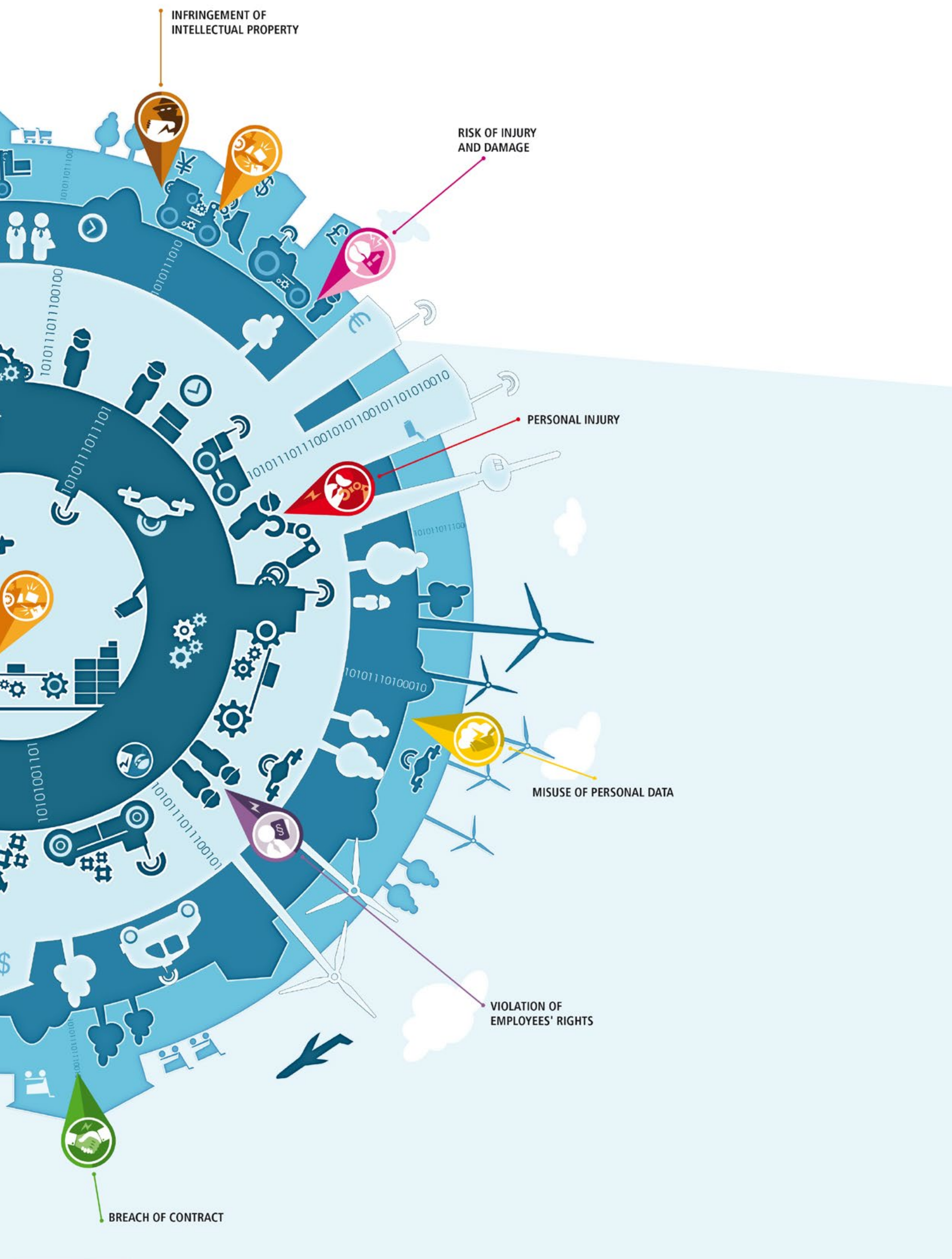
Occupational health and safety is deemed to be safety for employees at the workplace. Occupational health and safety means mastering and minimising risks to the safety and health of employees. Occupational health and safety legislation refers to those laws that serve to protect the life and health of employees. It is therefore not the purpose of occupational health and safety legislation to prevent damage to machines or working equipment or the failure of work results. However, occupational health and safety legislation does indirectly also protect the employer because accidents and occupational diseases also mean economic losses.

Section 618 (1) of the German Civil Code [§ 618 Abs. 1 BGB] is the basic rule of occupational health and safety legislation. According to this rule, employers have a duty of care for their employees which means, for instance, that the employer must set up and maintain (among other things) the facilities and equipment used to perform an activity under the employment contract in such a manner that the employee is protected against risks to life and limb.

The German Occupational Safety and Health Act provides a legal framework for occupational health and safety. The employer must design the work in such a manner that any risk to the life or physical/mental health of employees is avoided in as far as possible and the remaining risk is reduced to the furthest extent possible. The scope of the German Occupational Safety and Health Act applies to all groups of employees with the exception of domestic workers employed in private households, section 1 (2) of the German Occupational Safety and Health Act [§ 1 Abs. 2 ArbSchG]. It hence covers a wide range of different activities ranging from the salaried employee in a medical lab to a worker at a conveyor belt in a factory. Since the Act cannot address all occupation-specific risks, it contains a host of so-called framework rules which generally outline the employer's protection obligations. Typical for these regulations is the use of abstract terms, such as the reference to the „state of the art" in section 4 of the German Occupational Safety and Health Act [§ 4 ArbSchG].

The Act is defined in more detail for various industries and supplemented by European Union Directives which are transposed into national law through regulations. There are also binding rules imposed by accident insurance


DAMAGE TO PROPERTY
LOSS OF CONTROL ON MACHINES
PRODUCTION ENVIRONMENT
COMPANY
VALUE CHAIN PARTNERS
CUSTOMERS/USERS


INFRINGEMENT OF INTELLECTUAL PROPERTY
RISK OF INJURY AND DAMAGE
PERSONAL INJURY
MISUSE OF PERSONAL DATA
VIOLATION OF EMPLOYEES' RIGHTS
BREACH OF CONTRACT

associations, i.e. the employers' liability insurance associations and the accident insurers of the German Statutory Accident Insurance scheme, which are particularly committed to accident prevention. Other rules for the individual sectors are negotiated by the collective agreement partners.

Working on machines is particularly subject to the German Ordinance on Industrial Safety which determines (in section 1) the provision of work equipment by employers and the use of work equipment by employees. This is laid down in greater detail in the so-called technical rules for operating safety which contain, based on the state of the art, occupational medicine and hygiene, rules and other secured and scientifically based work findings for the provision and use of work equipment and for the operation of systems that require monitoring. These technical rules are identified by the committee for operating safety and are published in the Federal Labour Gazette by the Federal Ministry of Labour and Social Affairs.

The government's trade supervisory offices or the occupational safety offices and the statutory accident insurance associations monitor adherence to the occupational health and safety rules.

The rules of occupational health and safety legislation are supplemented by civil, criminal and labour law: Anyone responsible for occupational health and safety who violates safety regulations, either intentionally or through negligence, can be personally prosecuted under criminal law, for instance, on the grounds of negligent manslaughter, or under civil law, with a view to claims for compensation. Any employee who does not observe safety regulations can be dismissed under certain circumstances.

5.6 Intellectual property rights

The German legal system addresses the protection of intellectual property in certain areas only. Strictly speaking, the term „intellectual property" poses problems because only things, i.e. physical objects, can be owned. This means that in a legal sense „ownership" is only possible for things, but not for ideas or other intellectual products. That being said, however, copyright (which falls under the Act on Copyright) grants creators (= authors) special rights in „their" works. This is based on the view that without such protection there would be a steep decline in willingness to develop new ideas and to make these accessible to others. The market economy relies on effective author protection. Examples of protected intellectual products include works of literature (technical literature included), art (pictures, musical works, sculptures), as well as photographs, films, databases and computer programs. Designs (two-dimensional) and models (three-dimensional) are also protected by so-called design rights. Copyright warrants, among other things, special rights of use and the right to prevent others from using the work. Any violation of this can lead to claims for damages and may even result in criminal prosecution.

6 The Ju-RAMI axis of legal risk areas

The following section provides examples of special types of damage and risks which can occur in conjunction with Industry 4.0. Since the real situation can result in a vast range of different practical scenarios, this list is in no way exhaustive.

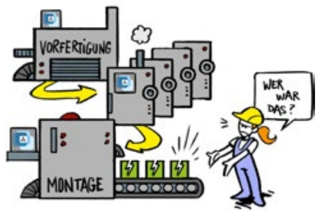
6.1 Personal injury

If people are injured, this is referred to as personal injury. Injuries can range from minor to fatal. Personal injury must be generally borne by the person suffering such injury (the person affected). In exceptional cases only, i.e. when special grounds for a claim apply, the person affected (or their heirs) can demand compensation for the damage incurred from another party, usually the injuring party. Such grounds for a claim can be a contract (contractual liability) or a special provision in law (statutory liability). This corresponds to the rules for material damage. If the body of the other person is injured intentionally or due to negligence, this can lead to criminal prosecution. The applicable legal provisions are, for instance, bodily harm caused by intent (section 223 of the German Criminal Code [§ 223 StGB]) or by negligence (section 229 of the German Criminal Code [§ 229 StGB]). If a person is killed, this may be intentional manslaughter (section 212 of the German Criminal Code [§ 212 StGB]) or negligent manslaughter (section 222 of the German Criminal Code [§ 222 StGB]).

Examples

1. Due to an incorrect instruction by the assistance system, a person is injured during assembly.
2. As a result of a sensor error, a machine moving autonomously on the premises of the company injures a person.
3. The assistance system detects poor ergonomic postures and movements. The worker is then instructed and the correct postures and movements are to be shown to the worker. If this information is incorrect or even harmful, this could result in the employee being injured.
4. A 3D-supported engineering platform generates error-prone proposals for the development of a production system which initially remain undetected so that the system injures people after it is put into operation.

6.2 Damage to property



Damage to property can apply to all kinds of things. A "thing" is defined by law as any corporeal object (section 90 of the German Civil Code [§ 90 BGB]), i.e. anything that you can touch. This includes machines as well as the (physical) products produced by them, utensils, as well as clothing worn on the body. The human body itself and its parts are not things. This is also true of rights. Damage to property is always the case when, following an event, the as-is properties of a thing deviate from its original properties. Damage can be damage to a substance (example: clothing that is torn) or any other form of impairment (e.g. heavy soiling). Damage to property must be generally borne by the owner of the thing affected. The owner can only claim compensation for damage that occurred if a special legal foundation exists for this, e.g. a contract (so-called contractual liability) or a provision under law (such as section 823 of the German Civil Code [§ 823 BGB], so-called statutory liability). If damage is caused intentionally, the party responsible for causing the damage may under certain circumstances be prosecuted (section 303 of the German Criminal Code [§ 303 BGB] – criminal damage).

Examples

1. Possible damage to property that results from accidental collisions or parts moved by the DTS falling down, for instance, damage to the storage facility (shelves, walls, floor, other inventory), damage to other vehicles or damage to staff clothing/protective clothing.

2. As a result of an incorrectly programmed robot, damage can be caused by collisions with objects in the robot's working area. Incorrect or incorrectly adapted controller programs can also lead to damage to the objects being worked on by robots.
3. During the development of a decentralised production planning system for company X, relevant aspects were missed, causing defects in the connected machines.

6.3 Breach of contract

A breach of contract is a case where a contract was made and entered into between two or more contract parties, usually with mutual rights and obligations, and where one of the parties to the contract fails to fulfil its obligations under the contract.

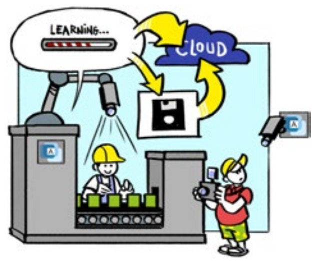
A breach of contract does not have to be intentional. A contract partner can, for instance, deliberately let a delivery date expire or simply forget it due to negligence, or a programmer creates a program which they are contractually obliged to deliver but which has so many errors that when used it causes considerable damage to the products produced. A breach of contract which leads to damage to property or personal injury usually results in a legal obligation on the part of the contract partner who failed to correctly perform the contract to compensate the other contract partner for the damage caused (see also damage to property, personal injury).

Examples

1. In violation of the contract, a production partner from a cross-company value chain delivers incorrect data or defective production material. The production resources specified in the contract are not available to the production partner.
2. The industrial robot "demands" from the worker that they work faster than agreed in the work contract (or in the works agreement).
3. The employee works together with a service robot without this being laid down in the work contract. The employee does not receive the agreed additional training for human-robot co-operation.

6.4 Misuse of personal data

Personal data is data that refers to the personal circumstances of a specific or identifiable person. Such data may only be collected, stored or processed with the express consent of the person in question or if such collection, storage or processing is provided for by law. In conjunction with "Autonomics and Industry 4.0", personal data is used, for instance, when a machine records data regarding the physical features of an employee (age, size, weight, etc.). Data like this is misused if it used for purposes that are not permitted by law. Examples of this include, for instance, the use of data for purposes other than those agreed to or the sale of such data (for instance to advertising companies). Data, which is not personal, can also be protected if such data is related to business secrets.



Examples

1. The assistance system monitors every assembly step in order to provide context-based instructions. In this case, sensitive personal data is collected and accidentally passed on.
2. Since an open innovation platform is closely connected to the production systems, company-relevant data can accessed by third parties (order processing, customer lists, production processes, utilisation, etc.).
3. Assistance systems record the work activities of the worker to a very far-reaching extent: time, speed, any errors and repetitions, if applicable, also the quality of the work result. Furthermore, the employee's emotional condition is to be identified (derived from an analysis of his facial expression). Any unlawful use and passing on of this data may lead to a considerable violation of personal rights.

6.5 Loss of control on machines

Machines normally run according to defined patterns. This applies not just to mechanical devices, but also to computers that work on the basis of algorithms. Autonomous (computer) systems hence also work according to rules defined by their creators and programmers. Loss of control is a case where these rules are no longer observed and returning to the original rule-based status is extremely difficult or not possible at all. In the context of Industry 4.0, a loss of control is a significant risk. This is where traditional (mechanical) machines, computer and autonomous systems work together. They are closely networked, so that errors and malfunctions can propagate from one device to the next. This means that the loss of control on a single machine can easily propagate to the other machines and machine complexes, causing considerable damage to property and personal injury.

Examples

1. A loss of control can be caused by incorrect programming of the autonomous controller, but also by errors in safety functions (reduction of speed right down to a stop if an obstacle is located in the area of autonomous vehicles). If the precise detection of the vehicles involved in the logistics process fails, too many or too few jobs may be accidentally sent to the mixing facility. If coordination of the supply vehicles is not correct, material bottlenecks can occur during assembly.

6.6 Violation of employees' rights

Employees are not only entitled to payment of the agreed wage, but must also be protected in many ways at the company. This includes observing certain safety standards and maximum working hours, as well as co-determination and other participation rights which employees can claim especially through the works council. In Industry 4.0, these rights are at times severely put to the test. Machines can work 24/7, they do not tire and, compared to humans, are extraordinarily robust. They communicate with other machines on a digital basis at a speed that is impossible for human beings to reach. Interaction between humans and machines in the connected factory hence poses a special challenge for employees' rights.

Examples

1. The worker is unable to keep pace with the cycle times of the HRC production system. The worker does not receive the training nor protective clothing needed when interacting with a heavy duty robot.
2. The worker works with a service robot without a protective barrier. The service robot determines the speed of the processes which is either very difficult or impossible for the worker to achieve.

6.7 Risk of injury or damage

A risk of injury or damage must be assumed if a situation exists that makes the occurrence of damage or injury likely. The likelihood of damage or injury occurring can differ, ranging from a minimum risk to a hazardous situation in which the likelihood of injury or damage is almost certain. Creating such a risk situation is legally relevant in exceptional cases only. As a rule employees may not be exposed to special risks unless the risk situation is limited and acceptance of such risk situation has been contractually agreed to with the employee (see also section 6.6 Employees' rights).

Examples

1. Incorrect programming of a semi-automated DVS controller, especially of the safety functions, results in a person being injured during operation (the injuries caused by an autonomous fork lift truck can be considerable and in the worst case even fatal).

6.8 Infringement of intellectual property

"Intellectual property" is understood to be any result of intellectual work that is protected by law. Intellectual property can refer, for instance, to special knowledge, inventions and other intellectual creations. Since cultural and scientific progress would come to a halt if there were no exchange of knowledge and inventions, there is a basic freedom to copy: Knowledge and ideas that originated elsewhere can be used and further developed. But this principle has its limits, i.e. where the law protects certain availability and exploitation rights in a particular manner and hence to a certain extent treats the protection of the said intangible goods as equal to the protection of "material goods" (things). This includes, for instance, copyright law, patent rights and the right to keep business secrets. In the context of autonomics and Industry 4.0, these risks can be seriously threatened, for instance, by hacker attacks and other forms of cyber crime, industrial espionage and even by attacks carried out by employees.

Examples

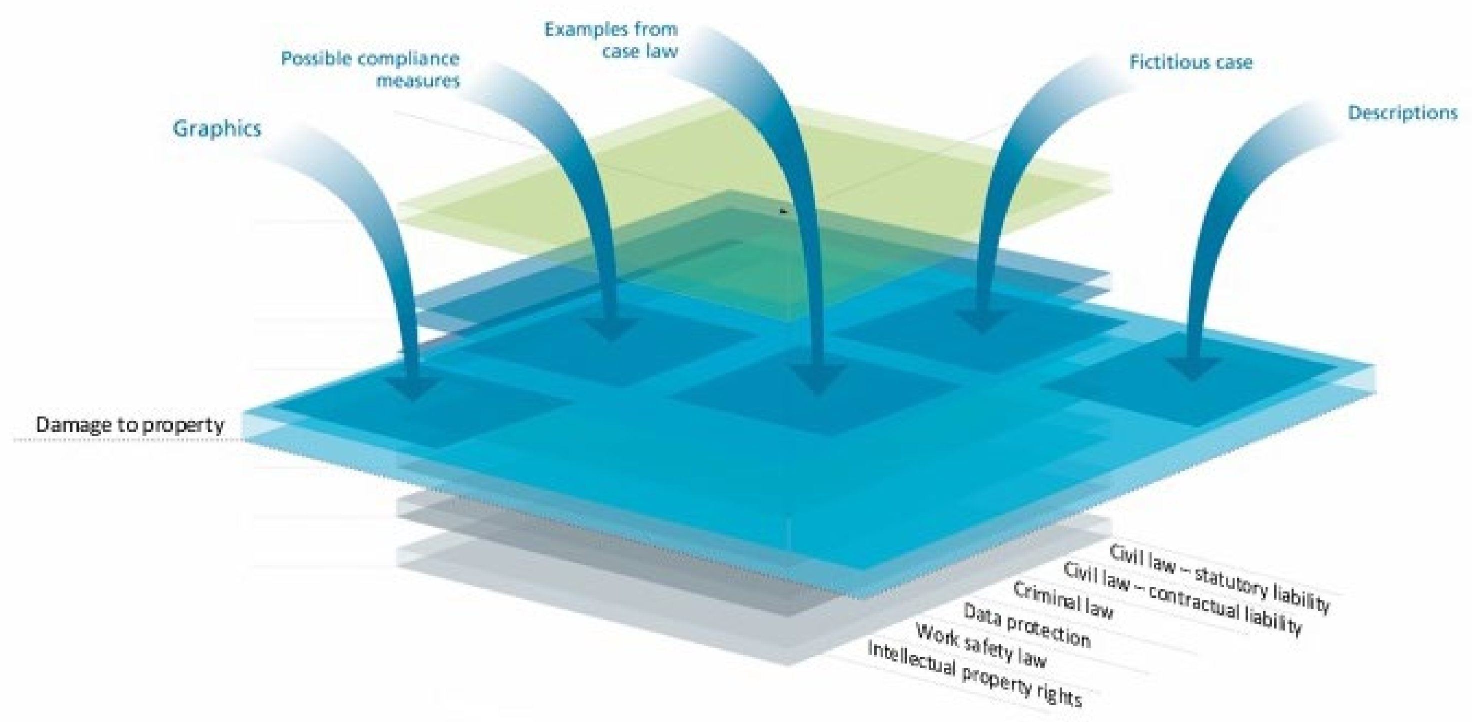
1. The employee secretly accesses the employer's computers and copies the production plans there.
2. . The customer develops its own design and orders the self-designed product from the manufacturer. The customer's intellectual property (design idea) is passed on to the manufacturer or the operator of the open innovation platform and can be economically exploited accordingly.

3. The services stored in the app store by system integrators, developers and even users are based on the intellectual creative work of suppliers. That's why special protection mechanisms are needed in order to adequately protect these services. Parts of the platform to be developed should be made available as open source. This poses the question regarding the rights to the applications created with this platform by the users.

7 Ju-RAMI 4.0 at work in industry

The overall view within the scope of Ju-RAMI 4.0 results in a suitable overview of the architecture as a whole. But an in-depth view of the individual levels, the legal risk areas and their specific classification in the existing legal framework are what make the model both manageable and useful. That's why each risk area is taken separately as a layer and specific case constellations are used to describe interaction between stakeholders and the respective area of law. By interpreting their own case examples, legal laypeople can also make a first assessment of their risk areas.

Damage to property



8 AUTONOMICS for Industry 4.0 – Explanation using project examples

With its Industry 4.0 Future Project, the federal government has launched a focus for its technology policy. The "AUTONOMICS for Industry 4.0" technology programme by the Federal Ministry for Economic Affairs and Energy (BMWi) is going a long way to ensure the success of this effort. 14 projects involving around 100 partners from industry and academia have qualified for support by the Federal Ministry which is backing the projects with funding in the order of €40m. Scientific assistance measures will also address important cross-cutting issues related to IT security, law and standards, as well as the future of work in Industry 4.0. The project examples presented below help to highlight the challenges of digitally based value chains and to provide users with an overall picture of the legal risk areas that are possible.

The APPsist project is developing a holistic approach for man-machine interaction in production. Based on the specific expertise of an employee, software-based assistance systems will automatically adapt to meet the employee's need for support. In this way, support and learning guides can be developed to meet very different needs, such as commissioning, operation, maintenance, repair and preventive servicing of systems. With made-to-measure support like this, employees with different levels of knowledge can be assigned a wider range of tasks than before.

www.appsist.de

Areas of law to be examined

Civil law – statutory liability, contractual liability
Criminal law
Data protection

CoCoS is developing a smart information and communication infrastructure with the ability to both recognise the different components of a production line, such as machines and workpieces, and to connect them to each other. It is also designed to form a communications bridge between the production, logistics and other management systems used that could then be designed as a distributed and virtual bridge. Separate networking of independent production systems at different locations is also to be enabled. No in-depth skills will be required, neither for commissioning the production line nor for any necessary adjustments.

www.cocos-project.de

Areas of law to be examined

Civil law – statutory liability, contractual liability
Criminal law
Data protection

FTF out of the box is developing smart, driverless transport vehicles which, after delivery and one introductory trip controlled by an operator, can find their way in the factory hall, remember their surroundings and can be assigned transport jobs, for instance, simply using voice and gesture commands. Previous systems involved long and difficult learning and reconfiguration phases, such as the prior implementation of a location map or the installation of artificial landmarks. Significant savings are now possible for customers.

www.ftf-out-of-the-box.de

Areas of law to be examined

Civil law – statutory liability, contractual liability
Criminal law
Data protection

The InnoCyFer project is developing a web-based open-innovation platform which provides customers with a toolkit that allows them to design technically viable products individually and according to their own ideas without the need for specific skills. Unique new autonomous production planning and control methods will be developed to manufacture these custom-innovated products. The methods will be based on flexible and adaptive forms of organisation found in biology. In this way, jobs can be planned at short notice and requests for changes can be permitted at late phases in the production process.

www.innocyfer.de

Areas of law to be examined

Civil law – contractual liability
Intellectual property rights
Data protection

In the InSA project, previously independent working areas of employees in production and of robot systems are monitored using sensor technology in order to coordinate safety precautions. The system records current activities and, taking the context and respective situation into account, assesses the risk potential which a worker, for instance, could be exposed to due to robot movements. The aim of this project is technical standardisation of these context-orientated production systems and their integration into smart production environments, so that the economic efficiency of industrial robots can be improved in mixed working environments.

www.insa-projekt.de

Areas of law to be examined

Labour law and industrial protection law
Data protection

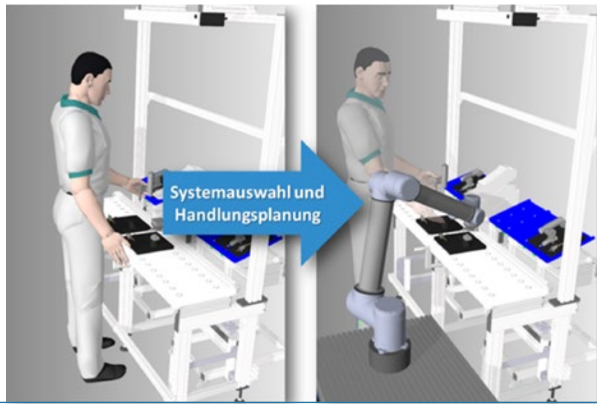
The aim of the InventAIRy project is to develop a system for automatic location and stock-taking of warehouse stocks using autonomous flying robots. The system sensors ensure that the flying robots can independently detect and analyse their environment so that they can navigate their way through the warehouse, detect logistics objects and do stock-taking. The system is to be used for both indoor and outdoor warehouses and can be easily networked with legacy warehouse management systems.

www.inventairy.de

Areas of law to be examined

Civil law – statutory liability, contractual liability
Intellectual property rights
Data protection

MANUSERV



The MANUSERV project aims to develop a planning and decision-making support system that uses service robots in order to automate processes that have been carried out manually up to now. The project will examine both technical viability as well as economic feasibility. The system provides support when it comes to selecting the most suitable service robot and its programming, right through to virtual commissioning. The solution is to be provided as a service for users via an Internet platform where suppliers will offer their service robot solutions in a technology catalogue, containing technical descriptions of the abilities of the products and robots.

www.manuserv.de

Areas of law to be examined

Civil law – statutory liability, contractual liability
Criminal law
Data protection

The aim of the motionEAP project is to use motion detection and prediction as a basis for developing a system to increase efficiency and assist in production processes at companies. With cameras and distance sensors, the system detects workers' activities and informs them of problems and potential for improvement. In addition to technical development, this product will focus on the issues of psychology and work ethics that arise from these new forms of interaction.

www.motioneap.de

Areas of law to be examined

Civil law – statutory liability, contractual liability
Data protection

OPAK

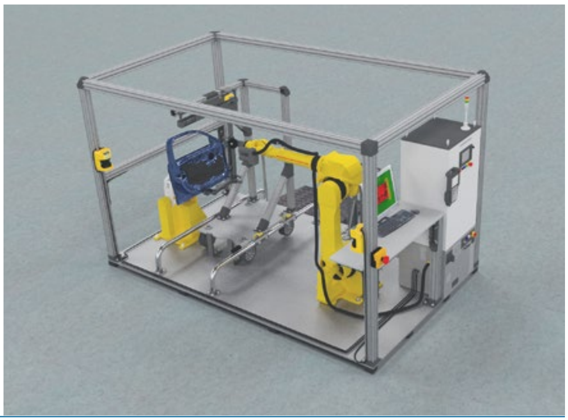
The OPAK project focuses on the development of a 3D-supported engineering platform for intuitive planning, development and commissioning of production plants. The plant can be initially planned, independent of the manufacturer, based on purely functional descriptions of the standard components of the automation system. The final components with the specific performance characteristics of the respective supplier are not added until later.

www.opak-projekt.de

Areas of law to be examined

- Civil law – statutory liability, contractual liability
- Criminal law
- Data protection

ReApp

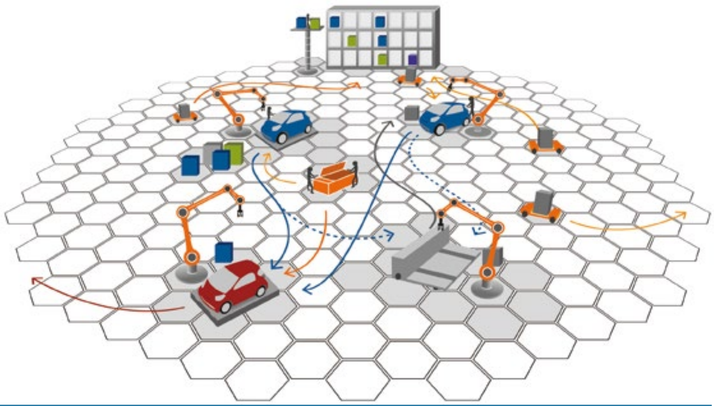


ReApp defines standardised interfaces for integrating hardware and software from different manufacturers for robot systems. Together with a catalogue of reusable smart services (robot apps) and a model-driven development environment, robot systems are to be adapted faster and at less cost to the specific requirements of small and medium-sized enterprises (SMEs). In this way, SMEs are to be able to make flexible and economic use of robot systems in production, assembly and logistics.

www.reapp-projekt.de

Areas of law to be examined

- Civil law – statutory liability, contractual liability
- Criminal law
- Data protection



The aim of SMART FACE is to develop distributed production planning and control systems. It is designed to adapt manufacturing structures to the demands of small-series production; parts to be assembled are individually requested via a network-supported application and self-organised machines distribute their workloads, making central workflow planning unnecessary. The advantages of this approach are flexibility, easy adaptation and an improved response to unforeseen changes in the workflow.

www.smartfactoryplanning.de

Areas of law to be examined

Civil law – statutory liability, contractual liability
Criminal law
Data protection

SMARTSITE develops smart control systems for autonomous construction machines and equipment which are also capable of co-operating along the entire logistics chain. A model motorway construction site is being viewed as an application case where a control centre sends the work jobs to the construction machines and equipment and provides additional information, for instance, regarding environmental conditions. The development of uniform standards for exchanging data and providing information outside the scope of the construction site is an important aspect of this project. The overall goal is to significantly improve the efficiency of road construction and the quality of the roads built, especially with a view to longer durability.

www.smartsite-project.de

Areas of law to be examined

Civil law – statutory liability, contractual liability
Data protection

SPEEDFACTORY

Automated custom production is being developed in the SPEEDFACTORY research project where humans and machines work together in a common working environment to produce sports goods and car seat covers in the shortest possible time, from the design to the final product at low cost and in a flexible manner.

Areas of law to be examined

Civil law – statutory liability, contractual liability
Criminal law
Data protection

9 Prospects for networking in industrial settings

The design of Ju-RAMI 4.0 was rooted in the premise that the frequently seen innovation-damming effect of law was often due to technicians and legal people finding it difficult to communicate. If this is true, we then have to identify the reasons for these communication barriers and create ways in which to overcome them. That's why the core task of legal scientific assistance is to present in an understandable manner the legal requirements for each project and to provide the project partners with access to the legal topics that are relevant for them. It is not so much a matter of detail, but more about communicating the basic legal principles that often pave the way for a reasonable understanding of the problem even without in-depth legal knowledge.

Visualising law can be an important means to overcome barriers in understanding. This is, at least in the case of technology law, a new form of access which must be tried and tested first. In this case, it makes sense to push ahead with visualisation using Ju-RAMI for more specialised topics and to perform evaluations that could help to improve the model further.

The partners in practice are of the opinion that the Ju-RAMI model will not reach its full potential until its structures have been mapped in software. Access to the applicable areas of law via risk scenarios could then be even more differentiated and tailored to specific challenges. It would then be conceivable to provide users with other detailed diagrams and educational solutions for comparable cases on the level of the selected area of law along with applicable laws, introductory legal texts, case law (summaries, but also as full-length versions) as well as the relevant short assessments. A glossary of terms and legislation would also be useful.

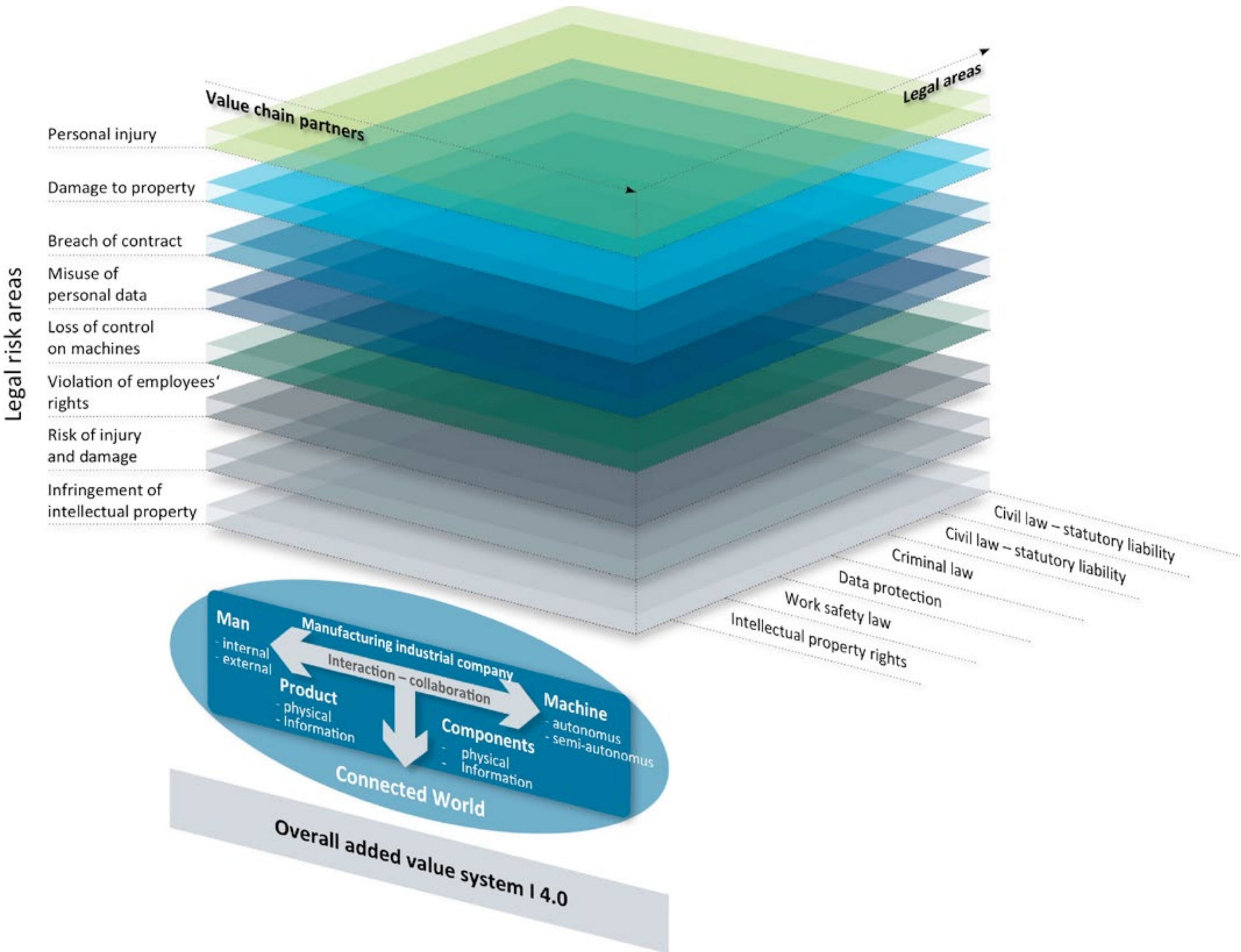
As a more advanced version, digitised Ju-RAMI could also feature test units with test-your-knowledge questions, multiple-choice modules and small educational case solutions, thus providing an online learning environment which could be used by engineers and other technicians for self-learning and to prepare before contacting legal experts. Generally speaking, all Internet contents, including all sources of specialist legal information, could be included. In digitised form, there would be almost no limits to the extent to which Ju-RAMI could be extended. It could become an innovative support service for legal orientation in Industry 4.0 with a potential that has yet to be fully realised.

The Ju-RAMI structure is certainly suitable for transferring the visualisation of legal problem fields to other legal systems and hence to add to discussions regarding international standardisation matters. When used, the methods could make it easier to draw up contracts and/or service level agreements.

10 Summary

In the Autonomics for Industry 4.0 technology programme backed by the Federal Ministry for Economic Affairs and Energy, more than 100 partners from industry and science are conducting research into new technologies and systems for industrial production. On top of that, accompanying scientific research measures are addressing important crosscutting issues related to IT security, the future of work in Industry 4.0, standardisation, business models and legal frameworks. Comprehensive networking and autonomy as part of the Industry 4.0 concept are posing completely new questions related to the legal framework for interaction between smart machines, systems and workers. Data protection and IT security are just as important here as are issues of liability, e.g. in the case of accident scenarios.

But often the questions (especially the legal ones) being asked are completely new and complicated so that technicians working in the projects have difficulty understanding them and putting them in the right perspective. But that is exactly what they have to do so that they can tell us whether the system or product developed by them could come into conflict with legal norms or even be in violation of applicable law.



Ju-RAMI 4.0 to support legal and technical compliance

In order to make the legal risks involved in digital production as understandable as possible, research accompanying the technology programme has come up with the first version of a „legal" reference model for Industry 4.0 which is based on RAMI 4.0. „JuRAMI 4.0" is designed to allow legal lay people to identify specific legal risk areas, damage and hazards across the entire networked value chain. Just like the reference architecture model, JuRAMI 4.0 comprises a threedimensional coordinates systems that maps the key areas of law and legal risk areas in conjunction with Autonomics for Industry 4.0 along the entire networked value chain. It serves as a basis for analysing relevant legal issues and, as an easytounderstand diagram, it should enable practical application without extensive legal knowledge. The aim here is to quickly present a first reference framework for Industry 4.0 project stakeholders that helps them to identify existing legal loopholes and offers first approaches to solving these problems. The individual legal layers are filled with practical case examples which makes orientation easier for legal lay people.

The layers are used to depict concrete legal risk areas, damage and hazards that can occur along the entire networked Industry 4.0 value process. On a second axis, the stakeholders are defined as sociotechnical addedvalue levels. Axis three then presents the legal areas that form the legal framework for the individual risk areas. There are plans to make an interactive version of this layer model available next year.

For more detailed information, please go to:
www.ju-rami.com

www.autonomik40.de