

The impact of engineering management on the establishment of strict product liability and the legal defenses available against AI-based smart products

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Abstract

This study explores the intersection between engineering management and strict product liability in the context of AI-based smart products, emphasizing how technical systems can substantiate or exclude liability and activate legal defenses. Traditional civil liability frameworks, particularly in Jordanian law under Article 261 of the Civil Code, recognize external causes such as force majeure, fault of the injured party, and fault of third parties as grounds for exemption.

However, these provisions remain general and do not fully address the technological complexities of smart products, which are dynamic, continuously updated, and reliant on algorithmic processes.

By contrast, recent European legislation, notably Directive 2024/2853, integrates engineering controls into liability assessments, requiring producers to demonstrate compliance through documented technical practices. This comparative gap highlights the need for Jordanian law to evolve toward incorporating engineering evidence into liability defenses. The research adopts an analytical–comparative methodology, combining legal analysis of statutory texts and judicial decisions with technical evaluation of engineering management systems such as Product Lifecycle Management (PLM), quality assurance, and risk management frameworks. These systems not only reduce risks but also generate objective records digital logs, traceability data, and risk assessments that can serve as admissible evidence in litigation.

Findings reveal that liability outcomes depend on balancing consumer protection with producer fairness, achieved through integrating legal doctrine with engineering evidence. The study recommends legislative reforms in Jordan to align with European approaches, recognition of engineering records in courts, and adoption of standardized management practices by producers. Future research should expand comparative analysis to other jurisdictions and examine the role of AI governance frameworks in shaping liability standards.

Keywords: AI-based smart products, strict product liability, Engineering management, Risk management, Consumer protection.

1. Introduction:

1.1 Research Topic: The growing reliance on artificial intelligence (AI) in smart products has reshaped the foundations of civil liability, particularly in the field of product liability. Traditional liability regimes, which were historically grounded in fault-based responsibility, are increasingly challenged by the distinctive nature of strict liability for defective products. In this context, engineering management emerges not merely as a technical discipline but as a decisive factor in shaping the scope of liability, the effectiveness of defenses, and the evidentiary standards required to exempt producers from responsibility.

The research topic therefore focuses on the impact of engineering management on the establishment of strict product liability and the defenses available to producers of AI-based smart products. Strict liability for defective products is characterized by its independence from fault, requiring only proof of defect, damage, and causation. However, the complexity of AI-driven systems marked by evolving algorithms, continuous updates, and dynamic data environments introduces new challenges in determining the origin of defects and the scope of producer responsibility Al-Maaiteh B. (2026). Engineering management systems such as Product Lifecycle Management (PLM), software release management, quality assurance frameworks, and digital traceability mechanisms have become indispensable tools for producers seeking to demonstrate compliance with safety standards and to invoke legally recognized defenses. These systems provide technical evidence that can substantiate claims of non-placement on the market, absence of defect at the time of release, or confinement of the product to experimental environments prior to commercialization (Stark, 2015; INCOSE, 2023).

Recent legislative developments in the European Union, particularly Directive (EU) 2024/2853, highlight the increasing integration of technological control into liability assessments.

The Directive reflects a shift toward evaluating the producer's degree of control over algorithms, software, and updates throughout the product lifecycle (Al Maagbeh et al., 2026b). This approach underscores the necessity of engineering management not only as a preventive mechanism but also as a source of documented evidence capable of supporting defenses such as force majeure, fault of the injured party, or fault of a third party (European Union, 2024; Howells et al., 2023). In parallel, Jordanian civil law, notably Article 261 of the Civil Code continues to recognize external causes such as force majeure and third-party fault as grounds for exemption, though without specific provisions tailored to the risks of AI systems Sarah M. (2026). This divergence between European and Jordanian approaches provides fertile ground for comparative legal analysis. From an engineering management perspective, defenses to strict liability acquire new dimensions. For instance, the fault of the injured party is no longer assessed solely through legal reasoning but through technical evidence such as digital operating logs, user-centered design compliance, and risk management practices. Similarly, reliance on third-party fault requires producers to document supply chain activities, software modifications, and external interventions using configuration management and digital traceability systems (Al-Dabbas, Altarawneh, et al., 2026). In the case of force majeure, engineering management tools such as predictive analytics, risk assessment frameworks, and business continuity systems play a critical role in demonstrating that the event was unforeseeable and irresistible despite adherence to recognized standards (ISO, 2018; Hopkin, 2018). This research topic therefore seeks to explore the intersection of law and engineering management in shaping the contours of strict product liability for AI-based smart products. It aims to analyze how engineering systems provide technical evidence that strengthens or weakens defenses, how legislative frameworks in Europe and Jordan diverge in regulating exemptions, and how comparative scholarship can inform the development of balanced liability regimes. Ultimately, the study underscores that liability for intelligent products is not absolute; it rests on a delicate equilibrium between protecting consumers and recognizing the producer's reliance on robust engineering management practices. By integrating legal doctrine with engineering evidence, this research contributes to a deeper understanding of how liability rules must evolve to address the challenges posed by AI-driven technologies (Al-Qaisi et al., 2026).

1.2The Research Problem: The research problem lies in the fact that strict liability for smart products based on artificial intelligence raises new challenges that go beyond the scope of traditional legal analysis. It intersects with engineering management systems that govern the product lifecycle, software quality, and risk management. This overlap makes it difficult to determine the source of the defect, the moment it arises, and the extent of the producer's liability. Therefore, there is a pressing need for an integrated study that combines law and engineering to provide balanced solutions that protect consumers while enabling producers to invoke effective defenses. The main question:

To what extent does engineering management shape the establishment of strict product liability, and how does it contribute to the effectiveness of legal defenses in the context of AI-based smart products?

To address this dilemma, the study answers the following sub-questions:

- **To what extent can product lifecycle management systems and quality management frameworks provide technical evidence that supports the producer's defenses against strict liability?**
- **How does the regulation of liability defenses differ between European and Jordanian legislation with respect to smart products and AI-based systems?**

- **What role does engineering management play in establishing special exemption grounds such as force majeure, the fault of the injured party, or the fault of a third party in the context of smart products?**

1.3 Significance of the Research: The significance of this research stems from its focus on a contemporary and complex issue: strict liability for smart products based on artificial intelligence. This issue is no longer confined to the scope of traditional legal analysis but has become closely linked to engineering management and its technical systems. The rapid development of AI technologies, accompanied by continuous updates and evolving algorithms, imposes new challenges on legislators, producers, and consumers alike. Hence, studying the impact of engineering management on the establishment of strict product liability and its role in activating legal defenses represents a valuable contribution to both legal and engineering knowledge.

This research helps bridge an existing gap between legal theory and engineering practices, demonstrating how product lifecycle management systems, quality management, and risk management can provide reliable technical evidence to support producers' defenses before courts. It also highlights the importance of comparing European and Jordanian legislation in regulating liability defenses, offering practical insights that may assist in developing national laws to keep pace with the challenges of the digital age.

Furthermore, the research enhances consumer protection by proposing balanced solutions that safeguard their rights while simultaneously equipping producers with effective legal and technical tools to avoid unfair liability. Thus, it constitutes both a scientific and practical contribution to the advancement of legal and engineering thought, laying the foundation for future studies in the field of civil liability for smart products.

1.4 Objectives of the Research: This research aims to examine the relationship between engineering management and strict product liability in the context of AI-based smart products, focusing on how engineering systems contribute to establishing or excluding liability and activating legal defenses. First, the study seeks to such as product lifecycle management (PLM), quality management, and risk management in providing reliable technical evidence that supports producers in demonstrating compliance with safety standards during design, development, and testing, updating, and monitoring processes.

Second, the research aims to highlight the legislative gap between European and Jordanian legal frameworks in regulating liability defenses for smart products. By conducting a comparative analysis of statutory provisions and judicial approaches, the study intends to extract practical lessons that can inform the modernization of national legislation to address the challenges of digital and AI-driven technologies. Third, the study seeks to reassess traditional legal defenses including force majeure, the fault of the injured party, and the fault of a third party in light of the technological environment of smart products. It emphasizes how engineering management practices, such as digital traceability, operational logs, and risk-based design, can substantiate these defenses with objective evidence. Ultimately, the research aims to build an integrated framework that balances consumer protection with fairness to producers, bridging law and engineering in addressing civil liability for smart products.

1.5 Research Methodology: This research adopts an analytical comparative methodology that integrates law and engineering to highlight the impact of engineering management on strict product liability and the legal defenses applicable to AI-based smart products. First, the legal analytical approach is employed to examine legislative texts and judicial rulings in both the European Union and Jordan, with particular focus on defenses such as force majeure, the fault of the injured party, and the fault of a third party. Second, the study applies a technical engineering

approach to analyze product lifecycle management, quality management, and risk management systems as tools for generating technical evidence that supports or excludes liability. Third, a comparative legal analysis is conducted to identify similarities and differences between European and Jordanian frameworks, offering practical recommendations for legislative development.

2. Literature Review: The literature on strict product liability and engineering management reveals a growing intersection between legal doctrine and technical systems, particularly in the context of AI-based smart products. Traditional civil liability frameworks, such as those outlined by **Al-Sanhuri (1998)** and **Marqous (1992)**, emphasize the role of defect, damage, and causation as the foundation of liability. However, these frameworks often assume static products, whereas smart systems are dynamic, continuously updated, and reliant on complex algorithms.

Recent scholarship in Jordanian law, including **Abu Al-Basal (2018)**, **Al-Sarhan & Khater (2022)**, and **Al-Zu'bi (2009)**, highlights the importance of external causes such as force majeure, fault of the injured party, and fault of third parties as grounds for exemption. These studies align with Article (261) of the Jordanian Civil Code, which explicitly recognizes external causes as defenses. Yet, they do not fully address the technological dimensions introduced by AI systems.

Comparative studies in European law, particularly the **European Union Directive (2024)**, demonstrate a shift toward integrating engineering management into liability assessments. Scholars such as **Howells et al. (2023)** and **Fairgrieve & Goldberg (2020)** argue that liability must be evaluated in light of the producer's technical control over algorithms, updates, and digital supply chains. This perspective underscores the evidentiary role of engineering practices, including **Product Lifecycle Management (PLM)**, **quality assurance**, and **risk management systems**, in substantiating defenses. From an engineering standpoint, works like **Stark (2015)**, **Leveson (2011)**, and **Salvendy (2021)** emphasize the preventive and evidentiary functions of engineering management. These systems not only reduce risks but also generate technical records such as digital logs and traceability data that can be used in litigation to prove compliance or to demonstrate external causes of damage.

Thus, the literature reveals a dual gap: (1) the need to adapt traditional legal defenses to the technological realities of smart products, and (2) the need to integrate engineering management evidence into liability assessments. This research builds upon these insights by offering a comparative analysis of Jordanian and European approaches, while highlighting the operational role of engineering systems in shaping liability outcomes.

Before presenting the table, it is important to note that previous literature has addressed strict product liability from both legal and engineering perspectives. Traditional civil law studies emphasized defect, damage, and causation, while modern scholarship particularly in Europe has begun integrating engineering management systems as sources of technical evidence. The following table summarizes key contributions:

Table 1: Summary of Previous Studies on Product Liability and Engineering Management

Author Reference	Year	Field		Key Findings / Contribution
Al-Sanhuri	1998	Traditional Law	Civil	Defined liability elements (defect, damage, causation) without addressing technical dimensions.
Marqous	1992	Comparative Law		Examined force majeure as a defense, limited to legal analysis.
Abu Al-Basal	2018	Jordanian Law	Civil	Highlighted external causes (force majeure, injured party fault, third-party fault) under Article 261.
Al-Sarhan & Khater	2022	Jordanian Law	Civil	Emphasized proof of independence of external causes to sever causation.

Al-Zu'bi	2009	Jordanian Law	Civil	Discussed strict liability and defenses, without integrating smart product technology.
Howells et al.	2023	European Law		Linked liability to producer's technical control over algorithms and updates.
Fairgrieve & Goldberg	2020	Comparative Law	EU	Stressed importance of technical evidence in supporting or excluding liability.
Stark	2015	Engineering Management		Highlighted PLM systems as tools for documenting design and development stages.
Leveson	2011	Systems Engineering		Focused on risk management and causal analysis of accidents to support liability defenses.
Salvendy	2021	Human Engineering	Factors	Emphasized user-centered design to minimize human error and strengthen producer defenses.

Note: This table shows the shift from purely legal analyses to integrated approaches combining law and engineering, and highlights the gap in Jordanian scholarship compared to European studies that incorporate engineering management into liability assessments.

3. General Defenses to the Producer's Strict Liability in Light of Engineering

Management: The distinctive nature of strict liability for defective products, particularly those supported by artificial intelligence systems, lies in its relative independence from the traditional rules of civil liability regarding its elements and legal consequences. Such liability is established on the basis of the risk arising from the defect itself, without the need to prove fault. Although the European Product Liability regime limits the grounds upon which a producer may be exempted from liability, the general rules governing exemptions from liability remain an essential legal basis for excluding the producer's obligation to provide compensation. Force majeure and other forms of external causes operate by negating the causal link between the defect and the resulting damage. Despite the absence of an explicit reference to force majeure in the European Product Liability framework, largely due to differences among Member States in defining the concept, legal doctrine and jurisprudence consistently recognize it as a general defense. Since strict product liability requires the existence of a defect, damage, and a causal relationship between them, proving an external cause, whether force majeure, a sudden unforeseeable event, the fault of the injured person (user), or the act of a third party, necessarily interrupts the causal connection and relieves the producer from liability for compensation. This principle is reflected in the general rules of Jordanian civil law, particularly Article (261) of the Jordanian Civil Code No. 43 of 1976. While these defenses originated within the framework of traditional civil liability, their application to AI-based smart products can no longer be confined to purely legal analysis. Instead, it has become closely linked to the systems and practices adopted within engineering management, particularly quality management, risk management, product lifecycle management, supply chain management, and post-market monitoring and updating systems. These managerial systems are based on a preventive approach aimed at identifying, assessing, and mitigating potential risks before they materialize into actual harm. This approach is emphasized in international quality management standards that incorporate risk-based thinking and in functional safety standards applicable to electronic and software-based systems (International Organization for Standardization [ISO], 2015; International Electro technical Commission ([IEC], 2010) (Almajali, Alshanty, Althnaibat, & Almahasnah, 2024).

Furthermore, recent developments in European product liability law demonstrate an increasing interaction between legal responsibility and the technological environment within

which products are designed, developed, and maintained, particularly in relation to software, artificial intelligence systems, and complex digital supply chains. Consequently, engineering practices and organizational measures implemented by producers have become important factors in assessing the existence of a defect, establishing causation, and determining whether liability may be excluded or mitigated (European Union, 2024). Accordingly, engineering management can no longer be viewed merely as a tool for enhancing operational efficiency or product quality. Rather, it has become an important source of technical evidence that may be relied upon to demonstrate product safety, identify the source of failures, and prove the adoption of appropriate preventive measures. Such evidence may strengthen a producer's ability to invoke legally recognized defenses or to challenge the existence of a causal link between the defect and the damage. Therefore, the study of general defenses to strict liability in the context of smart products requires an integrated legal and engineering perspective that considers the impact of engineering management on the establishment or exclusion of liability and on the effectiveness of defenses based on the fault of the injured party, the act of a third party, and force majeure. Therefore, we will study the general means of paying the product's objective liability as follows:

3.1 The Fault of the Injured Party as a Defense to Strict Product Liability: An Engineering Management Perspective: The governing criterion for invoking the fault of the injured party as a ground for reducing the producer's liability lies in the actual and direct contribution of the user to the occurrence of the damage, regardless of whether the fault is serious or minor, provided that it effectively contributed to the harmful result. Principles of justice require the allocation of liability in proportion to the respective roles played by both the product defect and the user's conduct (Al-Sarhan & Khater, 2022; Al-Zu'bi, 2009). Conversely, where the fault of the injured party completely dominates the chain of events leading to the damage and satisfies the requirements of force majeure, namely unforeseeability and irresistibility, the producer shall be fully exempted from liability due to the complete interruption of the causal link between the defect and the damage (Al-Sanhuri, 1998; Marqous, 1992). From an engineering management perspective, the assessment of the injured party's fault is not limited to verifying an apparent violation of operating instructions or safety warnings. Rather, it extends to examining the engineering environment within which the smart product was designed to operate, as well as the producer's compliance with the principles of user-centered design, human factors engineering, and operational risk management. Accordingly, the producer's legal position is strengthened when it can demonstrate that it provided clear user interfaces, comprehensible operating instructions, effective warning mechanisms, and protective safeguards designed to minimize the probability of human error. In such circumstances, the damage is more likely to be attributed to the user's deviation from safe operating procedures rather than to any deficiency inherent in the product itself (Salvendy, 2021; ISO, 2019).

Moreover, contemporary engineering management systems provide technical evidence that assists in determining the extent of the user's contribution to the occurrence of the damage. Such evidence may include digital operating logs, technical monitoring reports, and analyses of the actual use of the smart product. These tools make it possible to distinguish between a latent technical defect within the system and misuse attributable to the injured party. In this context, risk management and product lifecycle management have become essential mechanisms for reconstructing incidents and identifying the causal relationship between human behavior and the resulting damage, thereby supporting judicial assessments concerning total or partial exemption from liability (Leveson, 2011; ISO, 2018). This analysis is particularly significant in the context of artificial intelligence-based products. Merely proving that the user committed an error is

insufficient; it must also be determined whether such conduct was reasonably foreseeable under prevailing design and operational standards. If the human error was technically foreseeable and could have been mitigated through reasonable engineering safeguards, the producer's liability may remain wholly or partially intact. Conversely, where the user's conduct was abnormal and could neither be reasonably anticipated nor prevented according to recognized engineering standards, the producer's reliance on the defense of the injured party's fault becomes considerably stronger and may result in the exclusion of liability through the interruption of causation (Endsley, 2017; Leveson, 2011). This approach is consistent with the position adopted by Jordanian legal scholarship, which maintains that liability is excluded only when the injured party's conduct constitutes the independent and effective cause of the damage, thereby absorbing the defect and severing the causal connection between it and the harmful outcome (Al-Sarhan & Khater, 2022; Al-Zu'bi, 2009). Accordingly, the fault of the injured party in the context of smart systems is no longer confined to the traditional forms recognized in civil liability law. Rather, it acquires new operational and technological dimensions arising from the interaction between users and AI-based systems. Its practical manifestations vary according to the nature of the product and its operating environment, and its most prominent forms are as follows:

3.1.1 Abnormal Use of the Smart Product in Violation of Operating Instructions: From an engineering management perspective, it is insufficient for the producer to rely solely on proving that the user violated the operating instructions in order to invoke this defense. Rather, the producer must also demonstrate that reasonable technical measures were adopted to prevent foreseeable misuse, including the design of clear user interfaces, the provision of effective warnings, and the implementation of user-centered design principles and operational risk management practices. Furthermore, digital operating logs and actual usage data generated by the smart product can assist in verifying whether the user exceeded the authorized scope of use, thereby supporting the conclusion that the damage resulted from abnormal use attributable to the user rather than from a defect in the product or its algorithms (ISO, 2019; Norman, 2013; Al-Sarhan & Khater, 2022).

3.1.2 Failure to Verify the Smart Product's Validity for Use (Exceeding Its Operational or Temporal Lifespan): Operating a smart product or relying on its outputs after the expiration of its declared period of validity constitutes an error attributable to the user, as the responsibility for ensuring safe use shifts to the user. However, the producer's failure to clearly indicate the product's expiration date or software support updates constitutes evidence of a defect in the product and negates the defense based on the user's fault (European Union, 2024; Al-Sarhan & Khater, 2022). Mere negligence by the user in inspecting the smart product before operation, where such inspection is reasonably possible, does not amount to a gross and overriding fault that completely exempts the producer from liability. The governing standard remains the level of safety that the product is expected to provide when placed into normal circulation (Al-Sanhuri, 1998; Al-Zu'bi, 2009). Scholarly opinion and prevailing judicial approaches generally maintain that, particularly in the context of medical products and sensitive smart systems, the user's conduct in such circumstances does not entirely break the causal link between the defect and the damage. Rather, it results in shared liability (partial exemption), thereby balancing the protection of the injured party with the producer's strict obligation to ensure product safety.

From an engineering management perspective, maintenance management, software update management, and product lifecycle management constitute essential tools for ensuring the continued fitness of a smart product for use. Update logs and technical support records can assist in determining whether the damage resulted from operating the product after the expiration of its validity period or from deficiencies in the producer's management and monitoring of the product.

Such information plays an important role in assessing whether the producer is entitled to invoke the defense based on the user's fault (ISO, 2018; Stark, 2015; Al-Khalidi, 2021).

3.2 Exemption from Liability by Proving the Fault of a Third Party: For the act of a third party to constitute an external cause that completely exempts the producer from strict liability for a smart product, it must satisfy the conditions of force majeure. Accordingly, the third party's conduct must be overwhelming, unforeseeable, irresistible, and constitute the sole and effective cause of the damage. This may occur where the defect results from the error of an independent carrier or from unauthorized algorithmic interference by an external developer. However, where the fault of a third party coincides with a defect in the product without completely absorbing it, the producer remains liable, while retaining a right of recourse against the third party. Although the general rules allow compensation to be apportioned between the producer and the third party according to the degree of fault or equally where apportionment is impossible, modern legislation, including Articles (5) and (8) of the European Directive, Article (1245-10) of the French Civil Code, Article (265) of the Jordanian Civil Code, and Article (7) of the Jordanian Consumer Protection Law, has adopted the principle of mandatory joint liability of producers toward the injured party whenever multiple actors contribute to the chain of smart product manufacturing and development. Such situations include multiple producers involved in the final product and external parties contributing to the emergence of a software defect.

3.2.1 The Impact of Multiple Producers on Liability: Under both the European Directive and the French Civil Code, producers are subject to mandatory joint liability toward the injured party whenever more than one producer is involved. Consequently, a producer may not escape strict liability by alleging the fault of another producer or by arguing that the defect originated at an earlier stage of manufacture. As an exception to this principle, Article (1245-10) of the French Civil Code (corresponding to Article 7 of the Directive) permits the producer of a specific component to avoid liability by proving that the defect resulted exclusively from the overall design of the product and that the component producer complied with the standards and mandatory instructions issued by the final producer responsible for placing the product on the market.

3.2.2 The Effect of Third-Party Contribution and Judicial Applications: Regarding the contribution of a third party, Article (1245-13) of the French Civil Code (corresponding to Article 8(1) of the Directive) prevents the producer from invoking the contribution of a third party as a ground for reducing liability vis-à-vis the injured party. Accordingly, the producer remains obligated to provide full compensation, while preserving a personal right of recourse against the third party in proportion to that party's contribution. However, this restriction applies only in cases of joint contribution. Where the act of the third party entirely dominates the sequence of events and constitutes the sole and effective cause of the damage, the producer is fully exempted from liability because the requirements of force majeure are fulfilled and the causal link is severed.

Moreover, exemption from liability does not require the precise identification of the third party; it is sufficient to establish that the damage resulted from the independent act of another person. This position has been consistently adopted in French jurisprudence, such as in cases where a pipe manufacturer was absolved of liability due to a gas contractor's failure to inspect an aging gas cylinder for more than twenty years, or where an automobile manufacturer was not held liable because the purchaser or a subordinate had dismantled and incorrectly reassembled the engine. Under Jordanian law, Article (261) of the Civil Code permits the producer to obtain complete exemption from liability where it is proven that the damage resulted from the fault of a third party as an overwhelming external cause. In cases involving multiple liable parties, Article (265) of the Jordanian Civil Code requires liability to be apportioned according to each party's contribution,

or equally where such contribution cannot be determined, unless the court orders joint liability. It may be observed that the Jordanian legislator confines the defense to the concept of the “fault of a third party,” which presupposes wrongful conduct or deviation, whereas both the French and European approaches employ the broader expression “act of a third party,” encompassing both positive and negative conduct without requiring a particular degree of fault. This broader formulation provides stronger consumer protection in light of the increasing complexity of modern product supply chains. From an engineering management perspective, the producer’s reliance on the fault of a third party acquires increasing significance in the context of AI-based smart products due to the multiplicity of actors involved throughout the product lifecycle, including algorithm developers, software suppliers, cloud service providers, and entities responsible for updates, maintenance, and system integration. Consequently, proving third-party fault is no longer a purely legal issue; rather, it is closely associated with the producer’s ability to document the stages of design, development, supply, and updating through Digital Supply Chain Management systems and Product Lifecycle Management (PLM) systems, thereby enabling the precise identification of the source of the defect or the external interference that caused the damage (Christopher, 2022; Saaksvuori & Immonen, 2008). Modern Configuration Management systems and software change management practices also play an important role in documenting all modifications made to smart systems after they have been placed on the market. Such documentation assists in establishing whether the damage resulted from unauthorized third-party intervention or from modifications for which the producer cannot be held responsible. The significance of this evidence becomes even greater in AI-based products that rely on multiple digital components and externally sourced services, where identifying the actual source of the fault depends largely on the effectiveness of the producer’s traceability and technology governance systems (INCOSE, 2023; Project Management Institute, 2021). In this context, the role of engineering management extends beyond merely reducing the likelihood of defects arising from third-party activities. It also strengthens the producer’s legal position when invoking the defense of third-party fault by enabling the use of technical records and digital traceability data to demonstrate that the third party’s conduct was independent of the producer’s manufacturing or programming activities, and that such conduct constituted the sole and effective cause of the damage. This approach is consistent with the position adopted in Jordanian legal scholarship, which maintains that an external cause can only operate as a complete defense when its independence and decisive role in producing the damage are established, thereby severing the causal link between the defendant’s conduct and the harmful outcome (Al-Sarhan & Khater, 2022; Al-Zu’bi, 2009).

3.3 Exemption from Liability by Establishing Force Majeure: Although neither Article (1245-9) of the French Civil Code nor Article (4) of the European Directive expressly recognizes force majeure and fortuitous events as grounds for exemption from liability for defective products, established civil law doctrine acknowledges both as general defenses capable of severing the causal link between a product defect and the resulting damage. Once the injured party establishes the existence of damage, a defect, and causation, the producer is entitled to prove the existence of an external cause that destroys that causal connection, provided that force majeure satisfies its legal requirements of unforeseeability, irresistibility, and externality to both the industrial undertaking and the product itself. In our view, the French legislator’s decision not to expressly recognize force majeure as a ground for exemption is open to criticism, given that force majeure, by its very nature, interrupts causation as a matter of law (Al Maagbeh, Altarawneh, E’layan, and 2026b).

The effects of force majeure may be divided into two situations. First, complete

exemption arises where force majeure entirely dominates the sequence of events and constitutes the sole cause of the damage. Second, full liability remains where force majeure coincides with a defect in the product, since liability cannot be apportioned in such circumstances and the producer remains fully responsible because force majeure was not the exclusive cause of the damage (Rayyan, Hazeem, & Alamawi, 2024).

With respect to the burden of proof where the causes of an accident remain unknown, French courts have generally imposed liability on the producer in situations involving uncertainty, such as the explosion of a product and the dispersal of its remnants where various explanations remain possible, including a manufacturing defect, fault of the injured party, or force majeure. In such circumstances, compensation is typically imposed on the producer based on the likelihood of fault or a failure to comply with duties of information and warning, as well as on the producer's superior ability to bear risks. This approach is fully consistent with the philosophy of strict product liability, which does not permit exemption unless the producer conclusively establishes the existence of an external cause. By contrast, the Jordanian legislator adopted a position more consistent with general principles by expressly recognizing force majeure and fortuitous events as examples of external causes capable of exempting a producer from liability under Article (261) of the Jordanian Civil Code. From an engineering management perspective, the criterion of unforeseeability underlying force majeure is no longer confined to purely legal assessment. Rather, it has become significantly influenced by advances in risk management tools and predictive analytics used in smart systems. The implementation of risk assessment systems, business continuity plans, operational scenario analyses, and proactive monitoring mechanisms for artificial intelligence-based systems enables producers to identify potential risks and evaluate their likelihood before they materialize (ISO, 2018; Hopkin, 2018). Consequently, a producer relying on force majeure must demonstrate that the event causing the damage remained beyond reasonable anticipation and control despite compliance with recognized engineering standards and appropriate risk-management measures. Furthermore, modern engineering resilience and business continuity management systems assist in documenting the preventive measures undertaken by the producer to address exceptional events, thereby generating technical evidence that may be relied upon to establish that the damage could neither have been prevented nor mitigated. Conversely, the force majeure defense may be weakened where the damage was reasonably foreseeable or capable of containment through monitoring systems, control mechanisms, or risk-management procedures that were expected to be implemented within the operating environment of the smart product (Hollnagel, 2018; ISO, 2019). In this regard, engineering management serves not only a preventive function in reducing the effects of operational risks but also an evidentiary and legal function in strengthening the producer's position when invoking force majeure. Through technical records, operational data, and documented risk-management practices, engineering management enables the producer to demonstrate that the event in question was exceptional, external, and unforeseeable according to the state of technical knowledge existing at the relevant time. This approach is consistent with Jordanian legal scholarship, which maintains that an external cause produces its exonerating effect only when its complete independence and decisive role in causing the damage are established, thereby severing the causal link between the defendant's conduct and the harmful outcome (Al-Sarhan & Khater, 2022; Abu Al-Basal, 2018). It is also consistent with comparative product liability scholarship, which requires the external event to constitute the sole and effective cause of the damage in order for complete exemption from liability to be granted (Fairgrieve & Goldberg, 2020; Howells et al., 2023).

4 .Specific Means of Discharging Objective Product Liability: The inherently

specific nature of the producer's objective liability for damages caused by AI-based products necessitates the establishment of specific legal means that allow them to be released from warranty without compromising the requirements for protecting the injured party. This approach is explicitly guaranteed by the French legislator in Article (10-1245) of the Civil Code – corresponding to Article (7) of the European Directive – through the regulation of "special grounds for exemption" that suit the nature of algorithms and intelligent software. In contrast, Jordanian legislation, whether in the Civil Code or in special laws such as the Consumer Protection Law and the Commercial Law, lacks the regulation of special grounds for exemption that correspond to the risks arising from artificial intelligence systems, merely referring them to the general rules of external causes. From this perspective, it is important to highlight the French and European legislative approach to demonstrate that the producer's liability for intelligent products is not absolute, but rather rests on a delicate balance that allows them to disclaim their warranty obligation when they prove the existence of one of the specific grounds for release. From an engineering management perspective, the grounds for exemption in the smart product sector are no longer solely dependent on meeting the legal requirements for exemption. They are now directly influenced by the efficiency of the manufacturer's engineering systems in managing the product lifecycle and documenting the design, development, testing, and post-marketing updates. Proving that the product was not released to the market, that there were no defects at the time of release, that the product conforms to mandatory standards, or citing the risks of technological development all these arguments depend on the manufacturer's ability to provide technical evidence derived from their Product Lifecycle Management (PLM) systems, quality management, regulatory compliance, and technological innovation management (Stark, 2015; Kerzner, 2022).

The effectiveness of these arguments hinges on the manufacturer's ability to provide technical evidence derived from their PLM systems, quality management, regulatory compliance, and technological innovation management (Stark, 2015; Kerzner, 2022). Furthermore, European legislative developments in the field of liability for digital and smart products reflect a growing trend towards linking the assessment of a producer's liability to their degree of technical and organizational control over the product throughout its lifecycle, including software, updates, and associated digital components (European Union, 2024; Fairgrieve & Goldberg, 2020). In this context, engineering management not only plays a preventative role in reducing the likelihood of defects but also represents a significant source of technical evidence that supports or refutes the existence of specific exemption grounds, thus justifying the study of these methods from a comprehensive legal and technical perspective.

4.1 Product liability defenses due to lack of conditions: From the perspective of engineering management, these defenses acquire additional specificity in the environment of AI-based products. Such products rely on advanced algorithms, dynamic operational data, and continuous updates, all of which may affect the determination of the moment a defect arises, its source, or the scope of the producer's liability. Consequently, systems for smart product lifecycle management (PLM), software release management, software quality management, and digital tracking of data and algorithms have become key tools in substantiating special defenses for the producer particularly in proving that the product was not placed on the market, that no defect existed at the time of release, or that the product remained within experimental and research environments prior to commercial marketing (Stark, 2015; INCOSE, 2023). Moreover, recent legislative developments in the field of digital products and intelligent systems reflect a growing trend toward linking the assessment of producer liability to the degree of technical control exercised over algorithms, software, and updates throughout the product's lifecycle. Thus, the effectiveness of special

exemptions is no longer tied to abstract legal claims, but rather to the producer's ability to provide documented technical evidence demonstrating the integrity of engineering procedures applied in the design, development, testing, updating, and digital tracking of the smart product (European Union, 2024; Howells et al., 2023).

4.1.1 Non-Placement of the Smart Product on the Market: Article (1245-10/1) of the French Civil Code (corresponding to Article 7(a) of the Directive) exempts the producer from liability if it proves that the smart systems or software were not placed on the market, or that they left the producer's control without its consent, such as in cases of theft, breach of trust by a custodian, or cyberattacks. The voluntary release of smart products into circulation constitutes the connecting factor establishing the causal link between the algorithmic defect and the resulting damage.

The timing and meaning of placing a smart product on the market may raise doctrinal difficulties. Article 2 of the Council of Europe Convention defines it as the "loss of control through delivery to a third party," whereas Article (1245-4/1) of the French Civil Code adopts the concept of the producer's "voluntary transfer" of the product. This approach removes much of the ambiguity surrounding the concept. Consequently, a product is not deemed to have been placed on the market merely because a third party performs testing or repairs on it. Accordingly, the producer may avoid liability by proving that unauthorized software or algorithmic modifications were introduced by the party carrying out the repair.

Article (1245-4/2) further confirms that a product is subject to a single act of placement on the market, which occurs either upon delivery of the smart product to a distributor or directly to the final consumer. In the case of a composite product involving multiple producers, such as developers of embedded algorithms and subsidiary smart systems, the prevailing doctrinal view considers the decisive moment to be the voluntary transfer by the final producer. Therefore, if the final producer establishes that the product was never placed on the market, liability is entirely excluded. In the context of smart product management, proving that a smart product was not placed on the market extends beyond the legal characterization of market placement and depends on the producer's ability to demonstrate continued technical and organizational control over the product throughout its lifecycle. Product Lifecycle Management (PLM), Digital Traceability systems, and Configuration Management mechanisms play a central role in documenting the stages of product design, testing, updating, and transfer, thereby enabling the identification of the precise moment at which the product either left the producer's control or remained subject to its technical supervision. Moreover, digital records, software version histories, and testing reports allow the producer to establish that the product was still in the development, testing, or sandbox phase and had not yet entered commercial circulation, or that the modifications causing the damage were introduced by third parties after the product had left the producer's control, thereby strengthening the effectiveness of this defense before the courts (Saaksvuori & Immonen, 2008; INCOSE, 2023). The importance of such evidence is even greater in AI-based products, which rely on continuous algorithmic updates and multiple digital components. Determining the precise moment of market placement and identifying the entity exercising actual control over the product has therefore become both a technical and a legal issue. Consequently, the producer's success in invoking this defense depends largely on the effectiveness of its engineering documentation and traceability systems, as well as its ability to provide a comprehensive digital record demonstrating that the product was never placed on the market or that it left the producer's possession without its consent (Stark, 2015; Howells et al., 2023).

4.1.2 Absence of an Algorithmic Defect at the Time of Placement on the Market:

Article (1245-10/2) of the French Civil Code (corresponding to Article 7(b) of the Directive and

Articles 5(1) and 5(2) of the Council of Europe and European Community Conventions) exempts the producer from liability where it proves that the smart product which caused the damage was not defective at the time it was placed on the market, considering all relevant circumstances, or that the defect arose subsequently. Accordingly, if the producer establishes that the algorithms and software were free from defects prior to commercialization, or demonstrates that the defect emerged later due to external circumstances, such as inadequate maintenance, unsuitable transportation or storage conditions, or machine-learning drift caused by improper use by the user, liability may be avoided. This defense serves as evidence that the product satisfied the level of safety legitimately expected by consumers and third parties. With regard to proof, the general rule governing latent defects places the burden on the purchaser to establish that the defect existed prior to delivery, often requiring costly technical and digital expert analysis. Consequently, the European Directive, the Strasbourg Convention, and French law have shifted the burden of proof to the producer, who, as a professional actor, is in the best position to demonstrate that its algorithms were free from defects when the product was placed on the market (Althnaibat et al., 2025).

Although the European Directive does not specify the exact moment at which proof must be established, whether upon delivery from the manufacturer to the distributor, from the distributor to the retailer, or from the retailer to the final consumer, producers remain obligated to retain all documents and digital records documenting the condition of the product throughout transportation and delivery. Accordingly, once the producer demonstrates that the product was free from defects at the time of placement on the market, the presumption of liability for subsequent damage is rebutted. This is also applicable to producers of raw materials or embedded algorithms who are not liable for defects arising after the component has been delivered to the producer of the final smart product.

From the perspective of quality management in smart systems, establishing the absence of an algorithmic defect at the time of market placement extends beyond reliance on legal arguments alone and depends fundamentally on the producer's ability to document the development, testing, and validation processes applied to software and algorithms before commercialization. Software Quality Assurance systems, Verification and Validation (V&V) procedures, and AI testing frameworks play a crucial role in demonstrating that the product met the required safety and performance standards at the time of its release. Testing records, technical documentation, and software version histories further enable the producer to prove that the defect was not present at the moment of placement but emerged later due to operational, environmental, or external factors, thereby strengthening the effectiveness of this defense before the courts (Pressman & Maxim, 2020; IEEE, 2022; Sommerville, 2025).

Such evidence is particularly significant for AI-based products whose performance may be influenced by changing datasets, evolving operating environments, and continuous learning processes. Algorithmic deviations may therefore arise after commercialization despite the system being safe and compliant at the time of release. Consequently, the producer's ability to rely on this defense is closely linked to its capacity to provide a comprehensive technical record demonstrating the soundness of the algorithm at the moment of placement on the market and documenting all subsequent updates and modifications (Howells et al., 2023; ISO/IEC 25010, 2023).

4.2Exemption from Liability under Regulatory Compliance and AI Governance: Article (1245-10/5) of the French Civil Code, corresponding to Article (7) (d) of the European Directive, recognizes a special ground for exemption from strict liability where the producer proves that the defect affecting the smart product resulted directly from compliance with mandatory legislative or

regulatory requirements imposing specific technical or software specifications that the producer was not permitted to modify. A significant body of legal scholarship characterizes this defense as an application of the “Act of the Prince” doctrine in civil law, whereby liability is not attributed to the producer when the defect results from compulsory compliance with public regulatory requirements rather than from an inherent deficiency in the design of the product or its algorithms. In the context of artificial intelligence-based systems, however, this defense cannot be separated from engineering management practices and Technical Compliance Management. The producer must demonstrate that the algorithms and software systems were developed and implemented in accordance with binding regulatory specifications and that it possessed neither the technical nor legal authority to depart from them. Accordingly, AI governance systems, software configuration management, and regulatory requirements management play a crucial role in documenting the relationship between mandatory specifications and the design decisions embedded within the smart product, thereby enabling the determination of whether the defect arose from compliance with regulatory instructions or from an independent engineering deficiency attributable to the producer (ISO/IEC, 2023; ENISA, 2024). Nevertheless, French law conditions this exemption upon the producer’s obligation to take appropriate corrective measures immediately after discovering the defect, including software updates and post-market remedial actions. Engineering management therefore assumes a second and equally important role. Mere proof of initial compliance with regulatory requirements is insufficient; the producer must also establish the existence of an effective system for risk management, technical monitoring, and continuous updating (Alayaydeh, E'layan, et al., 2026b). Failure to do so may deprive the producer of the right to invoke this defense despite its original compliance with the prescribed specifications (Howells et al., 2023; Wirtz et al., 2020).

The analysis further requires a distinction between two categories of regulatory standards. The first consists of standards establishing only a minimum level of safety requirements. Compliance with such minimum standards does not exempt the producer where it was technically capable of enhancing safety features beyond the prescribed minimum level. The second category consists of mandatory standards imposing exclusive technical or algorithmic specifications that the producer is not permitted to alter or replace (Alayaydeh, E'layan, et al., 2026a). In such cases, engineering compliance and regulatory governance systems become essential means of demonstrating that the defect resulted directly from the mandatory requirements imposed by public authorities rather than from deficiencies in the producer’s design, development, or testing processes. Accordingly, the success of this defense is no longer dependent solely upon the existence of a mandatory regulatory rule. Rather, it depends on the producer’s ability to provide a comprehensive technical and regulatory record documenting the engineering decision-making process, compliance with mandatory specifications, subsequent updates, and monitoring procedures. Such documentation enables a clear distinction between defects imposed by regulatory requirements and those attributable to the producer itself. This also raises the broader question of whether a public authority may incur liability when defective regulatory specifications constitute the true source of the defect, particularly where engineering compliance documentation demonstrates that the malfunction originates from the mandatory requirements themselves rather than from the smart product or its developer (Al-Hobabseh, et al., 2026).

4.3 Exemption from Liability Based on Development Risks (Scientific and Technological Progress): Human knowledge is inherently limited and continuously evolving. What is considered scientifically and technically acceptable at a given point in time may subsequently prove to be incorrect or may reveal previously unknown risks. These knowledge-based risks, which cannot

reasonably be identified at the time of manufacture, pose a significant challenge to producers of advanced technologies and smart systems. As a result, considerable legal and scholarly debate has arisen regarding whether *development risks* should constitute a ground for exemption from strict liability. This defense is regarded as one of the non-traditional grounds for exemption because it has no equivalent in the general rules of civil liability. The German legislature was among the first to regulate this concept through the Pharmaceutical Products Act of 24 August 1976 while maintaining consumer protection guarantees. At the European level, development risks were recognized as a defense under Article 7(5) of Directive 85/374/EEC, while Article 15(1) (b) granted Member States the option of excluding this defense and maintaining producer liability even where the state of scientific and technical knowledge at the time of market placement did not allow the defect to be discovered. of Law No. 389 of 1998 (later incorporated into and amended within the Civil Code by Law No. 131 of 2016). However, economic pressures and concerns regarding the competitiveness of French industry ultimately led to the inclusion of this defense in Article 1245-10(4) of the French Civil Code. The French legislature initially opposed the adoption of this defense, which delayed the enactment. From an engineering perspective, the scope of development risks is not determined solely by the limits of scientific knowledge available at a given time, but also by the effectiveness of the producer's research and development systems, innovation management practices, and technological governance mechanisms in monitoring scientific advancements and identifying potential risks. Accordingly, engineering management becomes an important factor in assessing whether a producer is entitled to rely on the development risks defense (Tidd & Bessant, 2021; OECD, 2024).

3.4.1 Management of Scientific and Technological Development Risks and Its Impact on Exemption from Liability for Artificial Intelligence Systems: Development risks are defined in legal scholarship as causes of damage inherent in a product that could neither be predicted nor discovered on the basis of the scientific and technical knowledge available at the time the product was placed on the market. This may be due either to the limitations of the technical knowledge then available or to the existence of exceptional circumstances that rendered detection impossible. Accordingly, the concept of development risks presupposes that the product (or artificial intelligence system) was not defective at the time of its release according to the scientific and technical standards then prevailing, but that subsequent scientific or technological progress later revealed latent defects, such as concealed algorithmic flaws or unforeseen deviations in deep learning models. In such circumstances, the producer is confronted with a situation of absolute impossibility of detection at the time of market placement (Althnaibat et al., 2025). These risks are particularly evident in pharmaceutical and food products, as well as in artificial intelligence systems and smart software. Algorithms may be designed in accordance with the most advanced data science techniques available at the time of development, only for subsequent scientific advances to reveal previously unknown algorithmic biases or harmful behavioral responses generated by adaptive self-learning processes that could not reasonably have been anticipated when the product was first placed on the market.

The level of knowledge that may reasonably be expected at the time of market placement is assessed according to an objective and comprehensive standard rather than a subjective standard dependent upon the producer's personal circumstances or actual knowledge. Consequently, the concept of knowledge must encompass all scientific and technical information reasonably available within the global scientific and technological community, taking into account its accessibility and dissemination. Accordingly, a producer of an artificial intelligence system cannot evade liability merely by arguing that the relevant domestic industry or the country in which it

operates lacked the technological capability to identify the algorithmic defect, provided that such knowledge could reasonably have been obtained from another sector or jurisdiction. This strict objective standard was affirmed by the Court of Justice of the European Union in its judgment of 29 May 1997, which held that producers are expected to remain informed of scientific and technological developments at the global level and that liability must be assessed according to what the producer ought to have known rather than what it actually knew. Accordingly, a producer cannot rely on the narrowness of its field of specialization as a basis for escaping liability.

In the context of AI-based smart products, development risk cannot be separated from engineering management practices and technology innovation management. The ability to detect algorithmic defects or foresee their emergence depends largely on the producer's capacity to monitor scientific and technological developments and to establish continuous mechanisms for observing, testing, and validating the performance of intelligent systems. Accordingly, the assessment of this defense is no longer confined to the legal question of whether the defect could have been discovered at the time the product was placed on the market; it is also linked to the effectiveness of the organization's technology knowledge management, research and development processes, and its commitment to tracking relevant scientific advancements (Tidd & Bessant, 2021; OECD, 2024). Furthermore, innovation management systems and AI governance frameworks play a significant role in documenting the limits of technical knowledge available at the time a product is developed and released. Such systems assist in distinguishing between defects that could reasonably have been detected given the scientific knowledge and technical means available at that time and those that only became apparent as a result of subsequent scientific and technological developments. In this context, research records, testing reports, and algorithm validation results constitute important technical evidence that a producer may rely upon to demonstrate that a defect falls within the scope of development risks rather than negligence or technical deficiency (ISO, 2019; Garry et al., 2023). Consequently, the effectiveness of this defense in the field of artificial intelligence systems does not depend solely on demonstrating the limitations of scientific knowledge existing at the time of market placement. It also depends on the producer's ability to establish that the best available engineering practices in design, testing, verification, and technological risk management were followed at that time. The more mature and transparent the producer's innovation management and technology governance systems are, the stronger its legal position becomes when invoking development risk as a ground for exemption from liability (Howells et al., 2023; Wirtz et al., 2020).

3.4.2 Constraints on the Producer's Reliance on Development Risks in the Digital Environment and AI Systems: The European Directive recognizes, in principle, the possibility of invoking development risks as a defense to liability without expressly defining its scope, unlike certain national legislations. The French legislator, however, adopted the development risks defense subject to two important limitations under which the producer remains liable even where development risks exist: products relating to the human body and failure to comply with the obligation to monitor and update the product.

3.4.2.1 Smart Products and Devices Related to the Human Body: French law established a special regime for damage arising from products related to the human body by excluding them from the scope of the development risks defense under Article (1245-11) of the French Civil Code. Accordingly, a producer may not rely on development risks where the damage results from a component of the human body or products derived from it. Article 6 of the French Health Care Reinforcement Act of 1 July 1998 (incorporated into Article L.793-1 of the Public Health Code) defines such products as including all products intended for therapeutic or cosmetic human use,

particularly medicines, pharmaceutical preparations, drugs, and substances used in pharmaceutical applications. Following the blood contamination scandals, blood products were definitively excluded from the application of this defense for historical and public policy reasons.

This exception has been criticized in legal scholarship because it creates an arguably unjustified distinction between victims. It differentiates between harm caused by defective biological products and harm arising from technologically sophisticated or algorithmic products. This raises an important question in the context of AI-enabled medical technologies: should the development risks defense be excluded because the product relates to the human body, or should it remain available where the defect originates from software, algorithms, or digital functions embedded within the device? The issue becomes even more complex with hybrid products integrating medical and AI components, such as smart pacemakers or algorithmic insulin delivery systems. From an engineering management perspective, this exception reflects the growing importance of safety engineering and medical risk management in AI-enabled healthcare products. Owing to the potentially severe consequences of failure, medical AI systems are subject to enhanced validation, verification, reliability assessment, and continuous risk monitoring requirements. Consequently, engineering practice increasingly treats patient safety as a lifecycle obligation extending beyond initial design and market placement, thereby justifying stricter liability standards for producers operating in this field (AAMI, 2022; ISO, 2019).

3.4.2.2 The Obligation of Monitoring and Updating in the Digital Environment: French law imposes a continuing obligation upon producers to monitor products placed on the market. Accordingly, a producer may not invoke development risks as a defense if it fails to take appropriate measures to prevent harm once a defect becomes known within ten years of circulation. Such measures include product recalls, withdrawal from the market, corrective action, and the deployment of software and cybersecurity updates. Although Article (1386-12/2) of the former French Civil Code, which excluded the defense when the producer failed to monitor the product, was repealed following intervention by the Court of Justice of the European Union, the French legislator subsequently reintroduced and expanded this obligation through Article (L.221-1-2) of the French Consumer Code. Under this provision, producers must ensure product safety through consumer warnings, risk communication, ongoing monitoring, corrective modifications, software updates, recalls, and other appropriate remedial measures (Heif et al., 2025).

Notably, this obligation extends beyond the original ten-year period and continues throughout the expected operational and economic life of the product. It becomes particularly important when recurring technical incidents or complaints indicate the possible existence of a defect. Producers are also required to comply with product notification and recall obligations using all appropriate communication channels. Similarly, Article (19) of the Egyptian Consumer Protection Law No. 181 of 2018 obliges suppliers to notify the competent authority of defects within seven days of discovery, or immediately where safety is affected, and requires warning consumers, stopping distribution, and repairing, replacing, or refunding defective products free of charge. In the contemporary digital environment, monitoring obligations have evolved beyond purely legal requirements and become an integral component of engineering management throughout the lifecycle of AI systems (AlSalamat et al., 2024). AI-enabled products continuously learn and adapt to changing data and operating environments, making post-market monitoring and risk assessment ongoing responsibilities rather than one-time activities. Consequently, advanced organizations increasingly rely on Post-Market Surveillance systems, Reliability Engineering methodologies, and AI Lifecycle Management frameworks to identify algorithmic drift, emerging risks, and unintended behaviors before they result in actual harm (ISO/IEC, 2023; FDA,

2024). Engineering management systems contribute to documenting monitoring, updating, and risk-response activities, thereby providing technical evidence that demonstrates the producer's compliance with the legal duties of monitoring and due care. Conversely, failure to monitor products or delays in addressing identified defects may be regarded as deficiencies in sound engineering governance, weakening the producer's ability to rely on the development risks defense even where the defect could not reasonably have been discovered during the initial design stage (European Commission, 2024; OECD, 2024). These considerations are particularly important in medical products and AI-enabled systems directly related to the human body, where safety engineering and medical risk-management principles require continuous oversight and corrective updates whenever new risk indicators emerge. Consequently, excluding the development risks defense in this category reflects not only the need to protect injured parties, but also an engineering approach that considers ongoing monitoring and safety assurance as continuing responsibilities throughout the operational life of an intelligent system (AAMI, 2022; ISO 14971, 2019). Accordingly, the limitations imposed on the development risks defense are not based solely on legal considerations of victim protection; they are also linked to the producer's commitment to modern engineering management practices, including monitoring, updating, and technological risk management. Engineering management therefore becomes an important factor in determining whether a producer may legitimately rely on this exceptional ground for exemption from liability (Aldaoud et al., 2024).

5. Conclusions and Recommendations: This chapter serves as the culmination of the theoretical and comparative analysis conducted throughout the study, combining findings from both the legal and engineering frameworks and offering practical recommendations to develop legislation and enhance the integration of technical evidence with legal defenses in the field of strict liability for AI-based smart products.

5.1 Conclusions:

This research concludes that strict product liability for AI-based smart products cannot be fully understood through traditional legal analysis alone. The dynamic nature of algorithms, continuous updates, and digital supply chains requires integrating engineering management into liability assessments. Engineering systems such as Product Lifecycle Management (PLM), quality assurance, and risk management frameworks provide technical evidence that can substantiate or refute liability claims. Comparative analysis shows that European legislation (Directive 2024/2853) explicitly incorporates engineering control into liability defenses, while Jordanian law remains reliant on general civil code provisions (Article 261), creating a gap in addressing technological risks. Ultimately, liability outcomes depend on balancing consumer protection with fairness to producers, achieved through combining legal doctrine with engineering evidence.

This diagram illustrates the integration of legal and engineering frameworks in assessing strict product liability for AI-based smart products, highlighting the balance between consumer protection and producer fairness.



Figure 1: Integration of Law and Engineering in AI Product Liability

5.2 Recommendations:

1. Legislative Development in Jordan: Introduce specific provisions addressing liability for AI-based products, modeled on European approaches, to ensure alignment with technological realities. Integration of Engineering Evidence: Encourage courts to recognize engineering management records (digital logs, PLM documentation, risk assessments) as admissible evidence supporting defenses such as force majeure or third-party fault.
2. Producers should adopt standardized engineering management practices (such as ISO 9001 and risk management frameworks) to strengthen compliance and reduce liability exposure, while reforms must ensure a balanced approach that protects consumers yet allows producers fair opportunities to invoke defenses based on documented engineering evidence. Future research should expand comparative studies to other jurisdictions and examine the role of AI governance frameworks in shaping liability standards.

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