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A Model for Regulating Artificial Intelligence Liability through Comparative Jurisprudence between the U.S. and EU

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Abstract
The rapid proliferation of Artificial Intelligence (AI) systems across sectors has intensified debates on liability, accountability, and governance in the event of harm caused by autonomous or semi-autonomous systems. This paper develops a model for regulating AI liability through a comparative jurisprudential analysis between the United States (U.S.) and the European Union (EU). It argues that divergent legal philosophies common law pragmatism in the U.S. and regulatory formalism in the EU have produced distinct yet complementary frameworks for attributing liability to AI developers, operators, and users. The model synthesizes doctrinal insights from U.S. tort law, product liability precedents, and emerging jurisprudence on algorithmic accountability with the EU's risk-based and precautionary approaches reflected in the proposed AI Act, Product Liability Directive revisions, and General Data Protection Regulation (GDPR) enforcement mechanisms. Through comparative examination, the study identifies structural asymmetries: while U.S. courts emphasize causation, foreseeability, and negligence standards, the EU's legislative model favors ex ante regulation, mandatory conformity assessments, and strict liability for high-risk AI systems. These differences underscore varying conceptions of fairness, innovation incentives, and consumer protection. The proposed regulatory model integrates best practices from both jurisdictions advocating hybrid liability standards that combine the U.S. doctrine of proximate causation and reasonableness with the EU's tiered risk classification and harmonized accountability mechanisms. It further introduces an adaptive governance framework featuring algorithmic impact assessments, explainability audits, and mandatory insurance pools to ensure compensation where attribution is indeterminate. The study concludes that an effective transatlantic AI liability regime must balance innovation with ethical restraint by embedding dynamic feedback loops between regulators, courts, and industry. Such a model encourages interoperability, global standards convergence, and equitable redress while fostering public trust in AI systems. Future research should explore the integration of causal inference models, document AI, and privacy-preserving compliance mechanisms to operationalize this hybrid framework. This work thus contributes to the emerging global discourse on AI law by offering a comparative, empirically grounded model for aligning accountability with technological complexity.

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Introduction

Artificial intelligence unsettles the classic architecture of fault, causation, and redress because learning systems are probabilistic, data-dependent, and dynamically updated in ways that blur the line between product and process. Algorithmic opacity frustrates inquiry into breach and proximate cause; model performance shifts with retraining, data drift, and fine-tuning; and socio-technical harms emerge from interactions among datasets, deployment contexts, and human oversight. Traditional doctrines assume relatively stable artifacts, identifiable defects, and linear chains of control, yet contemporary AI often embeds open-source components, third-party models, and platform services, diffusing responsibility across providers, integrators, deployers,

and end users. As a result, the same incident an erroneous medical triage, a defective credit decision, an unsafe autonomous maneuver can implicate design choices by the developer, configuration and monitoring by the deployer, and usage patterns by the operator, with each party contesting foreseeability and control (Adereti, Toromade & Ogunsola, 2022, Toromade, Ogunsola & Adereti, 2022). Remedies are further complicated by information asymmetries: victims seldom possess logs, documentation, or expertise necessary to demonstrate defect or negligence, while providers face uncertainty about liability exposure when models behave stochastically yet within expected distributions.

This paper delineates the scope of a liability model spanning the full AI lifecycle: upstream model developers and data curators; downstream integrators who embed models into products and services; deployers who configure thresholds, guardrails, and human-in-the-loop controls; and users whose operational decisions interleave with machine outputs. It addresses harms ranging from physical injury and property loss to economic and dignitary harms (e.g., discrimination, privacy violations), and it contemplates both high-risk, safety-critical systems and general-purpose models repurposed in regulated domains (Elebe & Imediegwu, 2024, Farounbi, Oshomegie & Ogunsola, 2024). The objective is to construct a comparative U.S.–EU framework that reconciles common-law pragmatism tort and product liability doctrines grounded in reasonableness, causation, and evidentiary burdens with the EU's ex ante, risk-tiered regulatory formalism emphasizing conformity assessment, documentation, post-market monitoring, and strict-liability adjustments for high-risk use. The model seeks principled allocation of duties (design, data governance, testing, explainability, monitoring), calibrated burden-shifting and evidentiary presumptions where opacity impedes proof, and interoperable compliance tools such as algorithmic impact assessments, audit-ready technical files, incident reporting, and mandatory or pooled insurance for attribution-hard harms (Elebe & Imediegwu, 2020, Imediegwu & Elebe, 2020). By mapping convergences and gaps standards, remedies, enforcement pathways, and private rights of action the paper aims to offer a hybrid liability architecture that protects innovation incentives while guaranteeing reliable redress, fosters transatlantic interoperability, and provides regulators and courts with a tractable, technology-aware basis for resolving AI-related disputes.

2. Methodology

This study adopts a mixed-methods, design-science methodology joined to comparative jurisprudence to build and test a workable model for regulating AI liability across the United States and European Union. The research begins with a doctrinal corpus collection and structured coding of U.S. tort and product-liability doctrines, Section 230 content-platform cases, and EU instruments covering the AI Act, revised Product Liability Directive, market-surveillance rules, and GDPR accountability. Legal texts are parsed into machine-readable clauses and control statements that describe ex-ante duties, evidentiary artifacts, and post-market obligations. In parallel, sectoral implementation literature is mined to operationalize legal duties as auditable engineering controls: privacy-preserving threat-intelligence sharing and encrypted analytics inform the audit layer (Abdulkareem et al., 2023), AI governance and automation lessons from healthcare revenue-cycle programs guide workflow and evidence management (Adeleke & Ajayi, 2023; 2024), and blockchain-enabled supply-chain exchanges provide patterns for tamper-evident logging, provenance, and multi-party assurance (Adeshina & Ndukwe, 2024). A first-cut "controls dictionary" is generated that maps each legal requirement to concrete artifacts technical files, Algorithmic Impact Assessments, bias and robustness reports, calibration dashboards, incident schemas, and model/version attestations using standards-ready data elements and lineages derived from business-intelligence and KPI frameworks (Adeshina, 2021; 2023; Akinbode et al., 2023; 2024).

Comparative synthesis proceeds through a three-stage analytic lens. Stage one aligns functionally equivalent duties risk management, documentation, logging, oversight, post-market monitoring and codes divergences on allocation of proof and remedies. Stage two constructs risk-tiered control profiles that scale from minimal to high-risk contexts, embedding explainability audits, bias testing, and incident reporting with explicit acceptance criteria; explainability protocols leverage interpretable intrusion-detection research for encrypted traffic to define audience-appropriate rationales without exposing sensitive inputs (Akande et al., 2023). Stage three specifies evidence pipelines and audit procedures that are reproducible under discovery or regulatory inspection while preserving confidentiality. Here, secure enclaves, homomorphic evaluation for narrow metrics, and federated or differentially private summaries are selected case-by-case to satisfy transparency with minimal exposure (Abdulkareem et al., 2023; Okon et al., 2024). Control profiles and artifacts are organized as policy-as-code checks that can be automated at release gates and update events; immutable registries and distributed ledgers provide time-stamped attestations for versions and incidents, following multi-industry exchange patterns (Adeshina & Ndukwe, 2024; Ogunyankinnu et al., 2022).

Model validation combines expert elicitation, simulation, and quasi-experimental field evaluation. A two-round Delphi panel of legal scholars, regulators, assurance professionals, and safety engineers reviews the controls dictionary and artifacts for completeness, proportionality, and interoperability. Moderation protocols and consensus thresholds are adapted from competency-framework development in healthcare program management to ensure role clarity and traceability from requirement to evidence (Adeleke & Baidoo, 2022; Adeleke & Olajide, 2024). Synthetic case dossiers are then created to stress-test the evidentiary spine of the model: each dossier bundles coded legal facts, model cards, data sheets, validation suites, logs, alerts, override traces, and incident files. Scenarios include safety-critical and rights-impacting use cases with intermittent updates and cross-border data flows. Assessment notebooks define a priori causal identification strategies difference-in-differences for policy or threshold changes, synthetic controls for phased roll-outs to decide when safer feasible alternatives would likely have prevented harm, operationalizing causal adequacy in legal proof (Taiwo, Akinbode & Uchenna, 2024). Bias-and-calibration monitors and KPI dashboards from clinical and operational BI practice supply continuous metrics for subgroup performance, drift, and alert SLAs (Adeshina, 2021; Akinbode et al., 2024).

Field pilots are undertaken with consenting organizations in two domains credit decision support and clinical triage augmentation selected for mature logging and oversight. Each pilot runs an A/B or stepped-wedge design where feasible, with pre-registered outcomes: audit reproducibility rate, time-to-evidence assembly, subgroup calibration stability, incident reporting latency, and adjudication clarity in mock disputes. Evidence processing uses document-AI pipelines to extract entities (model/version IDs, dataset lineage, policy references) from technical artifacts and bind them into a queryable case file; privacy and trade-secret protections are enforced via role-based views and redaction-by-default templates drawn from encrypted analytics and privacy-by-design work (Okon et al., 2024; Bamigbade et al., 2024). Where cloud or edge contexts are involved, infrastructure-as-code and resilience frameworks are used to create repeatable audit environments and rollback paths for recalls and corrective updates (Bodie-Ansah et al., 2024; Olufemi et al., 2024).

Evaluation adopts a triangulated approach. Quantitatively, the model is judged on reduction in discovery cycle time, increase in successful reproducible audits, maintenance of parity and calibration within predefined confidence bands, and timeliness of corrective action following drift alerts. Qualitatively, panelists score proportionality, clarity of duty allocation, and cross-walk fidelity between U.S. reasonableness tests and EU conformity obligations. Economic feasibility is appraised by simulating premium adjustments in a mandatory insurance pool and processing times for no-fault fund claims using incident taxonomies, drawing on risk-pooling and resilience research from healthcare, finance, and cyber-physical systems (Halliday, 2024; Davies et al., 2024; Aniebonam & Aniebonam, 2024). Governance viability is tested by mapping artifacts to board-level GRC dashboards and verifying that alerts and exceptions cascade into accountable workflows, borrowing KPI and process-automation patterns proven in healthcare and financial operations (Adeleke & Ajayi, 2023; Imediegwu & Elebe, 2020–2024).

Threat, safety, and supply-chain edge cases incorporate encrypted collaboration for multi-party audits and provenance checks. For cross-organizational investigations, homomorphic counters or enclave-based replay of contested inferences verify outputs without disclosing raw data; blockchain attestations record who ran what, when, and under which hash-pinned artifacts (Abdulkareem et al., 2023; Adeshina & Ndukwe, 2024). For recalls and updates, canary cohorts and kill-switch runbooks are formalized and evaluated with time-to-patch and regression-escape metrics, mirroring reliability patterns in safety-critical operations and predictive maintenance (Wegner et al., 2023; Olufemi et al., 2024). Throughout, documentation maturity and auditability are treated as first-class outcomes, and safe-harbor eligibility rules are stress-tested against incomplete or inconsistent files to ensure presumptions and rebuttals operate fairly.

The methodology's success criteria are met when the hybrid model demonstrably enables courts and regulators to reconstruct contested decisions with high reproducibility, allocate duties credibly among providers, integrators, deployers, and users, and maintain privacy and trade-secret protections through privacy-preserving audits. Additional acceptance conditions include actionable crosswalks that let one artifact set satisfy both EU technical-file obligations and U.S. reasonableness evidence, incident pipelines that achieve predefined latency targets, and economic instruments that clear claims promptly while sharpening incentives for monitoring and explainability. Iteration cycles are scheduled after each pilot and mock adjudication to refine controls, artifacts, and audit notebooks, with change logs maintained in the registry for full traceability.

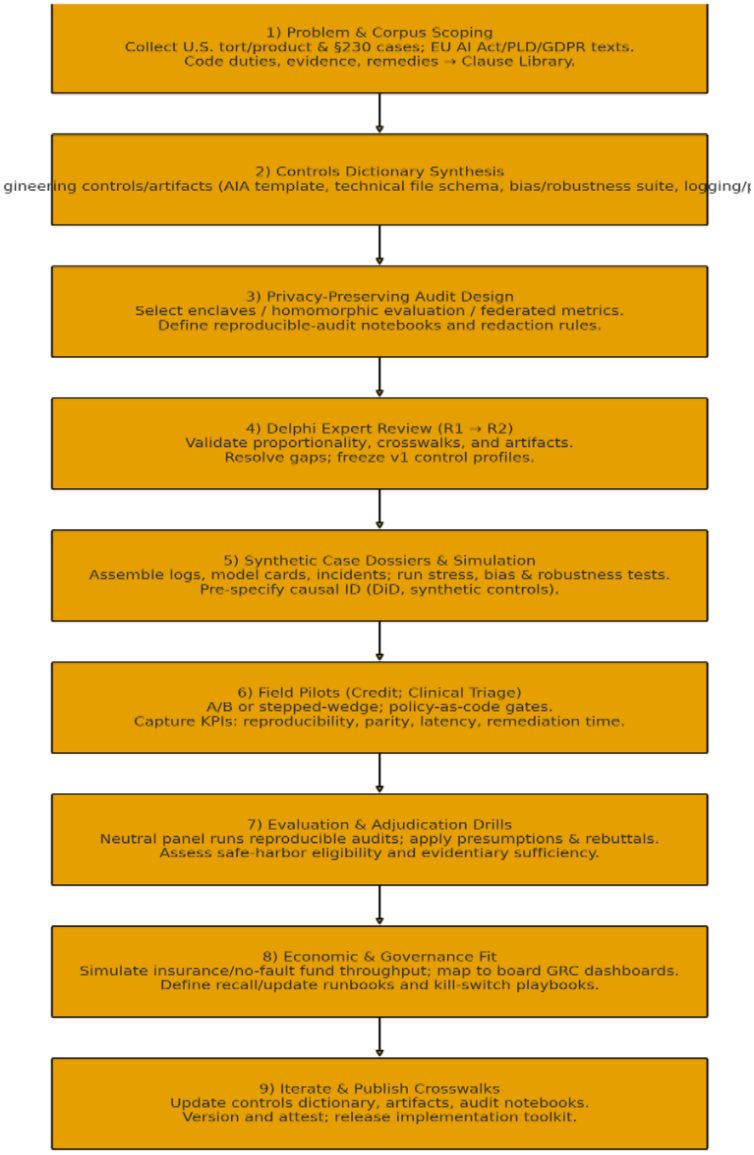

Fig 1: Flowchart of the study methodology

3. Doctrinal Baselines

A coherent model for regulating artificial intelligence liability must start from clear doctrinal baselines on both sides of the Atlantic, because the posture of courts and regulators toward fault, product defect, causation, and accountability determines how harms are prevented, proven, and compensated. In the United States, the default frame is tort and product liability refined through case law. Negligence centers on duty, breach, causation, and damages, with the "reasonableness" of design, testing, monitoring, and warnings judged against industry customs and evolving knowledge (Ezeh, et al., 2022, Imediegwu & Elebe, 2022). For AI, negligence inquiries quickly turn to whether developers and deployers exercised reasonable care in data governance, robustness testing, bias mitigation, post-deployment monitoring, and human-in-the-loop controls. Design-defect theories ask whether a feasible safer alternative design existed e.g., a model architecture with stronger guardrails or a threshold setting that reduced foreseeable misuse while failure-to-warn claims scrutinize documentation, known limitations, and the clarity of hazard communication to integrators and end users (Akinbode, et al., 2024, Isa, 2024, Olufemi, Anwansedo & Kangethe, 2024). Product liability adds strict-liability pathways for manufacturing defect, design defect, and inadequate warnings, but AI strains the product–service boundary. Some jurisdictions treat software as a "product" when embedded in tangible goods or distributed as packaged software; others incline toward service characterization, which pushes plaintiffs back into negligence. The "defect" inquiry also runs into the probabilistic nature of machine learning: is a model defective because it sometimes produces outliers within an expected error distribution, or only when it deviates from its own documented performance envelope? Courts revert to foreseeability and risk–utility balancing, asking whether the residual error rate and the contexts of deployment were acceptable relative to the benefits and whether safer configurations were practicable without destroying utility (Egemba, et al., 2020, Gado, et al., 2020). Proximate cause remains a gatekeeper: plaintiffs must show that the defendant's breach was a substantial factor and that the type of harm was within the scope of foreseeable risk. In multi-actor AI chains open-source components, foundation model providers, integrators, deployers the analysis fragments:

design decisions upstream may be too attenuated if a downstream deployer misconfigured thresholds or ignored monitoring alerts, yet upstream omissions in data curation or red-team testing can remain proximate when harms are the kind models predictably create (Ajayi, et al., 2024, Bamigbade, Adeshina & Kemisola, 2024, Taiwo and Akinbode, 2024).

Section 230 of the Communications Decency Act further complicates liability for platforms that host or amplify AI-generated or AI-ranked content. Historically, Section 230 immunized providers from liability as publishers of third-party content, but algorithmic recommendation and curation have prompted questions about whether amplification is a neutral "tool" or an affirmative content development act. For AI, two lines of uncertainty matter. First, if a platform's own model synthesizes content (e.g., generative outputs), that content may be first-party, narrowing 230 defenses. Second, even for third-party inputs, plaintiffs argue that targeted recommendation engines or ranking models materially contribute to harmful content (Nwokediegwu, Bankole & Okiye, 2019, Ogunsola, 2019). Courts have been cautious, but the trend is toward granular inquiry: immunity persists for neutral tools, while bespoke designs that foreseeably steer users to harmful content risk falling outside 230's shelter. For AI liability design, that means platform deployers should not assume blanket immunity; documentation of neutral, content-agnostic ranking rationales and guardrails becomes evidentiary armor, and policies should anticipate carve-outs for clearly unlawful categories (Ajayi & Akanji, 2022, Isa, 2022). Figure 2 shows a flowchart of proportional liability assessment based on risks taken by different parties involved presented by Bashayreh, Sibai & Tabbara, 2021.

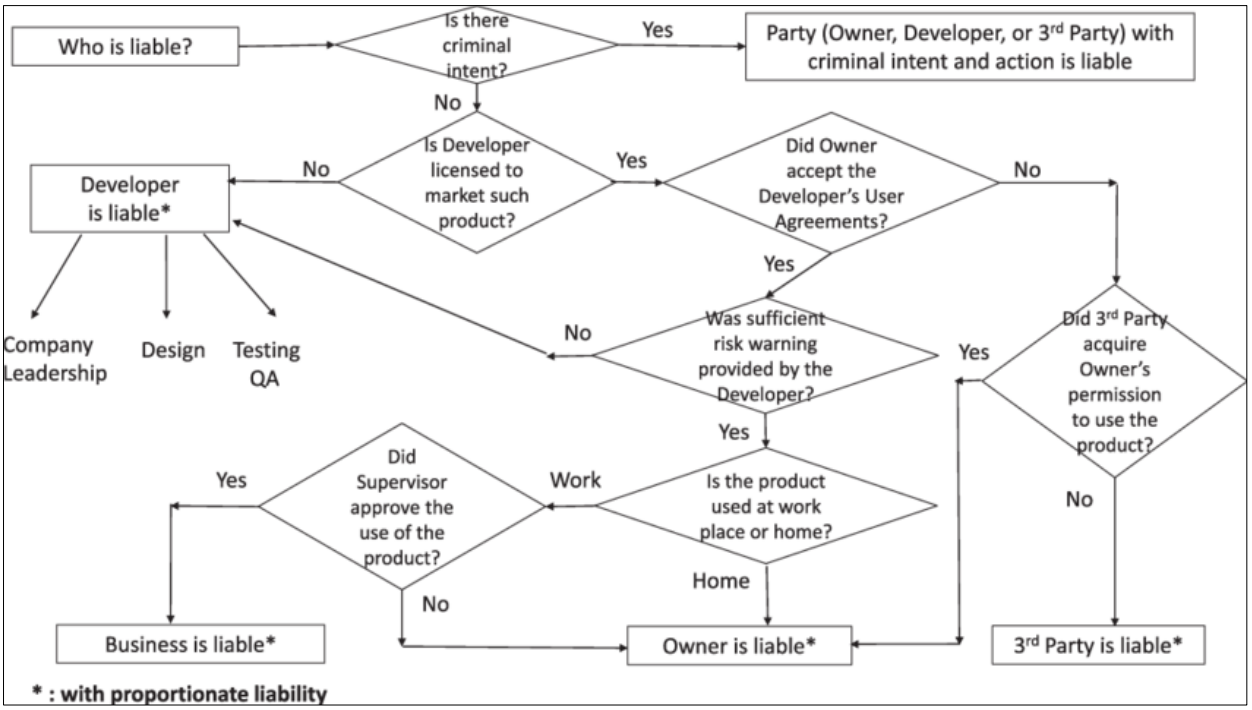

Fig 2: A Flowchart of proportional liability assessment based on risks taken by different parties involved (Bashayreh, Sibai & Tabbara, 2021).

Across the Atlantic, the European Union's baseline is legislative and ex ante. The AI Act constructs a risk-tiered regime: unacceptable-risk systems are prohibited; high-risk systems (for safety-critical or rights-sensitive uses) face stringent obligations; limited-risk systems carry transparency requirements; minimal-risk systems are largely unregulated. For high-risk AI, providers must implement quality management, data governance, technical documentation (the "technical file"), logging, robustness and cybersecurity testing, and post-market monitoring; they undergo conformity assessment, affix CE marking, and register in an EU database. Deployers assume duties too: appropriate use, human oversight, and monitoring. This architecture shifts liability debates: instead of litigating reasonableness post hoc, the law specifies ex ante process and documentation that, if absent, makes non-compliance readily provable (Anthony & Dada, 2020, Imediegwu & Elebe, 2020).

In parallel, the revised Product Liability Directive modernizes strict liability for defective products to capture software and AI components and clarifies evidentiary presumptions. Plaintiffs may benefit from alleviated burdens when complex, opaque technology makes proof of defect and causation disproportionately difficult; courts may presume defect or causal link if the product failed to comply with mandatory safety requirements or if lack of disclosure by the defendant hindered the plaintiff's proof. Importantly, the scope of "product" under the revised regime extends to digital elements, updates, and even standalone software in certain circumstances, reducing the ambiguity that hampers U.S. product claims (Ajakaye & Adeyinka, 2020, Bankole, Nwokediegwu & Okiye, 2020). Liability can attach to manufacturers, importers, and "fulfillment service providers" in EU supply chains, and to operators when modifications or integrations render the system unsafe. Because conformity assessment links to "state of the art," technical norms (CEN/CENELEC, ISO/IEC) become quasi-legal benchmarks; deviation without justification is probative of defect.

GDPR's accountability principle adds a parallel track for AI systems that process personal data. Controllers must have a lawful basis, observe data minimization, ensure accuracy, and implement appropriate technical and organizational measures. Data protection impact assessments are required for high-risk processing; transparency, access, and (in qualified forms) the right to information about automated decision-making reinforce procedural fairness. Security and breach notification duties create additional hooks for negligence-type failures (Adereti, Toromade & Ogunsola, 2023, Nnabueze, Ogunsola & Adenuga, 2023). Although GDPR is not a damages-oriented tort statute, administrative enforcement (fines, orders) and private claims for material and non-material damage create monetary exposure tied to process failures defective data governance, insufficient explainability, or inadequate safeguards independent of the AI Act's safety orientation. Figure 3 shows Legal and Ethical Consideration in Artificial Intelligence presented by Behailu, 2023.

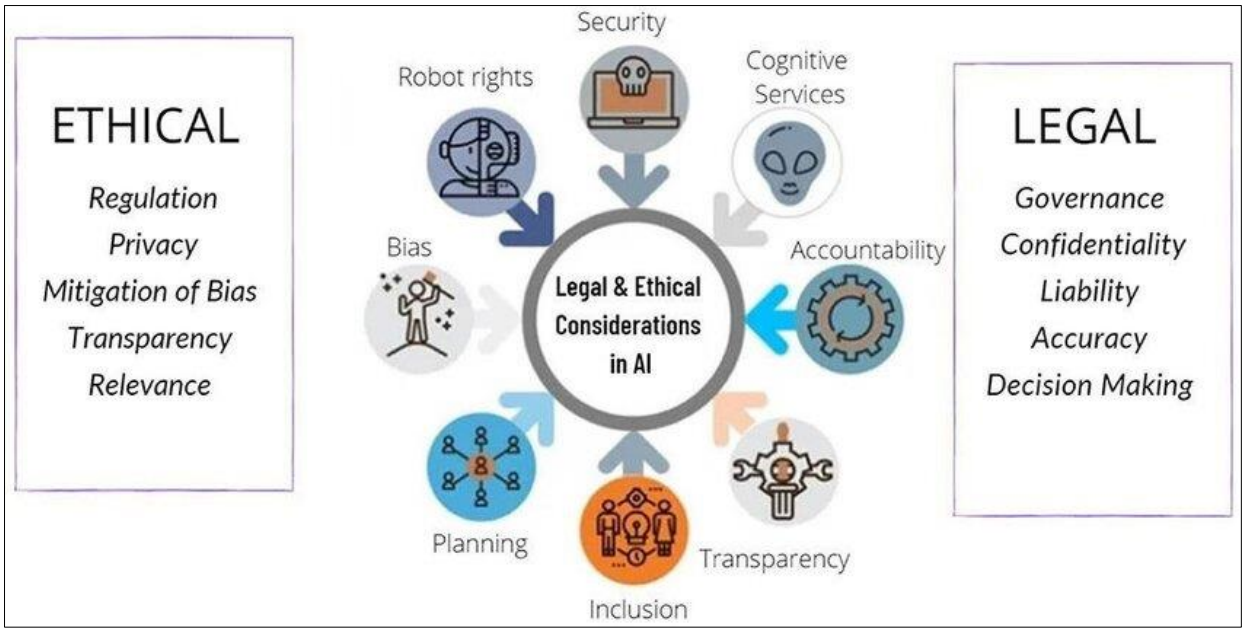

Fig 3: Legal and Ethical Consideration in Artificial Intelligence (Behailu, 2023).

The contrast between U.S. and EU baselines is not merely stylistic. The U.S. system's case-by-case pragmatism, built on fault and proximate cause, incentivizes evidence-rich demonstrations of reasonableness and causal nexus; it can be flexible but uncertain ex ante. The EU's ex ante formalism reduces ambiguity by prescribing process, documentation, and testing requirements; it increases predictability and shifts disputes toward compliance fact-finding. Each has blind spots. U.S. plaintiffs face steep discovery battles to overcome opacity and apportion fault across diffuse supply chains; defendants endure litigation uncertainty and forum variability (Anthony & Dada, 2022, Ogunsola, 2022). EU actors bear upfront compliance costs and face potential rigidity if conformity schemas lag technical innovation; yet victims benefit from documentation duties and burden-shifting that respond to black-box challenges.

An integrated liability model should therefore borrow selectively. From the U.S., retain rigorous causation analysis and reasonableness standards that avoid punishing merely because a model erred within expected distributions, while clarifying when foreseeable misuse or foreseeable emergent behavior renders design choices negligent. From the EU, adopt tiered obligations that scale with risk, mandatory documentation and logging that make ex post proof tractable, and clarified strict-liability coverage for software components whose defects manifest as hazardous system behavior (Elebe & Imediegwu, 2021, Imediegwu & Elebe, 2021). Across both, embed burden-shifting where defendants control critical evidence: if logs, model cards, data sheets, and post-market monitoring are missing, presumptions should fill gaps; if present and compliant, they should provide safe-harbor weight. Harmonized technical standards should serve as rebuttable proxies for "state of the art," not absolute shields, keeping room for innovation that demonstrably maintains or improves safety (Adeleke & Ajayi, 2024, Isa, 2024, Oboh, et al., 2024, Olufemi, et al., 2024, Umukoro, et al., 2024).

Finally, these baselines must accommodate the realities of contemporary AI. General-purpose models licensed downstream complicate role assignment; liability should follow control and knowledge providers accountable for design and training choices, integrators for context-specific safeguards, deployers for configuration, monitoring, and human oversight, users for policy-violating operation. Updates and fine-tuning blur version boundaries; regimes must treat continuous delivery as part of the product lifecycle, with responsibilities for regression testing and rollback (Ajakaye & Adeyinka, 2022, Okiye, Ohakawa & Nwokediegwu, 2022). And because evidence is the currency of both systems, legal design should mandate audit-ready artifacts: data governance records, training and evaluation reports, explainability traces, and incident logs that make breach and proximate cause knowable without heroic inference. With these doctrinal anchors, a comparative, hybrid model can allocate duties and remedies credibly, reduce adjudicative friction, and support innovation that is accountable by design.

4. Liability Allocation Map

A credible liability allocation map for artificial intelligence begins by defining role-specific duties across the lifecycle and then linking those duties to appropriate liability standards, evidentiary presumptions, and relief mechanisms. The provider who designs, trains, and maintains the model or foundational component bears primary responsibility for design choices, data governance, safety-by-design, documentation, and post-market monitoring where the provider has continuing control (Akomea-Agyin & Asante, 2019, Awe, 2017, Osabuohien, 2019). Core duties include curating and documenting training and evaluation data; stress, robustness, and bias testing across relevant subpopulations; publication of model cards, data sheets, and hazard analyses; secure development practices; versioning and reproducibility; telemetry for post-deployment risk signals; and timely patches or recalls when material defects emerge (Ezeh, et al., 2023, Obadimu, et al., 2023, Oyasiji, et al., 2023). When a provider markets a general-purpose model, duties extend to clear statements of intended use, prohibited contexts, known limitations, and integration interfaces that permit logging, rate-limiting, and human oversight. Contractually, the provider should offer a technical file and support audit access proportionate to risk, enabling downstream actors to meet their own obligations.

The integrator assembles components foundation models, third-party libraries, sensors, data pipelines into a product or system tailored to a domain. The integrator's duties are system safety and context fit: requirement capture, hazard and operability analysis, dataset suitability assessments, alignment of thresholds and guardrails to domain risks, red-team testing in realistic environments, and traceable validation that the integrated system meets safety and performance claims. The integrator must ensure explainability pathways, event logging, override mechanisms, and safe failure modes are operational (Elebe & Imediegwu, 2020). Because integration choices can amplify or mitigate provider risks, the integrator should implement change control, regression testing on updates, and an incident response plan. Allocation here recognizes shared control: if the integrator deploys the model outside the provider's stated domain or disables safeguards, the integrator's share of fault increases even when the underlying model behaved within its documented uncertainty.

The deployer configures, operates, and monitors the system in the field. Typical duties include lawful basis and transparency for personal data, operator training, human-in-the-loop checkpoints, ongoing drift detection, calibration checks, and periodic revalidation after environmental changes or major updates. The deployer must maintain complete logs inputs, outputs, decisions, overrides, and feedback plus audit trails tying decisions to policy and model versions. When the deployer sets incentives or workflows that predictably induce misuse (e.g., throughput targets that discourage human review), the deployer's negligence can dominate proximate cause even if upstream components are sound (Nwokediegwu, Bankole & Okiye, 2021, Obadimu, et al., 2021). The user often an individual professional or operator owes duties of reasonable use: following instructions, not circumventing guardrails, escalating anomalies, and providing accurate inputs. Where a user exercises professional judgment (clinician, pilot, underwriter), their role interfaces with learned intermediary concepts, discussed below.

Strict and fault-based standards should be applied with sensitivity to control and knowledge. Strict liability fits when the actor places a product into commerce and the defect is intrinsic to the product as sold or updated, the injured party cannot access proof, and society prefers shifting the loss to the party best able to prevent harm and spread cost. Providers fall into strict-liability scopes for manufacturing defects (erroneous weights, corrupted models) and for design defects where a safer feasible design existed (Elebe & Imediegwu, 2024, Nwanko, et al., 2024). With software, strict liability also applies to defective updates that degrade safety; continuous delivery is part of the product lifecycle, not a service afterthought. Integrators may face strict liability when the integrated system is sold as a product and the defect arises from integration choices (unsafe defaults, incompatible components) rather than operational misuse. Fault-based negligence, by contrast, should dominate when harm traces to failures of reasonable care in deployment poor monitoring, ignoring alerts, absent operator training, or mis-specified thresholds in a known-risk context. Fault standards should also apply to users whose departures from instructions or policy materially contribute to harm (Adeleke & Ajayi, 2024, Davies, et al., 2024, Egbemhenghe, et al., 2024).

Vicarious liability assigns responsibility up the chain when agents act within scope. Employers are vicariously liable for deployer staff who negligently bypass human-in-the-loop controls or falsify logs. Platform operators may be vicariously liable for integrator contractors who configure ranking models that materially contribute to foreseeable harms if governance is lax. Conversely, providers should not carry vicarious responsibility for rogue integrators who remove safety features and disclaim intended use, provided the provider exercised reasonable diligence: clear warnings, technical constraints against unsafe configurations, and monitoring to detect widespread misuse with a duty to warn or cut off access. Contractual indemnities can reflect these splits, but public policy should limit pre-injury waivers that would nullify core safety obligations (Ajakaye & Adeyinka, 2023, Okiye, Ohakawa & Nwokediegwu, 2023). Figure 4 shows Role of Artificial Intelligence in Modern Society presented by Ebenibo, et al., 2024.

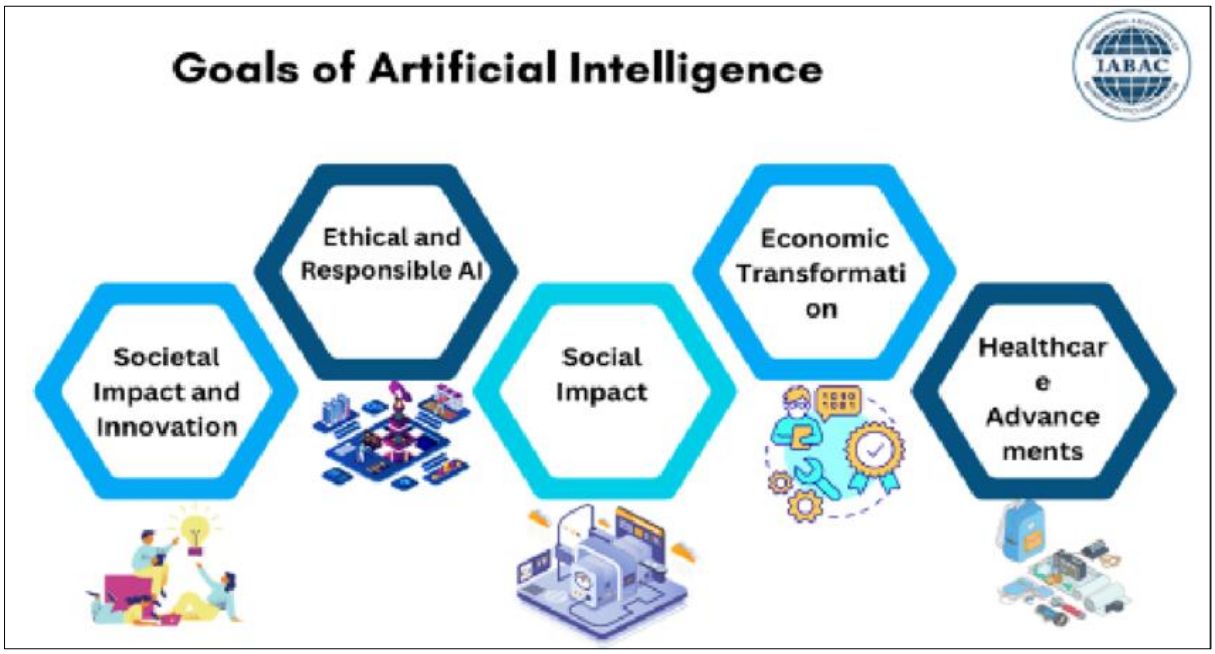

Fig 4: Role of Artificial Intelligence in Modern Society (Ebenibo, et al., 2024).

The learned intermediary doctrine offers an instructive analog for AI. In medicine, manufacturers discharge some warning duties by adequately informing physicians who, as learned intermediaries, individualize risk communication and application. An AI analog should exist where a trained professional mediates the model's effect on an end user. If a diagnostic model flags risk and a clinician, equipped with training and adequate documentation about limitations and failure modes, exercises judgment, liability may tilt toward the clinical employer for negligent reliance or inadequate training rather than toward the model provider, assuming the provider met its disclosure and validation duties (Ajakaye & Lawal, 2024, Egemba, et al., 2024). However, the doctrine should be cabined: it applies only where the intermediary has genuine expertise, legal authority to intervene, and practical opportunity to override, and where the AI's design supports meaningful oversight rather than presenting recommendations as opaque mandates. Where automation bias is foreseeable, providers and integrators must design for visibility of uncertainty, counterfactual explanations, and friction for high-stakes actions, or else learned intermediary protections should not attach (Adeleke, Olugbogi & Abimbade, 2024, Ikese, et al., 2024, Ojuade, et al., 2024).

Burden-shifting and evidentiary presumptions can align with allocation. When logs, model cards, and technical files are absent due to a defendant's control over evidence, a rebuttable presumption of defect or causation should arise to prevent opacity from defeating redress. Conversely, when actors produce compliant documentation risk management plans, bias and robustness results, post-market monitoring records safe-harbor weight should reduce exposure for residual harms that occur inside documented uncertainty bounds. Providers meeting recognized standards (ISO/IEC, NIST profiles) should enjoy rebuttable inferences of due care; integrators demonstrating conformity with domain safety norms and effective validation should receive similar credit; deployers running calibrated monitoring with prompt remediation should benefit when unforeseeable shocks occur (Alade, et al., 2024, Obadimu, et al., 2024).

Multi-actor incidents require proportional allocation keyed to causal potency. A foundational model with known failure modes used contrary to provider guidance suggests primary fault at the integrator or deployer; a hidden data poisoning vulnerability or training bug that predictably surfaces under ordinary use points back to the provider. If a deployer suppresses alerts to meet commercial KPIs, their share increases; if the integrator failed to enable human oversight in a safety-critical workflow, allocation shifts accordingly. Jurisdictions can implement comparative fault frameworks with joint and several liability for indivisible harms, coupled with contribution rights among defendants, so victims are made whole while defendants sort proportional shares (Aniebonam, 2024, Ogunsola, 2024, Udensi, Akomolafe & Adeyemi, 2024).

Insurance and economic instruments reinforce this map. Providers of high-risk systems should carry product liability and recall insurance, fund incident response, and participate in pooled schemes where attribution is uncertain. Integrators and deployers should maintain professional liability cover and business interruption policies, with premiums sensitive to maturity of safety and governance programs. Where harms are systemic and attribution-hard, no-fault funds financed by levies on high-risk deployments can provide swift compensation without diluting incentives to meet ex ante obligations (Elebe & Imediegwu, 2020, Imediegwu & Elebe, 2020).

Contracting practices should mirror doctrinal allocation without overreaching. Providers can offer warranties tied to documented performance envelopes, update commitments, and security patch SLAs; they should not attempt blanket disclaimers of safety duties. Integrators should commit to validation and change control, accept responsibility for domain fit, and flow down provider documentation to deployers. Deployers should covenant to training, monitoring, and lawful processing, and to furnish de-identified incident data upstream to improve safety. These promises should be auditable, with termination rights where material breaches persist (Nwokediegwu, Bankole & Okiye,

2022, Okiye, Ohakawa & Nwokediegwu, 2022).

Finally, governance mechanisms link roles to continuous accountability. Providers publish and maintain technical files and incident disclosures; integrators operate risk councils that review test evidence before release; deployers run safety management systems with defined hazard thresholds that trigger automatic review. Each actor's compliance posture influences liability through presumptions and safe harbors, turning paperwork into substantive protection only when it reflects real controls. With clear duties per role, calibrated strict and fault standards, principled vicarious liability, and a carefully bounded learned intermediary analog for AI, the allocation map supports innovation while ensuring that the party best positioned to prevent harm, prove safety, or spread cost bears the corresponding legal responsibility (Ezeh, et al., 2022, Gado, et al., 2022, Imediegwu & Elebe, 2022).

5. Evidence, Causation & Explainability

Evidence, causation, and explainability are the hinge on which any defensible AI-liability regime swings, because courts and regulators cannot allocate fault or redress without a tractable way to reconstruct what a system did, why it did it, and whether safer or more reasonable alternatives were available. In a comparative U.S.–EU model, the evidentiary architecture should combine burden-shifting rules that neutralize opacity, standardized documentation and logging that make reconstruction feasible, and safe harbors that reward reproducible audits and continuous compliance. The animating principle is simple: the party with superior access to the technical facts should shoulder proportionate duties to preserve and disclose them, and compliance with those duties should lower residual liability for harms that occur within documented uncertainty bounds (Ajakaye & Lawal, 2024, Sidney, 2024).

Burden-shifting starts with calibrated presumptions that activate when defendants control material evidence. Where a claimant shows a prima facie injury plausibly linked to an AI decision or action e.g., a denied benefit, a hazardous control output, or discriminatory triage and also shows that essential artifacts (model version, inputs, inference logs) are unavailable because of the defendant's retention practices, a rebuttable presumption of defect or causal contribution should arise (Anthony, et al., 2019, Ogunsola, 2019). This presumption is not strict liability by stealth; it is a response to information asymmetry. The defendant can rebut by producing compliant records or by showing a non-AI alternative cause (e.g., operator misuse, data tampering, environmental anomaly outside design assumptions). Conversely, when providers, integrators, and deployers produce full, timely, and audit-ready evidence, the burden should shift back: courts should presume due care for residual errors that fall inside validated performance envelopes, absent proof of negligent configuration, ignored alarms, or non-compliance with mandated processes (Ogunyankinnu, et al., 2022, Oyeyemi, 2022).

To make such presumptions fair, the model requires a common evidentiary grammar. Providers should maintain "technical files" analogous to those contemplated by the EU's AI Act: a living bundle of documents that includes purpose statements and intended-use constraints; training and evaluation data statements (sources, licenses, representativeness, known gaps); model cards and data sheets; hazard analyses and risk management plans; robustness, stress, and bias test reports across relevant cohorts; cybersecurity posture; and post-market monitoring procedures (Aniebonam, 2024, Ogunsola, Oshomegie & Farounbi, 2024). Integrators should add system-level evidence: context-of-use analyses, human-oversight design, threshold settings and guardrails, interface affordances that mitigate automation bias, and results from domain-specific validation and red-team exercises. Deployers should preserve operational artifacts: configuration baselines, operator training records, change-control logs, input–output pairs with timestamps and cryptographic hashes, override events with rationale, alerts and their acknowledgments, and incident response timelines. These bundles should be indexed to unique model and policy versions and anchored by tamper-evident logging to preserve chain of custody.

Explainability functions as both evidence and risk control. For complex models, local explanation traces (e.g., SHAP attributions or monotone partial-dependence plots for constrained models) attached to each contested decision allow reviewers to see which inputs most influenced the output. Global summaries document expected behavior and limitations: stability across subgroups, ranges where performance degrades, and interactions that elevate risk (Ajayi & Akanji, 2022, Isa, 2022). The point is not to force every system into simplistic linear transparency; it is to ensure that defendants can produce reasoned, reproducible accounts of behavior and that claimants and courts can test those accounts against counterfactuals. Where explainability is inherently limited (e.g., highly entangled architectures), the duty shifts toward stronger pre-deployment validation, conservative thresholds, and enhanced logging of intermediate signals that serve as proxies for reasoning (Elebe & Imediegwu, 2023, Imediegwu & Elebe, 2023, Udensi, Akomolafe & Adeyemi, 2023).

Causation must be made tractable without diluting rigor. U.S. courts will still require proof that breach was a substantial factor and that harm fell within the scope of foreseeable risk; EU regimes will still anchor liability in non-compliance and defect. The model proposes a structured, three-step causation test supported by records. First, factual sequence: did the system generate an output that, if relied upon as designed, would predictably lead to the harm? This is established by inference logs, user action traces, and workflow policies. Second, normative breach: did the relevant actor deviate from applicable duties provider design obligations, integrator validation norms, deployer monitoring and oversight or did the system perform outside its documented envelope? This is established by comparing logs and technical files to standards and policies (Ajakaye, et al., 2023, Bankole, Nwokediegwu & Okiye, 2020). Third, counterfactual adequacy: would a reasonable alternative safer configuration, human review, or feasible design alternative likely have prevented or significantly reduced the harm? Here, counterfactual analysis and causal inference techniques (propensity scores, synthetic controls) can be admitted to show that similarly situated cases with different thresholds or oversight produced different outcomes. Where logs and documentation are missing, step two triggers the burden-shifting presumption; where they are present and compliant, defendants earn a rebuttable inference of due care (Akande, et al., 2023, Akinbode, et al., 2023, Chukwuemeka, Wegner & Damilola, 2023).

Because continuous learning and frequent updates complicate reproducibility, the regime must require

snapshotting. Each training run and deployed model should be reproducible from version-controlled code, hyperparameters, and, where legal, a hashed reference to training/validation data with documented sampling procedures. Where privacy or trade secrets limit data disclosure, the framework should allow neutral expert review under protective orders, privacy-preserving audit (e.g., secure enclaves), or release of aggregate diagnostics that still permit independent verification of claims (Aniebonam & Aniebonam, 2023, Okiye, Nwokediegwu & Bankole, 2023). The same applies to third-party and open-source components: technical files must disclose dependencies and known vulnerabilities; where a supplier refuses audit access for high-risk components, integrators should treat the component as higher risk and compensate with testing, monitoring, or contractual guarantees.

Logging is the evidentiary backbone and should be specified with precision. At a minimum, systems must capture input identifiers and salient features (subject to minimization), model version and checksum, configuration/threshold IDs, salient intermediate signals when feasible, output scores with uncertainty measures, human-in-the-loop interactions (reviewed, overridden, deferred), and downstream actions taken. Logs should be time-synchronized, write-once (append-only with cryptographic sealing), and retained for a period proportionate to risk and limitation periods. For safety-critical applications, redundant logging with cross-system attestation mitigates disputes about tampering (Ajakaye, et al., 2023, Okiye, Ohakawa & Nwokediegwu, 2023). Data-protection obligations still apply: logs should store only what is necessary, apply access controls, and support de-identification or differential privacy in audit contexts consistent with law.

Safe harbors are the incentive mechanism that turns paperwork into safety. A defendant who demonstrates (i) conformity with applicable standards and regulatory obligations; (ii) complete, timely technical files and logs; (iii) pre-deployment and post-market testing commensurate with risk; and (iv) prompt remediation and notification when defects emerge, should receive safe-harbor weight (Okiye, 2021). That weight can take several forms: heightened thresholds for punitive damages in the U.S.; presumptions of due care and narrower remedial orders in the EU; or eligibility for pooled insurance coverage and accelerated settlement channels for attribution-hard harms. Safe harbors are not absolute shields: they do not protect intentional misconduct, reckless disregard, or concealment; they expire if monitoring detects drift and actors fail to act; and they can be pierced by evidence that validation omitted foreseeable use contexts or that documentation materially misrepresented limitations.

To prevent "audit theater," the regime should pair safe harbors with reproducibility tests. Regulators or courts can order a reproducible audit: rerun the model on archived inputs in a controlled environment and compare outputs and uncertainty scores; re-execute validation suites; and verify that explanations and logs align with the claimed decision path. Discrepancies trigger loss of safe-harbor protection and, where warranted, sanctions for spoliation or misrepresentation. Conversely, successful reproducibility should narrow the dispute to normative questions (e.g., threshold selection, oversight sufficiency) rather than basic factual reconstruction, reducing litigation cost and time (Aniebonam & Aniebonam, 2024, Udensi, Akomolafe & Adeyemi, 2024).

Finally, the framework must integrate discovery and confidentiality. In U.S. litigation, protective orders, staged discovery, and neutral experts can balance trade secrets against access to justice; in the EU, supervisory authorities and courts can use confidentiality rings and proportionate disclosure orders. Either way, the touchstone is necessity: claimants should access enough to test breach and causation, defendants should not be compelled to reveal more than required, and both sides should be deterred from strategic evidence games by the presumptions described above. Incident reporting and public summaries stripped of sensitive specifics can further social learning, while pooled, privacy-preserving benchmarks enable industry-wide improvement of validation practices without anticompetitive collusion (Elebe & Imediegwu, 2021, Gado, et al., 2021).

In sum, a transatlantic model that marries burden-shifting presumptions with standardized technical files, robust logging, explainability artifacts, and safe harbors for reproducible audits can make AI liability adjudicable without freezing innovation. It aligns incentives toward safety-by-design and continuous monitoring, ensures that opacity does not become impunity, and provides clear pathways for courts and regulators to separate unavoidable residual error from negligent design, reckless deployment, or ignored warnings (Bankole, Nwokediegwu & Okiye, 2021, Egemba, et al., 2021).

6. Risk-Based Controls & Compliance Tooling

A risk-based control system for AI liability draws strength from matching the intensity of obligations to the potential for harm, and from tooling that turns legal duties into repeatable engineering routines. Tiering begins before market entry and continues throughout the lifecycle. For pre-market conformity, providers and integrators operating in high-risk contexts must evidence fit-for-purpose data governance, robustness and safety testing, human-oversight design, cybersecurity hardening, and traceable documentation that binds claims to evidence (Awe, Akpan & Adekoya, 2017, Osabuohien, 2017). Conformity is not a ritualized checklist but a staged gate: intention and scope definition; hazard analysis and misuse mapping; dataset statements (provenance, licensing, representativeness, known gaps); training/evaluation protocols with stratified cohorts; stress and adversarial tests; explainability design choices tied to user competence; and a release justification that links residual risk to compensating controls. For moderate-risk systems, obligations scale down streamlined hazard analysis, targeted cohort testing, and lightweight documentation while minimal-risk systems default to transparency and basic logging. The EU's ex-ante orientation informs the form (technical files, registration, conformity assessment), while U.S. reasonableness doctrine shapes the substance (what a prudent developer or deployer would do given foreseeable risks and available mitigations). Post-market monitoring closes the loop by making safety a live commitment: telemetry on model performance, drift, calibration, and subgroup parity; event logs for inputs, outputs, overrides, and actions; feedback channels for users; and triggers that escalate from watchlist review to partial suspension or recall when risk indicators breach thresholds. Monitoring is proportionate denser logging and shorter review cadences for

safety-critical uses; privacy-preserving aggregation for lower-risk analytics yet always auditable (Adeshina & Ndukwe, 2024, Isa, 2024, Joeaneke, et al., 2024, Olufemi, et al., 2024).

Algorithmic Impact Assessments serve as the backbone artifact that integrates risk discovery, mitigation planning, and accountability. An AIA begins with context mapping (purpose, stakeholders, rights and safety interests, applicable law), then enumerates harms (physical, economic, dignitary) and affected cohorts, including intersectional subgroups. It documents alternatives analysis simpler rules, less intrusive features, human-only baselines and justifies choosing an AI approach. It then records data flows, lawful bases where personal data is processed, minimization strategies, and retention policies (Akpan, Awe & Idowu, 2019, Ogundipe, et al., 2019). On the technical side, the AIA catalogs model families considered, chosen architecture, features, hyperparameters, and evaluation metrics tied to the domain (e.g., false-negative cost in safety, equalized odds in eligibility). It includes a bias and robustness plan with measurement definitions (statistical parity, predictive parity, calibration), pre-deployment test results across strata, and contingency actions where trade-offs are irreducible. Finally, it sets monitoring SLAs, alert thresholds, human-in-the-loop checkpoints, and incident response playbooks with named roles. In EU practice, the AIA dovetails with the AI Act's technical file and, where personal data is central, with a data protection impact assessment; in the U.S., it functions as contemporaneous evidence of reasonable care and becomes a cornerstone for safe-harbor eligibility and discovery responses (Ajayi & Akanji, 2023, Oyeyemi & Kabirat, 2023).

Explainability audits operationalize the promise that users and overseers can understand and contest high-stakes outputs. They are two-layered. Globally, auditors verify that documentation makes model limitations legible: the ranges where performance degrades, the exogenous factors that shift predictions, and the intended degree of human discretion. Locally, auditors test that an individual decision can be accompanied by a stable, reproducible explanation appropriate to the audience clinician, loan officer, safety engineer without leaking protected attributes or trade secrets beyond necessity (Akinola, et al., 2024, Bobie-Ansah, Olufemi & Agyekum, 2024, Ikese, et al., 2024, Osabuohien, 2024). Tooling includes SHAP-based reports for tabular models, monotone partial-dependence checks for constrained tree ensembles, attention/attribution summaries for sequence models, and counterfactual "closest change" generators that show actionable paths to a different outcome where suitable. Audits confirm that explanations align with domain reality (e.g., temperature spikes driving refrigeration demand) rather than proxying for sensitive classes, and that the user interface presents uncertainty (intervals, confidence rankings) in ways that mitigate automation bias. Explainability controls are risk-scaled: when decisions are safety-critical or rights-impacting, confidence-only outputs are insufficient; systems must produce audit traces and human-review hooks, or they should not be deployed.

Bias testing is neither a single metric nor a one-time event. Pre-deployment, teams define fairness notions suited to the domain calibration within groups for risk scores, equal opportunity for screening tests, error-rate parity where appropriate and compute them across protected classes and context-relevant strata (age bands, regions, device types). Tests include adverse-impact ratios, conditional use accuracy equality, and subgroup calibration plots, with power analyses to avoid false comfort in sparse groups. Post-market, parity metrics are monitored with confidence bands; threshold shifts or data drift trigger re-evaluation (Odezuligbo, Alade & Chukwurah, 2024, Oyeyemi, Orenuga & Adelakun, 2024, Taiwo, Akinbode and Uchenna, 2024). Where trade-offs are inherent, governance records the chosen balance and why for example, prioritizing equal false-negative rates in a safety screen and documents mitigations (additional human review, targeted outreach, or alternative pathways) for groups at residual disadvantage. Bias remediation leans on data augmentation, reweighting, post-processing adjustments, or constraint-aware training, but only when they preserve validity; cosmetic parity that destroys predictive usefulness is rejected in favor of procedural fixes (better data capture, revised workflows) that address root causes (Adeleke & Baidoo, 2022, Oyeyemi, 2022).

Incident reporting transforms surprises into structured learning. A reportable incident is any event where an AI-mediated decision or action plausibly contributed to material harm or a narrowly averted near miss, including security or integrity breaches with safety implications. Reports capture the timeline (input, inference, action), environment, decision traces, human interactions, policy and model versions, and preliminary causal hypotheses. Severity classification drives response: high severity triggers containment (feature flagging to safe mode, partial disablement), user notification where rights are impacted, regulator notification where required, and a blameless post-mortem with specific corrective and preventive actions (Ayobami, et al., 2024, Davies, et al., 2024, Eyo, et al., 2024, Isa, 2024). Incidents feed shared taxonomies so that industry-wide patterns data poisoning attempts, misleading prompts, recurrent sensor failure modes are recognized early without disclosing competitive secrets or personal data. Reporting is protected from punitive misuse by safe-harbor concepts: timely, complete reporting and remediation reduce penalties, while concealment or falsification aggravates sanctions.

Compliance tooling turns expectations into daily habits. Policy-as-code engines encode gate checks conformance to intended use, documentation completeness, explainability availability, bias thresholds, security posture at deployment time and before high-risk updates, preventing drift into non-compliant states. Model registries bind artifacts (code, weights, datasets, metrics, cards) to immutable versions with approvals and rollbacks (Awe & Akpan, 2017). Telemetry pipelines compute calibration, drift, and parity metrics on rolling windows with alerting; dashboards show attainment against SLAs; and runbooks define what to do when thresholds trip (canary disablement, confidence-bound tightening, escalated human review). Secure enclaves and access controls allow auditors or regulators to reproduce results on sealed inputs without mass data exfiltration, aligning transparency with privacy and trade-secret protection. Procurement checklists ensure third-party components arrive with attestations and vulnerability disclosures, and that contractual rights allow audit or equivalent assurance for high-risk uses (Ogunyankinnu, et al., 2024, Okon, et al., 2024, Olulaja, Afolabi & Ajayi, 2024).

Transatlantic interoperability emerges when these controls are mapped to both regimes' logic. The EU's tiered conformity structure supplies the scaffolding for ex-ante

assurance and proportionate post-market monitoring; U.S. negligence and product-liability principles supply the evidentiary and reasonableness tests that prevent formalism from ossifying into paperwork theater. In both, safe harbors reward organizations that can prove they built and ran systems to a documented standard, logged faithfully, tested for bias and robustness with domain-appropriate metrics, offered meaningful explanations, and corrected promptly when incidents occurred (Akinbode, et al., 2024, Folorunso, et al., 2024, Orenuga, Oyeyemi & Olufemi John, 2024)). By scaling duties to risk, institutionalizing Algorithmic Impact Assessments, making explainability and bias testing verifiable, and treating incidents as mandatory sources of learning rather than reputational liabilities to bury, a comparative model delivers accountability that is both enforceable and innovation-compatible turning legal expectations into a living engineering discipline that prevents harm, proves care, and restores trust when AI fails.

7. Remedies, Insurance & Economic Instruments

Remedies, insurance, and economic instruments determine whether an AI-liability regime delivers timely redress, credible deterrence, and predictable risk financing without smothering innovation. In the United States, damages doctrine supplies granular tools. Compensatory damages cover economic loss (medical costs, property damage, lost earnings) and, where recognized, non-economic harm (pain, suffering, dignitary injuries from discriminatory automation). Foreseeability and proximate cause cabin recovery, but evidentiary presumptions tied to missing logs or technical files can shift burdens when opacity frustrates proof (Ajayi & Akanji, 2021, Ejibenam, et al., 2021, Osabuohien, Omotara & Watti, 2021). Punitive damages, available for willful or reckless disregard of safety, discipline egregious conduct concealed hazards, ignored drift alarms, falsified audit trails yet should be bounded by constitutional proportionality and calibrated to safe-harbor compliance: actors that can reproduce decisions, show documented testing, and promptly remediate ought to face higher thresholds for punitives. Injunctive relief compels updates, disables hazardous modes, or mandates human-in-the-loop checkpoints; courts can condition continued operation on monitored fixes and third-party audits. Restitution or disgorgement may be appropriate where unlawful data processing produced unjust enrichment, complementing privacy statutes. Class actions aggregate low-value, high-volume harms from algorithmic decisions, while arbitration clauses should not be allowed to extinguish public-interest remedies in safety-critical contexts.

In the European Union, harmonized remedies emphasize compensation within a structured product-liability and regulatory framework. Revised product-liability rules expand strict liability to software and updates, easing evidentiary burdens when complexity impedes proof; non-compliance with mandatory safety or AI-Act obligations supports presumptions of defect or causation. Administrative remedies orders, fines, corrective measures run in parallel to private claims, with supervisory authorities empowered to mandate withdrawals or modifications of high-risk systems (Akanji & Ajayi, 2022, Francis Onotole, et al., 2022). Non-material damage is compensable under data-protection law, and collective redress mechanisms can centralize claims arising from systematic bias or unsafe deployments. Proportionality guides sanctions: robust pre-market conformity, ongoing monitoring, and rapid incident response mitigate penalties, while concealment or repeat non-compliance aggravates them. Cross-border enforcement benefits from mutual recognition of measures and shared incident databases so that recalls or restrictions propagate swiftly across the single market.

Monetary remedies alone cannot guarantee solvency or speed, so mandatory insurance pools for high-risk AI absorb tail risk and stabilize payouts. Pool membership is tied to the deployment of systems in enumerated high-risk categories (safety-critical control, healthcare triage, credit underwriting at scale). Contributions are risk-weighted using auditable metrics: conformity status, bias and robustness test results, incident history, explainability availability, and post-market monitoring maturity (Awe, 2021, Halliday, 2021). Premium credits reward safe-harbor compliance and third-party certifications; surcharges apply for stale models, opaque logging, or lagging updates. Claims handling prioritizes rapid advance payments for clear, measurable losses (bodily injury, property damage), with technical causation disputes resolved later between pool members via contribution rules. Reinsurance and catastrophe layers cover correlated shocks (e.g., systemic model error after a widely deployed update), and parametric triggers such as regulator-confirmed recall events or breach severity indices unlock liquidity without protracted loss adjustment. Governance includes public-interest directors, audit rights for regulators, and transparency reports that anonymize data yet reveal systemic risk trends (Babalola, et al., 2024).

Attribution can be genuinely hard when multiple actors and stochastic behavior intertwine. No-fault funds address this by compensating victims without requiring granular fault allocation, then subrogating against responsible parties once investigations mature. Funding sources include levies on high-risk licenses, a small per-inference fee for covered categories, or earmarked portions of administrative fines. Eligibility criteria focus on plausibility and severity: documented temporal proximity between an AI-mediated action and harm, use within declared scope, and absence of claimant misconduct (Afolabi, Ajayi & Olulaja, 2024, Ilemobayo, et al., 2024, Selesi-Aina, et al., 2024). Caps and schedules (for medical payments or wage loss) speed relief; supplemental adjudication handles complex consequential damages. To avoid moral hazard, participation in the fund requires baseline safety practices from deployers; serial claimants or repeat non-compliant actors face higher levies and corrective-action mandates. Public dashboards, scrubbed of personal and trade-secret data, publish incident typologies that feed prevention efforts across the ecosystem.

Recalls and updates translate legal accountability into engineering action. Unlike static products, AI systems evolve; the regime must treat update duty as a core safety obligation. When post-market monitoring detects a material defect calibration collapse in a subgroup, adversarial exploit, unsafe behavior in a new environment providers and integrators must issue corrective updates or configuration changes with clear release notes, rollback plans, and regression evidence. Over-the-air updates in safety-critical contexts require staged rollouts, canary cohorts, and kill switches if adverse signals spike (Adeshina, 2021, Isa, Johnbull & Ovenseri, 2021, Wegner, Omine & Vincent, 2021). Where updates cannot promptly mitigate risk, temporary suspensions or degraded “safe modes” (stricter

thresholds, enforced human review) are mandated. Recall classifications mirror automotive practice: urgent safety recall, service campaign, or advisory; each carry notification SLAs to deployers and users, mandatory acknowledgement tracking, and downstream logs proving application. For legacy systems or long-tail deployments, "end-of-support" must be managed: providers publish LTS (long-term support) horizons, and deployers who operate beyond them assume explicit residual risk unless they procure extended support. Insurance pools can require enrollment in update-compliance programs as a condition of coverage, creating economic pressure to maintain patch discipline.

Economic instruments beyond insurance shape incentives at deployment speed. Performance bonds or letters of credit can be required for temporary high-risk pilots in public spaces, ensuring funds exist to remediate harms or remove systems if trials fail. Variable levies indexed to measured externalities e.g., carbon-aware routing incentives or data-protection compliance scores nudge design toward public goals without prescriptive mandates. Market-surveillance fees fund regulator capacity for audits and reproducibility testing; in return, compliant actors get expedited approvals and fewer intrusive inspections (Ajayi & Akanji, 2023, Halliday, 2023). Data-sharing trusts, structured with privacy-preserving computation, allow pooled benchmarking of bias and robustness without exposing raw data, improving safety while protecting rights. For catastrophic, low-frequency events, public-private backstops akin to terrorism or nuclear pools can provide extreme tail coverage, conditioned on strict adherence to safety regimes and transparent incident cooperation.

Remedy design should align with comparative fault and contribution so victims are paid promptly while defendants settle shares later. Joint and several liability can apply to indivisible harms, with contractual and statutory contribution rules reflecting control and knowledge: providers for hidden training defects; integrators for hazardous configurations; deployers for negligent oversight. Safe-harbor compliance modulates contribution percentages: a provider who documented risks and issued timely patches yet saw a deployer disable safeguards should bear less; an integrator who ignored provider limitations and skipped validation should bear more. Courts and pools can adopt standardized apportionment matrices linked to the lifecycle duties, reducing litigation cost and forum variance (Akinbode, et al., 2023, Onibokun, et al., 2023, Osabuohien, et al., 2023).

To prevent "audit theater" and strategic delay, economic levers must punish concealment and reward transparency. Late or incomplete incident reporting triggers higher fines, deductible penalties in insurance, and temporary market-access restrictions. Voluntary disclosure within short windows, coupled with concrete remediation steps, yields penalty abatements and access to fund fast-track channels. Repeat non-compliance escalates to licensing suspensions for high-risk categories. Conversely, proven safety innovations better drift detectors, more faithful explainability, robust red-team pipelines earn premium reductions and public recognition that strengthens market share, turning compliance into competitive advantage (Asonze, et al., 2024, Davies, et al., 2024, Odezuligbo, 2024, Wegner, 2024).

Finally, remedies and instruments must be interoperable across borders. Recognition of recall orders and conformity defects should propagate between U.S. and EU markets; insurers and funds should share anonymized incident signals to anticipate correlated risks; and dispute-resolution mechanisms should allow technical questions to be answered by neutral expert panels using reproducible audits. With compensatory and, where justified, punitive or administrative sanctions; with pooled insurance and no-fault funds that deliver liquidity; and with recall-and-update duties that make safety dynamic, a comparative AI-liability model can provide swift redress, credible deterrence, and bankable predictability (Akande & Chukwunweike, 2023, Awe, et al., 2023, Ogundipe, et al., 2023). The economic message is clear: invest in evidence, monitoring, explainability, and timely remediation to lower the cost of capital and insurance; neglect them, and the system will make risk expensive.

8. Governance, Enforcement & Interoperability

Governance, enforcement, and interoperability anchor a comparative model of AI liability by specifying who sets the rules, who checks compliance, who adjudicates disputes, and how actors operating across borders can meet overlapping duties without duplicative burdens. On the governance side, the United States relies on a distributed constellation of sectoral and cross-cutting agencies FTC for unfair or deceptive practices, CFPB for consumer finance, FDA for software as a medical device, NHTSA for vehicle automation, EEOC and DOJ for discrimination, OSHA for workplace safety, and state attorneys general and on courts that develop doctrine case by case (Ajayi & Akanji, 2022, John & Oyeyemi, 2022, Osabuohien, 2022). Rulemaking is often technology-neutral, so many obligations enter through guidance, consent orders, and post hoc enforcement that crystallize "reasonable" AI practices: truthful performance claims, adequate testing and monitoring, clear disclosures, and prompt remediation. In the European Union, governance is more centralized and ex ante: the AI Act designates national competent authorities and a European AI Office to coordinate supervision; notified bodies perform or oversee conformity assessment for high-risk systems; market-surveillance authorities' police the single market; and courts apply harmonized product-liability and data-protection rules. The asymmetry is intentional: U.S. pragmatism favors flexible standards enforced through litigation and case-based agency actions, whereas EU formalism sets tiered obligations in advance and relies on documentation, registration, and audits to verify conformity before harm occurs.

Enforcement ties these structures to consequences. In the U.S., agencies wield investigative powers, civil penalties, and injunctive relief, often requiring programmatic remedies like independent assessments, data deletion, and algorithmic impact improvements. Private rights of action, including class actions, supply leverage where statutory hooks exist or tort claims are viable, and discovery compels production of logs, model documentation, and update histories. Courts calibrate damages and tailor injunctions, sometimes installing monitors for high-risk deployments (Adeshina, 2023, Onyedikachi, et al., 2023, Wegner & Ayansiji, 2023). In the EU, administrative enforcement dominates: authorities can order corrective actions, withdrawals, or recalls; levy fines scaled to turnover; and require third-party reassessments. Private claims proceed under product-liability and data-protection frameworks, with collective redress available in member states for systemic harms. A crucial harmonizing principle in a comparative model is an

enforcement ladder: early deficiencies trigger corrective instructions; persistent non-compliance escalates to formal orders, fines, or market restrictions; egregious concealment or reckless deployment opens the door to punitive-style consequences in the U.S. and aggravated administrative sanctions in the EU. This ladder is coupled to evidence duties where technical files, logs, and monitoring are missing, presumptions and burden shifting apply; where they exist and show diligence, safe-harbor weight tempers penalties.

Courts sit at the apex of dispute resolution and must be equipped to evaluate technical claims without turning every case into a battle of inscrutable experts. The model envisions reproducible audits overseen by neutral panels: rerunning contested inferences on archived inputs, verifying calibration at relevant horizons, and testing whether safer feasible alternatives were available at the time. U.S. courts can incorporate these audits under Daubert-style reliability screening; EU courts can treat them as complementary to conformity records. Appellate review should stabilize doctrine on proximate cause in multi-actor chains, on when foreseeable misuse defeats defenses, and on how documented uncertainty bounds interact with defect findings (Akpan, et al., 2017, Oni, et al., 2018). Specialized judicial education and technical amici curiae can reduce error and variability, and procedural devices like confidentiality rings or secure enclaves can balance trade secrets with access to proof.

Private rights of action remain indispensable because administrative capacity is finite and harms are diffuse. The model favors clear standing and remedies for individuals adversely affected by automated decisions, including dignitary harms where discrimination or opaque deprivation occurs, while discouraging strike suits through safe-harbor presumptions for actors who can demonstrate compliance and reproducibility. Class actions or collective redress are essential where low-value injuries accumulate credit scoring drift, eligibility screens with biased false negatives, or small safety defects replicated at scale. Settlement frameworks should borrow from product-recall practice: prospective fixes, third-party oversight, and restitution formulas tied to measurable loss (Adeleke & Ajayi, 2023, Adeshina, Owolabi & Olasupo, 2023, Oyeyemi, 2023). To prevent forum shopping and contradictory outcomes, coordinated case-management protocols and cross-border judicial cooperation are encouraged when parallel U.S. and EU proceedings arise from the same incident.

Interoperability begins with a shared vocabulary of risk and controls and continues with crosswalks between standards. A practical bridge maps EU AI Act obligations risk management, data governance, technical documentation, logging, robustness, cybersecurity, human oversight, post-market monitoring to U.S. reasonableness evidence using widely adopted frameworks. ISO/IEC 23894 on AI risk management and ISO/IEC 42001 on AI management systems can supply auditable process scaffolding; ISO/IEC 23053 on machine-learning life-cycle concepts and ISO/IEC 5259 for data quality inform dataset governance; ISO/IEC 27001 and 27018 cover security and cloud privacy (Ajayi & Akanji, 2022, Leonard & Emmanuel, 2022). The NIST AI Risk Management Framework and its profiles translate these into U.S. agency expectations and internal controls. A crosswalk matrix aligns artifacts model cards, data sheets, hazard analyses, validation reports, monitoring dashboards so that a single set of documents can satisfy both EU technical files and U.S. discovery and consent-order practice. Convergence does not require identical texts; it requires mappability with minimal gaps that can be closed by addenda rather than duplicate programs.

Conformity assessment and independent assurance benefit from mutual recognition where feasible. While formal treaty-level recognition may be distant, regulators can accept third-party audits performed to ISO/IEC and NIST-profiled criteria, subject to spot checks, thereby reducing redundant assessments for transatlantic deployments. Notified bodies and accredited U.S. assessors can participate in a shared registry of certifications and incident-linked suspensions, enabling market-surveillance actions to propagate quickly. For post-market oversight, telemetry interfaces and incident schemas should be standardized so both jurisdictions can parse reports without custom integrations (Adeleke & Olajide, 2024, Awe, et al., 2024, Davies, et al., 2024). Where sectoral rules apply medical, automotive, aviation existing conformity channels (CE marking, FDA clearances, type approvals) can host AI-specific annexes rather than inventing entirely new pipelines, keeping assurance anchored in lived regulatory practice.

Data-transfer and privacy constraints demand careful threading because evidence duties can collide with minimization and cross-border limits. The comparative model requires privacy-by-design logging: capture only what proves safety and causation; hash or tokenize identifiers; segregate sensitive payloads; and enforce tight access control. Transatlantic transfers for audits or incident investigation should rely on established mechanisms adequacy decisions where available, standard contractual clauses, or binding corporate rules paired with transfer-impact assessments and technical measures like encryption and secure processing environments (Abdulkareem, et al., 2023, Adeleke & Ajayi, 2023, Halliday, 2023). When regulators or courts need to examine sensitive data, trusted execution environments or privacy-preserving computation can allow inspection without bulk exposure. For public transparency, incident summaries should be aggregated and anonymized, building systemwide learning without jeopardizing rights.

Institutional coordination keeps governance from fragmenting. A transatlantic AI safety forum composed of regulators, notified bodies, standards organizations, and industry and civil-society observers can publish crosswalks, incident taxonomies, and assurance profiles; maintain an anonymized repository of failure patterns; and issue joint advisories when emergent risks appear. Agencies can agree on rapid-alert protocols so that a recall or suspension in one jurisdiction triggers review in the other, with clear criteria for reciprocal measures. Memoranda of understanding can support cooperative investigations, evidence sharing under confidentiality, and coordinated remedies where harms straddle markets. These soft-law instruments move faster than legislation yet create predictable pathways for joint action (Ogunyankinnu, et al., 2022, Onibokun, et al., 2022).

Inside organizations, governance must be legible and enforceable. Boards should own AI risk at the same level as cyber and privacy, approving risk appetite, funding assurance, and reviewing incident post-mortems. Executives should designate accountable owners for model risk, data protection, and product safety; install policy-as-code gates that prevent non-conformant releases; and adopt metrics that

tie leadership compensation to service safety, bias reduction, and timely remediation. Internal audit should test conformance to the chosen ISO/IEC and NIST profiles, and legal should maintain discovery-ready evidence libraries. These investments reduce liability by making diligence provable, shorten response times when incidents occur, and ease cross-border approvals (Afolabi, Ajayi & Olulaja, 2024, Joeaneke, et al., 2024, Olulaja, Afolabi & Ajayi, 2024).

The comparative model thus converts divergent legal traditions into a workable whole: regulators specify proportionate duties and coordinate across borders; notified bodies and accredited assessors verify design and monitoring; courts adjudicate using reproducible audits and calibrated presumptions; and private rights of action supply deterrence and redress at scale. Standards bodies provide the lingua franca that lets one set of controls satisfy both regimes, while privacy and transfer tools ensure that proof does not become surveillance. Interoperability is not uniformity; it is disciplined translation (Akinbode, Taiwo & Uchenna, 2023, Onotole,et al., 2023). When actors can show that their processes, artifacts, and monitoring satisfy both the EU's ex ante obligations and the U.S. ex post reasonableness test, enforcement becomes consistent, innovation remains viable, and the public interest in safe, fair, and accountable AI is credibly served.

9. Conclusion & Future Agenda

A comparative liability framework that blends U.S. causation-and-reasonableness doctrine with the EU's risk-tiered formalism offers a pragmatic path to accountability that is both enforceable and innovation-compatible. From the U.S. we preserve the insistence that liability turns on demonstrable breach and proximate cause, tested against evidence of what a prudent actor would have done given foreseeable risks and available mitigations. From the EU we adopt graded ex ante obligations risk management, technical documentation, conformity assessment, logging, post-market monitoring, and human oversight that make safety measurable before harm and reconstructible afterward. Together these features create a governance flywheel: tiered controls reduce ambiguity and raise baseline diligence; explainable records, calibrated monitoring, and incident reporting equip courts and regulators to separate residual, documented error from negligent design or reckless deployment; and safe-harbor weight for reproducible audits rewards organizations that can prove care. The hybrid model, in short, turns uncertainty into a managed input and transforms "black-box" rhetoric into operationally testable claims about process, evidence, and outcomes.

Yet material gaps remain. Data sparsity undermines calibration for long-tail uses, new products, and minority or intersectional subgroups where harm may concentrate; even well-intentioned actors can misread risk when sample sizes are thin and noise overwhelms signal. Black-box opacity persists in systems whose complexity outruns current interpretability tools, especially when models update continuously and behave differently across contexts; absent disciplined snapshotting and logging, retrospective proof degrades to speculation. Cross-border harms complicate causation, discovery, and remedy: an update released in one jurisdiction can seed failures in another; privacy and trade-secret rules can choke the flow of evidence; and asynchronous regulatory responses invite forum shopping and delay. Legacy constraints also matter: shelf-life of models and dependencies, end-of-support realities, and fragmented supply chains leave responsibility blurry when defects surface years later in embedded systems. Finally, economic instruments are unevenly developed; without pooled insurance, no-fault funds, and premium signals linked to compliance maturity, compensation can be slow and deterrence haphazard.

The future agenda should close these gaps by advancing methods, tooling, institutions, and cadence. First, causal inference must move from academic aspiration to courtroom and regulatory practice. Liability turns on counterfactual adequacy whether a feasible alternative design, configuration, or oversight would likely have avoided harm. Embedding causal notebooks into technical files, with prespecified identification strategies (difference-in-differences, synthetic controls, instrumental variables where lawful) and power analyses, would let defendants justify thresholds and oversight choices and let claimants test those justifications with shared data under protective orders or secure enclaves. Regulators and standards bodies can publish causal evaluation profiles for common AI risk domains credit eligibility, medical triage, safety screens so that proof does not reinvent methodology case by case.

Second, document AI should be operationalized for evidence management across the lifecycle. High-risk systems generate sprawling artifacts: model cards, data sheets, hazard logs, validation suites, incident timelines, emails, and tickets. Applying structure-aware extraction to normalize entities (model version, dataset lineage, policy ID), link events to decisions, and auto-assemble chronology would slash discovery friction and reduce gamesmanship around "missing" records. Coupled with tamper-evident storage and cryptographic attestations, document AI can turn compliance from PDF theater into queryable truth. To avoid privacy overreach, pipelines should apply minimization and redaction by default and expose role-based views: fact-rich for internal safety teams and auditors; privacy-hardened for courts and counterparties. Standard schemas for incidents and conformity artifacts, aligned to ISO/IEC and NIST profiles, would enable cross-vendor, cross-border portability.

Third, privacy-preserving audit must become routine rather than exceptional. Secure enclaves, differential privacy where appropriate, and zero-knowledge or verifiable-compute techniques can allow neutral experts to reproduce contested inferences, replay validation, and verify subgroup calibration without mass data exfiltration. Insurance pools and regulators can condition safe-harbor eligibility on maintaining audit-ready environments with attested builds, seeded test suites, and point-in-time snapshots. Where source data cannot cross borders, federated audit auditors running approved notebooks inside each jurisdiction with hash-matched code and publishing signed metrics can supply comparable evidence. These approaches protect rights and trade secrets while denying bad actors the refuge of opacity.

Fourth, transatlantic interoperability needs living crosswalks rather than static concordances. A joint forum of regulators, notified bodies, accredited U.S. assessors, standards organizations, and civil-society observers should maintain a bilingual "controls dictionary" mapping EU AI Act obligations to NIST AI RMF functions and ISO/IEC management and lifecycle standards, with gap notes and acceptable compensating controls. When any node in this

lattice changes new harmonized standards, updated NIST profiles, revised product-liability presumptions the forum would publish a diff and migration guidance. Mutual reliance, even short of formal recognition, can grow from consistent third-party assurance: if an accredited audit attests to specified controls with reproducible evidence, counterpart authorities should default to acceptance subject to targeted spot checks.

Fifth, economic instruments should be tuned to measured risk. Mandatory insurance pools for high-risk AI and no-fault funds for attribution-hard harms should link premiums and access to observable compliance maturity: documented risk management, bias and robustness results, monitoring SLAs, incident response performance, and audit reproducibility. Parametric triggers regulator-confirmed recalls, calibration collapses above thresholds, or widespread exploit signatures can speed liquidity while contribution rules sort shares later among providers, integrators, and deployers. Performance bonds for high-stakes pilots, market-surveillance fees that finance reproducibility audits, and premium credits for superior drift detection or explainability fidelity would align capital costs with safety investment.

Finally, the system needs a cadence that keeps controls current without whiplash. Periodic regulatory "sunset-review" cycles say, every three years should revisit tiering thresholds, safe-harbor criteria, and documentation minima in light of incident data, advances in interpretability, and measured compliance burden. Sunset review should be evidence-driven: what incidents did controls prevent or fail to catch; where did audits prove decisive; which obligations delivered value and which ossified into checklists. Canary policy rollouts, public comment on draft profiles, and structured field experiments (with ethics safeguards) can validate proposed changes before they harden. Inside organizations, board-level reviews should mirror this cadence, linking compensation and investment to service safety, bias reduction, audit success, and time-to-remediation.

A liability regime cannot make AI infallible; it can make safety the default, evidence the currency, and learning the norm. By fusing U.S. causation reasonableness with EU risk-tier formalism, recognizing the persistent challenges of sparsity, opacity, and cross-border complexity, and pursuing a concrete agenda causal proof method, document AI for evidence, privacy-preserving audits, interoperable standards, calibrated insurance, and sunset-review cycles the comparative model matures from white paper to working constitution. The reward is tangible: faster redress when harm occurs, clearer incentives that put money behind diligence, and a transatlantic market where trustworthy AI can scale because accountability is engineered into its design, verified in its operation, and renewed as the technology evolves.

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