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# Master Thesis

# Connected Defense: Next-Generation Data Platform for Military Intelligence and Operations

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## ISO (International Organisation of Standardisation)

- Founded in 1947
- Largest development organisation for voluntary international standards production, technology, environmental protection, etc. (cross-industry)
- E.g. **ISO 27001** information security management; **ISO 27005** information security risk management; **ISO 31000** risk management

## Cyber Security and Cyber Resilience

- Traditional cybersecurity frameworks focus on **prevention and detection**
  - **Challenge:** Massive amounts of attacks are **inevitable**, their impact more **severe**
- Cyber resilience frameworks add **resistence, recovery and adaption** capabilities
  - **Objective:** Operational **continuity** and long-term **stability**

## Definition

- **ISO 31000:**
  - **Risk:** “Effect of uncertainty on objectives”
  - **Risk management:** “Coordinated activities to direct and control an organisation with regard to risk”
- **ISO 27005:**
  - Guidelines for managing security risks in digital context

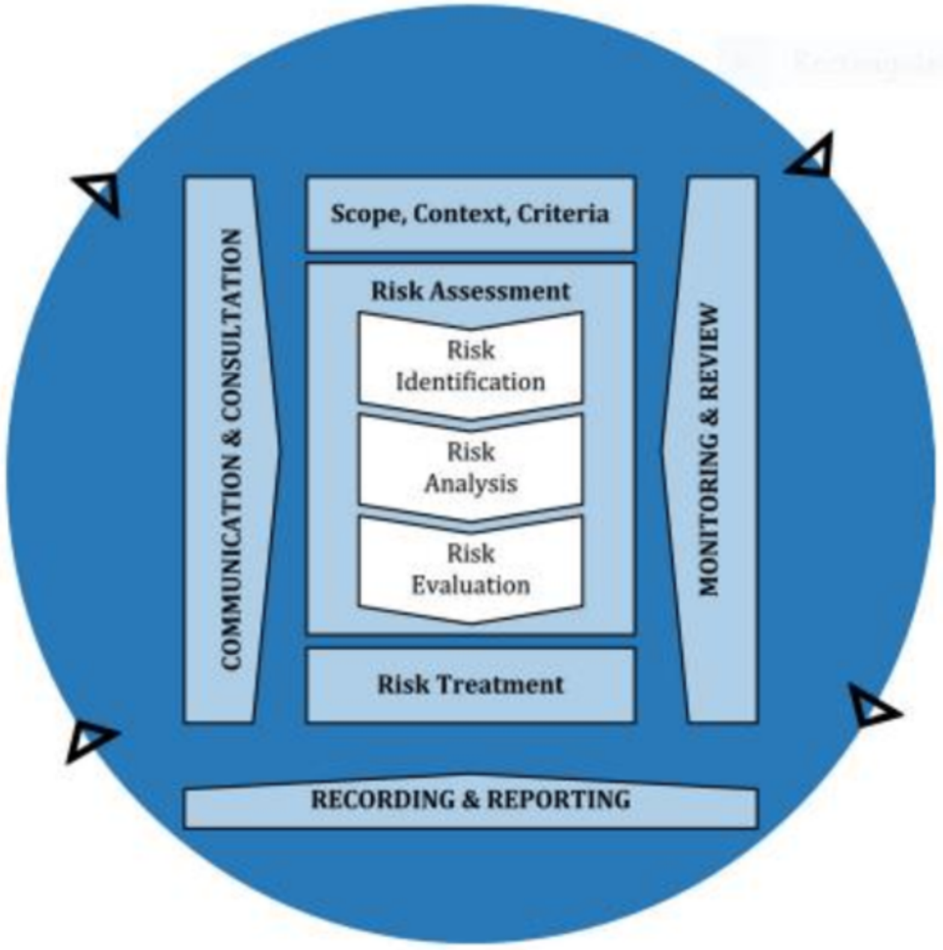



**Figure 1:** ISO 31000:2018 - Risk Management Process [1]

# Definition

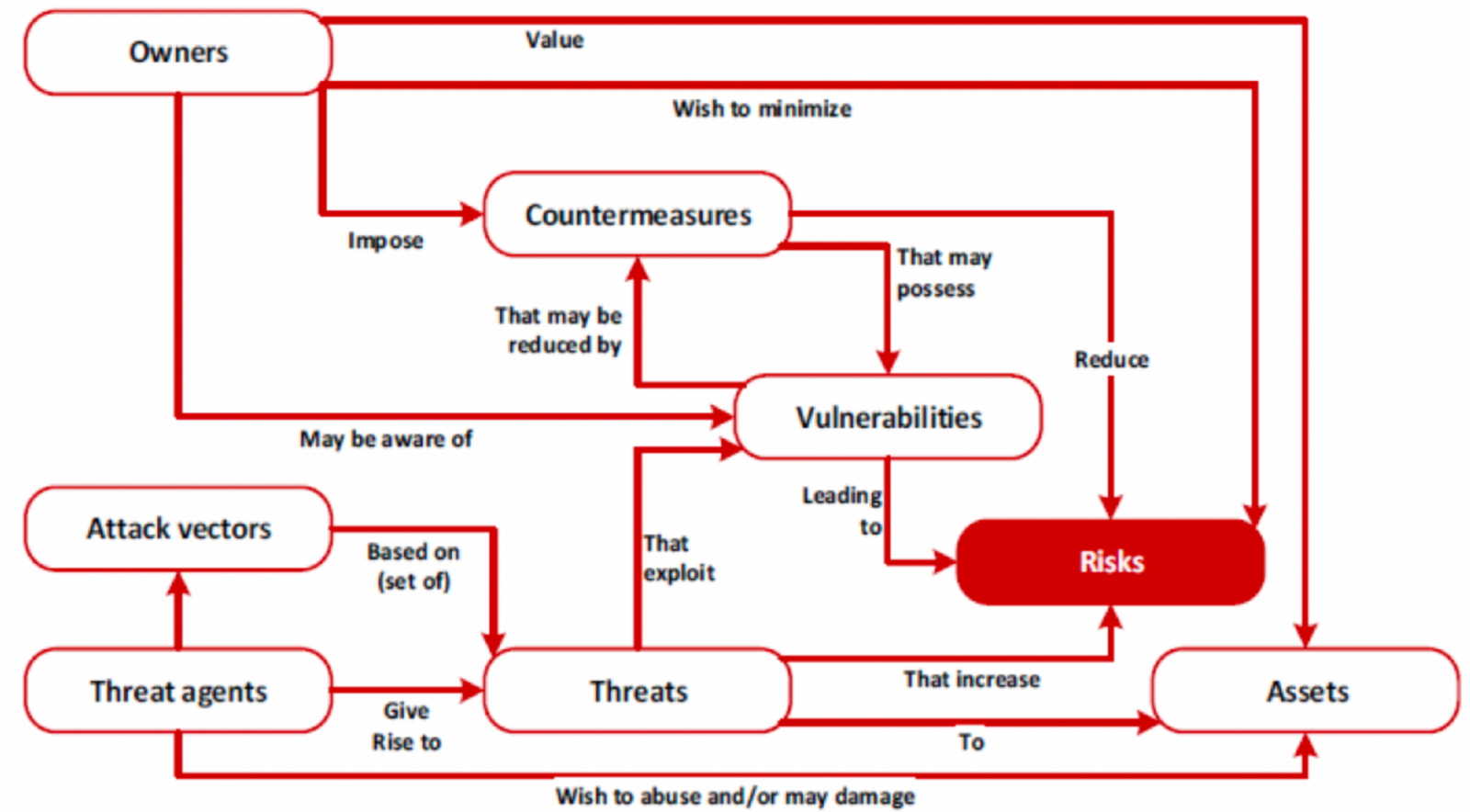



**Figure 2:** ISO/IEC 27005:2018 - Risk Management Methodology [2]

## Key Concepts

- Risk Assessment
- Mitigation Strategies
- Resilience

## Definition

- Context cyber defense: Application of advanced computational techniques
  - **Machine learning, neural network, natural language processing**
  - Improvement of detection, prevention and mitigation of cyber threats
  - **Enables Real-Time (RT) Analysis, Scalability, Automation and Efficiency and Predictive Capabilities**

## Key Concepts

- **Machine Learning (ML):** To learn from historical data, adapt to evolving threats and improve, contributes to GenAI
- **Natural Language Processing (NLP):** Analysis of textual data, e. g. security logs, extract valuable insights and enhances situation awareness, incl. advanced technologies, such as Large Language Models (LLMs), contributes to GenAI (text)
- **Neural Networks/Deep Learning:** Subset of ML designed to mimic human brain functionality, effective in image recognition and RT threat detection

## Concepts applied in Cybersecurity

- **Threat Detection:** ML models to treat malicious activities, neural networks for pattern recognition in network traffic
- **Predictive Capabilities:** leveraging historical data to predict emerging threats
- **Automation:** repetitive tasks, such as triaging alerts or threat classification can be automated
- **Improved Decision-Making:** AI data synthesis from multiple sources provides actionable insights more effectively

# Applications (Risk Management/AI) in Cybersecurity

## Broad Scope of Applications

- **Critical systems** (power grids, transportation, healthcare, etc.), **Predictive analytics, Automated operations**

## Enhancing Security

- **Compliance:** General Data Protection Regulation (GPDR), ISO 27001 to avoid penalties

## Industry Impact

- **Healthcare:** Information protection and incident response
- **Defense:** Monitoring threats and ensuring confidentiality
- **Financial sector:** Fraud detection and prot. customer data

# Challenges (Risk Management/AI) in Cybersecurity

## Evolving Threat Landscape:

- Advanced persistent threats (APTs, ransomware)
- Complex interconnected supply chains

## Technical Barriers:

- **Data quality:** Lack of diverse datasets for AI training
- **AI limitations:** Adversarial attacks, algorithmic bias
- Interoperability issues with legacy systems

## Organisational and Ethical Concerns:

- Compliance with GPDR/ISO 27001 adds complexity
- **Ethical concerns:** Data privacy, accountability
- Resistance to AI adoption due to trust and cost concerns

## Financial Constraints:

- High implementation costs and unclear Return on Investment (ROI)

## Definition

- **ISO 31000** defines risk management as

**"coordinated activities to direct and control an organisation with regard to risk."**

- **In AI-driven risk management**, this **is expanded** by leveraging AI to automate, enhance, and continuously refine these activities

**Alignment with ISO Standards (complements ISO 31000 and 27005)**

- Automating the *risk assessment* process through advanced ML models
- Supporting *risk treatment* with predictive analytics that prioritise mitigation strategies
- Enhancing *risk communication* by providing clear visualisations and actionable insights for stakeholders
- Facilitating *continuous improvement*, a core principle of ISO standards, by updating risk management practices in response to new data and threats.

# AI-Driven Risk Management for Cyber Resilience

## Summary

- Proactive Threat Mitigation
- Real-Time (RT) Response
- Scalable Risk Assessment
- Incident Recovery and Continuity
- Enhanced Decision-Making
- Adaptability to Evolving Threats

## Industry-Specific Contributions

- **Healthcare:** AI protects sensitive patient data, ensures system availability, maintaining the delivery of critical services during incidents
- **Finance:** RT fraud detection systems safeguard financial transactions, preserving trust and stability in financial markets
- **Energy:** Predictive maintenance powered by AI secures power grids and industrial control systems, reducing the risk of large-scale outages
- **Public Sector:** Governments leverage AI to ensure the resilience of critical infrastructure and digital services, enhancing national security

## EU AI Act - Key Points:

- Establishes stringent requirements for **high-risk AI systems** (e.g. transparency, robustness, governance)
- Focuses on **mandatory risk assessments**, bias mitigation, data privacy safeguards for critical applications
- Enforces accountability with **strict transparency obligations** and regular system updates
- Enhances **cyber resilience** by integrating ethical and technical measures into risk management
- Serves as a structured guideline for ensuring public trust while safeguarding organisational integrity

# AI-Technologies for Risk Assessment and Decision-Making

## Summary

- **Machine Learning (ML):** Supervised, Unsupervised, Reinforcement Learning for threat detection, categorisation, vulnerability discovery, optimisation of decision-making, contributes to GenAI
- **Natural Language Processing (NLP):** incl. LLMs to process and analyse unstructured data, contributes to GenAI
- Predictive Analytics: Statistical methods and ML for forecasting
- Anomaly Detection Systems: Autoencoders, Gaussian mixture models in network traffic, system logs, etc.
- **Visualisation and Decision Support Tools:** Dashboards and heat maps. Critical information, hightlighting of priorities

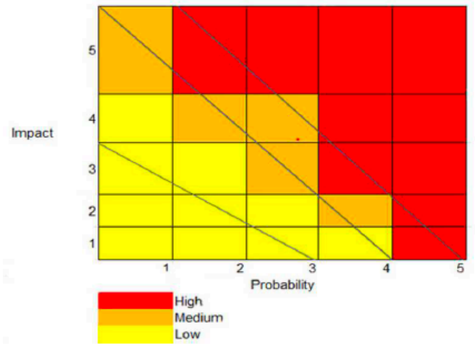
## GenAI and LLMs

- Significant advancements in AI-driven risk management tools, leverage massive datasets to enhance **unstructured data analysis** and provide insights for **risk assessment** and **mitigation**
  - **Unstructured Data Analysis:** e.g. GPT-based systems excel at processing and summarizing vast amounts of textual data, including incident reports, regulatory updates, and threat intelligence feeds
  - **Predictive Risk Scenarios:** Generative models simulate potential risk scenarios, enabling organisations to anticipate vulnerabilities and test mitigation strategies in a virtual environment
  - **Enhanced Decision-Making:** By synthesising contextual and historical data, GenAI facilitates strategic decision-making, improving

# Predictive Risk and Complexity Score Assessment Model (PRCSAM)


**Figure 3:** PRSCAM management framework - Risk Engine [5]

| 0-40% | 41-60% | 61-100% |
|---|---|---|
| Low | Medium | High |




| Category | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Project Characteristics | *0-40% - Low* | *41- 60 % Medium* | *61-100% High* |
| Strategic Management Risks | | | |
| Procurement Risks | | | |
| Human Resources Risks | | | |
| Business Risks | | | |
| Project Management Integration Risks | | | |
| Project Requirements Risks | | | |

**Figure 4:** Risk and Complexity Assessment - Concept [5]

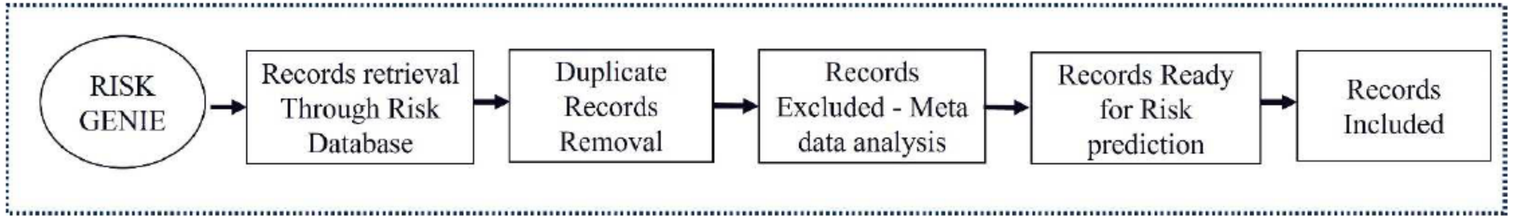



**Figure 5:** PRSCAM - Risk Prediction Genie [5]

# Business Continuity Management (BCM)

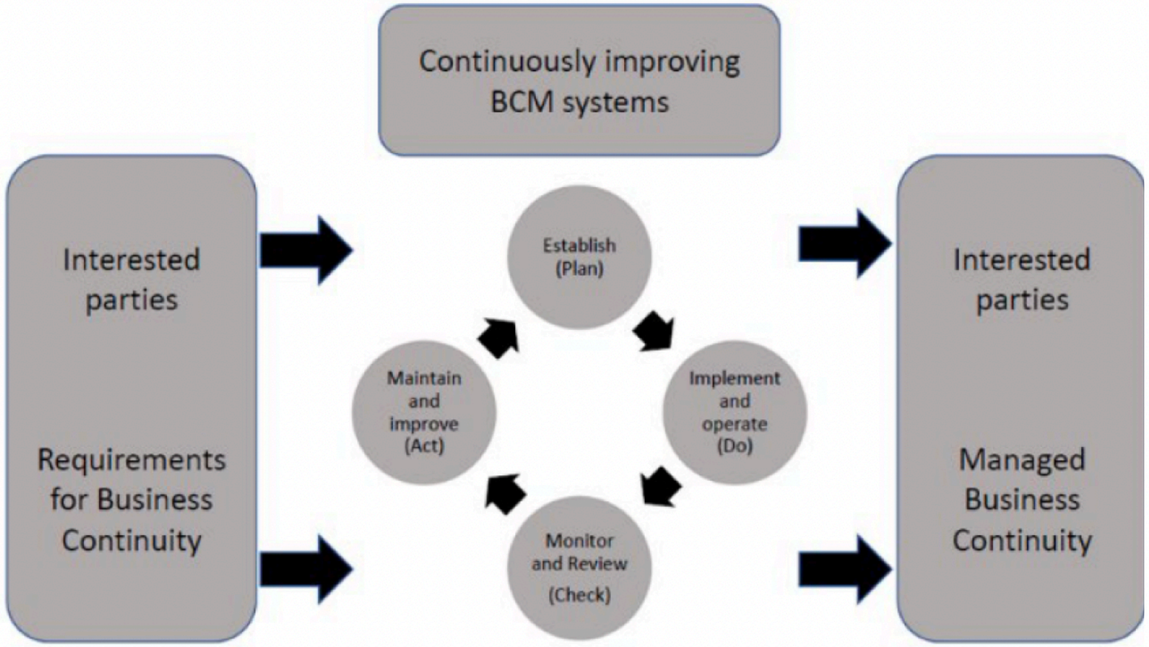



**Figure 6:** BCM - AI-enhanced Plan-Do-Check-Act (PDCA) cycle [9]

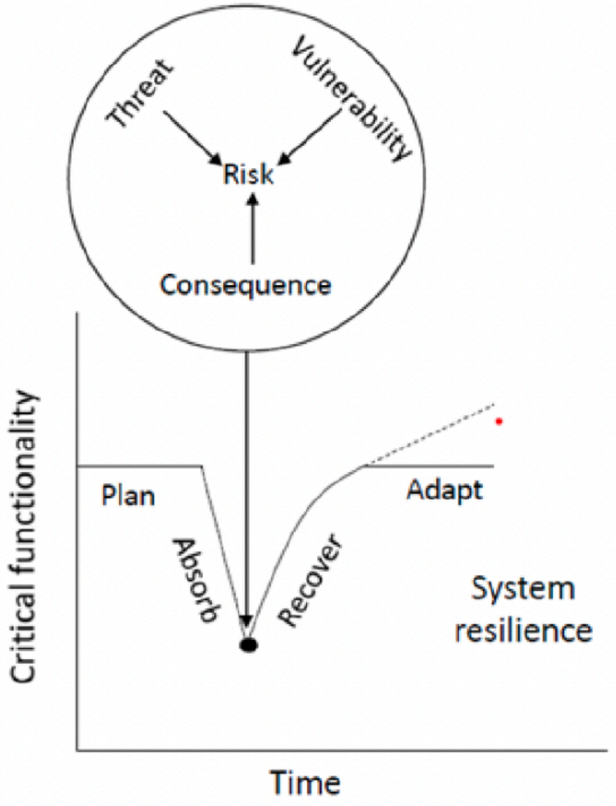



**Figure 7:** Resilience Management Framework [9]


**Figure 8:** BCM - AI-enhanced Resilience cycle [9]

## Benefits of AI-Driven Approach

- Enhances **efficiency and accuracy** by processing **large datasets** and **uncovering patterns** and **anomalies**
- Enables **proactive risk mitigation** through **predictive models** and **automated incident handling**
- Reduces **operational workload**, allowing teams to **focus on strategic decision-making**
- Ensures **cost-effectiveness** with long-term **savings from reduced incident costs** and **faster recovery times**
- Strengthens **collaboration** by providing **platforms for unified risk insights** and **strategies**
- Improves organisational **resilience** by **minimizing downtime** and **supporting** long-term **risk management**




# Challenges and Limitations

## Ethical, Technical and Regulatory Aspects and Limitations

- **Ethical:** AI systems face biases, lack of interpretability, and data privacy risks
- **Technical:** limited data quality, adversarial risks (e.g. data poisoning), high computational costs
- **Regulatory:** arise from compliance with evolving standards (e.g., EU AI Act) and adapting to global legal variations

## Outlook

- Advancements in AI (e.g., XAI, anomaly detection) will improve transparency, efficiency, and decision-making
- Proactive risk mitigation will focus on predictive strategies and resilience against evolving threats
- Collaboration between public and private sectors will drive ethical AI adoption and shared solutions
- **Goal:** build adaptive, sustainable risk management systems capable of thriving in uncertain environments

# Future Directions and Emerging Trends

## Potential Advancements

- **Explainable AI (XAI):** Enhances transparency and trust in decision-making processes
- **Large Language Models (LLMs):** Automate threat detection, optimise responses, and improve security awareness training
- **Domain-Specific AI Models:** Address sector-specific challenges, such as supply chain vulnerabilities and regulatory compliance
- **Integration with Emerging Technologies:** Blockchain for secure data sharing, Internet of Things (IoT)  for threat detection, and quantum computing for advanced security
- **Ethical AI Development:** Focuses on reducing bias, ensuring accountability, and aligning with societal values for reliable systems

# Future Directions and Emerging Trends

## Evolving Approaches

- **Integration of AI and Cybersecurity:** AI enables proactive threat detection and risk mitigation through advanced technologies
- **Tailored AI Solutions:** AI is increasingly customized for specific industries, such as finance, healthcare, and critical infrastructure
- **Focus on Ethics and Governance:** Emphasis on fairness, accountability, and transparency in AI systems, supported by robust framework
- **Sustainability in AI Deployments:** Sustainable AI practices reduce environmental impact and ensure long-term operational viability

## Regulatory and Ethical Developments

- Regulatory laws like the EU AI Act promote fairness, transparency, and accountability in AI
- Harmonized standards simplify compliance and encourage global adoption of ethical AI practices
- Regulatory efforts aim to foster trust in AI systems while minimizing risks and societal biases
- These developments ensure AI technologies remain innovative, socially responsible, and beneficial to society

- AI **transforms cybersecurity** by enabling **precise threat identification**, **assessment**, and **mitigation**
- AI-driven **frameworks** emphasize **resilience**, focusing on **recovery** and **adaptation** rather than just prevention
- Emerging technologies like **XAI** and **anomaly detection** expand **capabilities**, but introduce **challenges** such as **transparency, algorithmic bias**, and **compliance**
- **Collaboration** and continuous **innovation** are essential for **building adaptive** and **robust** risk management systems
- AI ensures **secure**, **sustainable**, and **adaptable strategies** for navigating the **evolving digital landscape**

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# Q & A

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