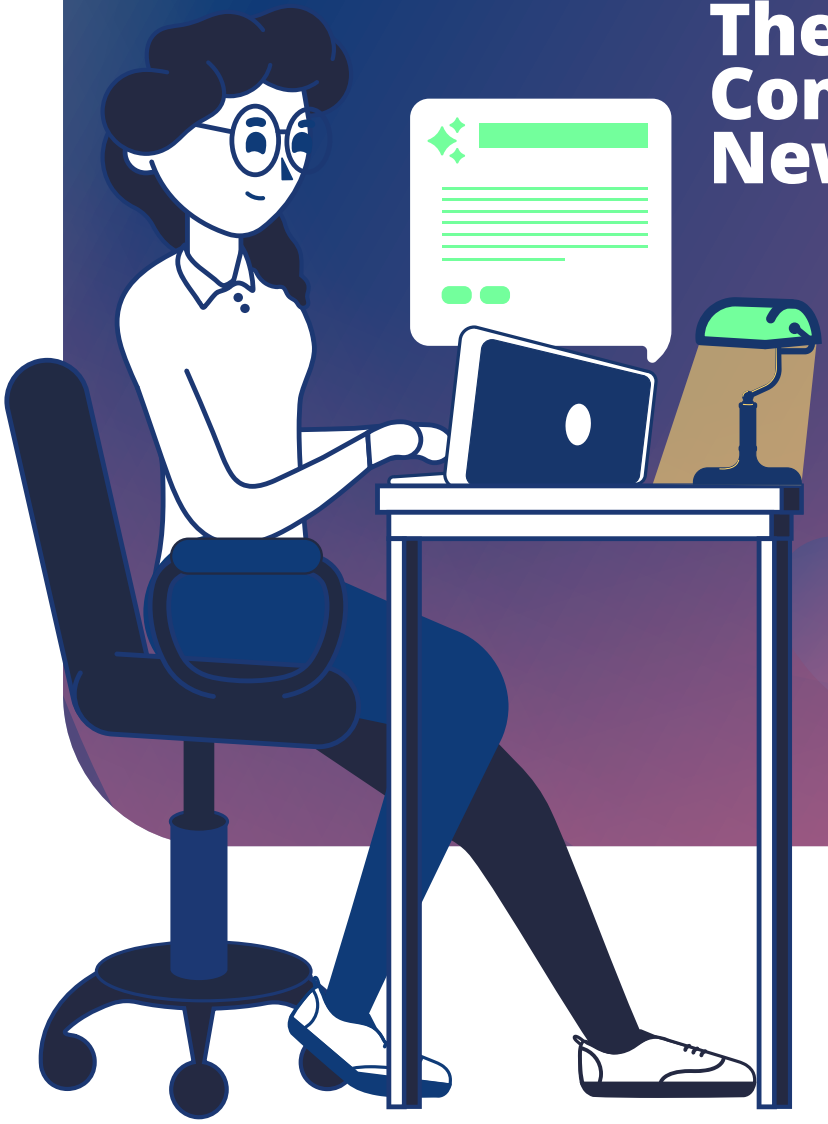
reflectiz

Whitepaper

SECURE VIBE CODING

The Complete New Guide



Executive Summary

Vibe coding marks a revolutionary leap in software development, enabling rapid code generation through natural language prompts. This paradigm shift dramatically accelerates prototyping, democratizes software creation for both developers and non-technical users, and allows a sharper focus on creative problem-solving over intricate syntax. Early adoption rates are significant:

25%

of Y Combinator startups leveraging AI for core codebase development by 2025 [2]

Developer productivity is increasing overall by up to

55% [24]

However, the speed and accessibility of AI-generated code come with a caveat: it often lacks built-in security. Large Language Models (LLMs) **are trained for completion, not protection,** and can introduce subtle, high-impact vulnerabilities. A deeper analysis of these risks is provided in Section 4.

This guide serves as an essential resource for navigating the complexities of vibe coding, emphasizing that its transformative potential can only be realized responsibly through a robust "human-in-the-loop" methodology. It outlines the imperative for:

- **Secure Prompt Engineering:**
  Crafting explicit and security-aware prompts to guide AI models towards generating safer code from inception.
- **Integrated Security Workflows:**
  Implementing continuous security validation pipelines, comprehensive human code reviews, and advanced automated testing (SAST, DAST, SCA) throughout the development lifecycle.
- **Proactive Governance:**
  Establishing clear organizational policies, audit models, and continuous monitoring to manage risks and ensure compliance with evolving regulatory frameworks like the EU AI Act and NIST AI Risk Management Framework.

By embracing these strategies, organizations can effectively mitigate the inherent security risks, leverage vibe coding as a powerful augmentation to traditional development, and foster a future where innovation is both rapid and secure.

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1. Introduction to Vibe Coding

1.1 Defining Vibe Coding: Natural Language to Code Generation

Vibe coding is an emerging and revolutionary approach to software development where users communicate their desired application functionality to AI tools using natural language, rather than engaging in manual code writing. The AI then assumes responsibility for the technical implementation, translating plain speech into executable code. This methodology fundamentally redefines programming as an "intent-based outcome specification," where the user articulates the desired end result, and the AI determines the precise technical steps to achieve it.

This approach marks a significant departure from traditional, manual coding paradigms, ushering in a more flexible and AI-powered development process. The emphasis shifts from meticulous syntax and intricate technical details to articulating the "vibe" or essence of the desired outcome, allowing for a more intuitive and creative development experience. The process is inherently iterative; users provide feedback to the AI on the generated code, describing issues or requesting changes until the desired functionality is achieved. This conversational, back-and-forth interaction is a central characteristic of vibe coding.

This shift means the democratization of software creation. The fundamental move from syntax-driven coding to natural language interaction inherently lowers the barrier to entry for software development. This is not merely about enhancing efficiency for existing coders; it is about empowering a much broader audience, including non-programmers, domain experts, entrepreneurs, and designers, to create functional applications. The ability to describe an application's behavior in plain language, rather than writing lines of code, removes many traditional technical barriers. This means that individuals who possess deep knowledge in a specific domain but lack coding proficiency can now directly contribute to digital solutions, addressing their personal or organizational needs. This broadening of participation is evident in various sectors, including government, where employees can create custom applications without extensive IT expertise, and in education, where students can focus on creative exploration rather than being bogged down by complex coding requirements. This expansion of access suggests a future where ideation is no longer confined to technical teams, leading to a potentially more diverse and innovative array of applications.

1.2 The Genesis and Core Philosophy

The term "vibe coding" was coined by Andrej Karpathy, co-founder of OpenAI, in February 2025, describing it as "giving in to the vibes, embrace exponentials, and forget that the code even exists."[1]
This philosophy prioritizes rapid experimentation over structural perfection, with AI agents functioning as real-time coding assistants that automate tedious processes. The approach shifts developer focus from syntax minutiae to higher-level intent and creative problem-solving.
However, the core tenet of "forget that the code even exists" creates significant security challenges. When users are encouraged to abstract away from code mechanics, they inherently bypass critical understanding of how and why the code functions. This abstraction gap makes it difficult to identify vulnerabilities, maintain complex systems, or critically evaluate AI-generated output—establishing a direct link between vibe coding's accessibility philosophy and its security risks.

1.3 How Vibe Coding Works in Practice

Vibe coding is characterized by a conversational, back-and-forth interaction with AI agents. Users describe their requirements, the AI generates corresponding code, and users then provide feedback on errors or desired changes, initiating an iterative refinement loop.

The practical application of vibe coding typically follows a structured, step-by-step process:

Every vibe coding session commences with a clear need or a defined idea for a software solution.

Users articulate their intention using natural language prompts. The effectiveness of the AI's output is highly dependent on the clarity, specificity, and contextual richness of these prompts.

Large Language Models (LLMs) interpret the natural language prompts and subsequently produce functional code based on the instructions provided.

Users review the generated output, test its functionality, and then iterate by providing further prompts to address any issues, refine existing features, or add new functionalities.

The tools utilized in vibe coding are predominantly large language models (LLMs) such as ChatGPT, Claude, OpenAI's Codex, GPT-4, and DeepSeek, which are capable of conversational code generation and structured code tasks. Additionally, integrated AI coding assistants like GitHub Copilot, Cursor AI, and Amazon CodeWhisperer play a crucial role, often functioning as "pair programmers" that offer real-time suggestions, fix bugs, and enhance code structure.

A significant implication of vibe coding is the evolving definition of a "programming language." This approach suggests that natural human language, such as English, is becoming a de facto programming language, abstracting away the need for traditional, formal syntax. This concept carries profound implications for how future developers are trained and how software is conceptualized. If natural language is sufficient to generate functional code, then the conventional understanding of a programming language – a formal, artificial language designed to communicate precise instructions to a machine – is being fundamentally challenged. The interface to computation is shifting from rigid, formal syntax to the more fluid and semantic nuances of human expression. This suggests a future where "coding" may involve less memorization of specific syntax rules and more precise articulation of intent, potentially leading to a convergence of roles traditionally separated, such as product management, design, and development. It also raises complex questions about the robustness and expressiveness of natural language as a programming interface for highly complex and mission-critical systems.

2. The Evolving Scope and Applications of Vibe Coding

2.1 Key Advantages and Use Cases

Vibe coding offers compelling advantages that are reshaping software development:

Speed and Accessibility

Rapid Prototyping
Build MVPs in hours rather than weeks, enabling fast idea validation and iterative development cycles

Democratized Development
Empempowers non-programmers, domain experts, and entrepreneurs to create functional applications by describing desired functionality in plain language

Productivity Gains
Up to 55% faster completion times by automating repetitive tasks like boilerplate code, basic data operations, and standard patterns [24]

Enhanced Focus and Innovation

Creative Problem-Solving
Frees developers from syntax details to focus on architecture, user experience, and complex challenges

Experimentation

Ideal for side projects, concept validation, and rapid iteration without significant time investment

Practical Applications
Vibe coding excels in building internal tools, automation scripts, simple web applications, chatbots, and lightweight integrations. It's particularly valuable for government process automation, educational projects, and helping experienced developers learn new frameworks through scaffolding and sample generation.

Strategic Positioning
Most teams adopt a hybrid approach—using vibe coding for rapid prototyping and repetitive tasks while maintaining traditional coding for complex, mission-critical systems. This suggests vibe coding functions best as augmentation rather than replacement, requiring new strategies for integrating AI-generated code into existing CI/CD pipelines and development workflows.

2.2 Current Limitations and Challenges

Despite its numerous benefits, vibe coding is not without its limitations and challenges:

Technical Complexity: While vibe coding can handle basic standard frameworks, it often becomes challenging for real-world applications with novel or complex technical requirements. The AI may generate basic or incomplete code for highly specific or intricate functionalities.

Code Quality and Performance Issues: AI-generated code frequently requires optimization and refinement to maintain high quality. It can be inefficient, difficult to comprehend, or stylistically inconsistent. It is generally not an ideal choice for distributed applications, which demand structured architecture and sophisticated optimization strategies.

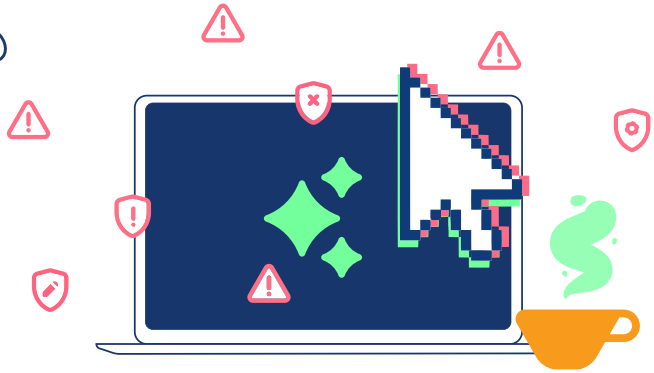
Debugging Challenges: Code generated by AI can be challenging to debug due to its dynamic nature, lack of architectural structure, opaque underlying logic, and absence of clear documentation or intent. Errors can compound rapidly if not addressed and fixed early in the development process.

Maintainability and Long-Term Reliability: The speed and convenience offered by vibe coding often come at the cost of flexibility and long-term maintainability, particularly for complex or large-scale projects where fine-grained control over every system component is essential.

Over-reliance on AI / Knowledge Gaps: There is a notable potential for users to become overly dependent on AI tools, which can hinder the development of their own fundamental coding skills and lead to knowledge gaps regarding the underlying "why" of the code. If issues arise, users may struggle to resolve them due to a lack of foundational understanding of how the code operates. This can become a critical issue in professional settings where a deep understanding of the system is paramount for long-term success.

Prompt Dead-Ends: Developers may encounter situations where the AI fails to adequately understand or fulfill complex or nuanced requests. In such cases, users must often reframe their prompts, break down the problem into smaller, more manageable parts, or even switch to different tools.

The rapid generation of code through vibe coding, coupled with potential issues in quality, consistency, and a lack of clear logic or documentation, creates a significant risk of accumulating "hidden technical debt". This debt may not be immediately apparent during initial development but can lead to increased maintenance load, longer debugging times, and scalability issues as projects evolve. The speed of generation can inadvertently mask underlying structural and quality issues. Without proper human review and refinement, these issues can compound over time, creating a burden that will eventually slow down development or lead to system failures, much like traditional technical debt but potentially harder to identify due to the opaque nature of AI-generated code. Organizations must therefore factor in the ongoing cost of "refactoring and maintaining AI-generated code" and invest in tools and processes that help visualize, document, and manage this new form of technical debt, rather than solely prioritizing initial generation speed.



2.3 Tool-Specific Analysis: AI Coding Systems Comparison

2.3.1 Comparative Analysis of Leading Vibe Coding AI Systems

This section will provide a detailed comparison of major AI coding systems, analyzing their specific security features, limitations, and best use cases.

Comparative Analysis of Leading Vibe Coding AI Systems:

AI System	Security Features	Notable Limitations	Optimal Use Cases	Security Considerations
OpenAI Codex / GPT-4 **Key Strengths:** Versatile, strong conceptual understanding	Code vulnerability detection in Copilot; Context window allows for architectural understanding	May suggest deprecated libraries; Occasional hallucination of non-existent functions	Full-stack web development; Complex algorithmic challenges	Tendency to generate verbose code that may obscure security issues; Strong at syntax but weaker at system-level security
Claude **Key Strengths:** Strong explanations, natural language focus	Risk-aware prompting capabilities; Strong documentation generation	Less specialized for certain programming domains; Newer to code generation	Documentation-heavy projects; Security-critical applications where explanations matter	Excels at explaining security implications; Conservative approach to security recommendations
DeepSeek Coder **Key Strengths:** Specialized for coding tasks; Deep knowledge of repositories	Repository-aware code suggestions; Built-in linting capabilities	More limited general knowledge outside coding domain	Performance-critical applications; System-level programming	Strong static analysis integration; Weaker at detecting logical security flaws
GitHub Copilot **Key Strengths:** IDE integration; Repository context awareness	Real-time security scanning; OWASP vulnerability detection	Over-reliance on context; Suggestions based on patterns not security	Rapid prototyping within existing codebases; Augmenting developer workflow	Rapid prototyping within existing codebases; Augmenting developer workflow
Amazon CodeWhisperer **Key Strengths:** AWS service integration; Policy-compliant code generation	Security scan feature; Compliance detection	AWS-centric solutions; Less effective for non-AWS environments	Cloud infrastructure code; Compliant environments	Strong in generating compliant code; Service-specific security features

Cursor AI **Key Strengths:** Focused on natural language editing of existing code; Context-aware refactoring	Integrated security linting and vulnerability highlighting within the editor	Relies heavily on existing codebase context; Less suited for generating entirely new, large codebases from scratch	Iterative code refinement; Security auditing of existing projects; Collaborative secure development	Can identify and suggest fixes for vulnerabilities in existing code; Effectiveness tied to the quality of the provided context; Good for human-in-the-loop security review
BASE44 **Key Strengths:** Complete no-code application builder; Conversational AI interface; Integrated deployment and hosting	Built-in authentication and authorization; Secure infrastructure with one-click deployment; Integration security with trusted services (AWS S3, GitHub, Supabase)	No direct code access or customization; Limited to platform capabilities; Dependency on platform vendor	Rapid MVP development; Non-technical users building full-stack apps; Business automation tools; Custom internal applications	Platform-managed security reduces individual responsibility but creates vendor dependency; Limited visibility into underlying security implementations; Requires trust in platform's security practices

2.3.2 Tool-Specific Security Behavior Analysis

Each AI system exhibits distinctive patterns when handling security-critical code generation:

GPT-4/Codex
Tends to prioritize completeness and elegance over security when not explicitly prompted. Requires specific security directives but offers the most comprehensive code generation capabilities. Security vulnerabilities often appear in edge cases handling.

Claude
More cautious with potentially risky operations. Often includes explanatory comments about security implications and tends to suggest conservative approaches. Provides more verbose documentation of security considerations but may generate less optimized code.

GitHub Copilot
Leverages GitHub's security datasets to flag common vulnerability patterns. Particularly strong at identifying issues present in public repositories but may struggle with novel security patterns. Benefits significantly from IDE-integrated security scanning.

Amazon CodeWhisperer
Optimized for secure AWS service integration. Includes built-in detectors for security and compliance issues related to AWS services. Security strengths are significantly AWS-centric.

DeepSeek Coder
Emphasizes performance and algorithmic correctness. Security approach focuses on static analysis rather than architectural security patterns. Strong at identifying syntax-level vulnerabilities but weaker at system-level security design.

Cursor AI
Excels at identifying and suggesting improvements for security vulnerabilities within existing code by leveraging its deep contextual understanding of the codebase. It often highlights potential security issues as part of its editing and refactoring suggestions, enabling developers to address them proactively.

BASE44
Takes a fundamentally different approach by abstracting security implementation entirely away from users. Security is managed at the platform level through built-in authentication, authorization, and secure infrastructure rather than through code-level controls. Users rely on the platform's security implementations and trusted third-party integrations (AWS S3, Supabase, GitHub) rather than implementing custom security measures. This approach eliminates many common coding vulnerabilities but creates dependency on the platform vendor's security practices and limits visibility into underlying security implementations. Security risks shift from code-level vulnerabilities to platform trust, configuration management, and vendor security posture.

2.3.3 Tool-Specific Secure Prompting Strategies

Different AI systems respond optimally to different prompting patterns:

For GPT-4/Codex:

"Generate [functionality] with explicit OWASP Top 10 protections. Include robust input validation for [specific attack vectors]. Follow zero-trust principles and explain your security reasoning."

For Claude:

"Please create [functionality] that prioritizes security over convenience. Implement defense-in-depth patterns including [specific security controls]. After generating the code, identify any potential security weaknesses that remain."

For GitHub Copilot:

"// Security-critical function

// Requirements: Must validate all inputs, use parameterized queries, and implement proper error handling

// Potential threats: SQL injection, XSS, IDOR

function..."

For Amazon CodeWhisperer:

"# Secure AWS Lambda function

 # Must comply with: least privilege, encryption in transit/at rest

 # Handle sensitive data according to compliance requirements
def..."

For DeepSeek Coder:

"/ Performance-critical and security-sensitive function*

** Constraints: No dynamic memory allocation, bounds checking required*

** Security: All inputs must be validated, no buffer overflows*
**/*

Void..."

For Cursor AI:

"// Analyze the following code for potential security vulnerabilities, focusing on [specific attack vectors like SQL injection or XSS]. Suggest refactorings to improve security, adhering to [security standard like OWASP Top 10]."

For BASE44:

"Build a [application type] that handles [sensitive data type]. Requirements: Implement multi-factor authentication for all users, role-based access control with [specific role definitions], data encryption at rest, audit logging for all user actions, and GDPR-compliant data handling. Ensure the application follows principle of least privilege and includes session management with automatic timeout. Integrate with [specific secure services] and configure secure backup procedures."

3. Vibe Coding Trends and Future Trajectories

3.1 Current Adoption and Industry Impact

Vibe coding has experienced rapid adoption since its emergence in early 2025. Key metrics demonstrate significant industry impact:

25%

of Y Combinator startups are building core codebases with AI assistance [2]

44%

of developers had integrated AI coding tools into workflows by 2023 [23]

Up to 55%

faster completion times reported across projects using vibe coding [24]

This acceleration enables startups to validate concepts in hours rather than weeks, dramatically shortening time-to-market. Notable successes include Pieter Levels' flight simulator game, which grossed $1 million in under 20 days using largely AI-generated code.

Beyond efficiency gains, vibe coding is democratizing software creation by expanding access to non-technical domain experts, entrepreneurs, and designers. This shift represents a fundamental acceleration in innovation cycles—Karpathy's "embrace exponentials" philosophy combined with rapid prototyping capabilities suggests we're entering an era of unprecedented application proliferation and faster market disruption.

3.2 Redefining Developer Roles

Vibe coding is fundamentally reshaping developer responsibilities, shifting focus from manual code crafting to guiding, testing, and refining AI output. Developers are becoming "conductors, guiding an orchestra of AI tools."

Emerging Core Skills:

Prompt Engineering: Articulating requirements precisely to yield effective AI responses

Critical Evaluation: Assessing and integrating AI-generated output

System Architecture: Focusing on higher-level design while AI handles implementation details

This evolution suggests the rise of a "product engineer" archetype—blending software engineering with product management skills. These professionals must understand both user needs and technical implementation, translating product vision into precise AI prompts while critically evaluating outputs. The core competency shifts from writing efficient code to effectively orchestrating AI capabilities and ensuring quality outcomes.

3.3 The Future of Human-AI Co-Agency

Vibe coding marks the beginning of human-AI co-agency, where humans and intelligent systems collaborate to achieve outcomes neither could accomplish alone. This future emphasizes intuitive, human-centered development with AI adapting to human expression rather than forcing conformity to machine logic.

Key Developments:

Evolution of Development Environments: Tools like Cursor AI enable seamless natural language-to-code workflows

Voice-to-Code Interfaces: Developers can literally speak solutions into existence

Adaptive AI Systems: Technology increasingly conforms to human modes of expression

Success Strategies for Professionals:

Cultivate clear communication and prompting skills

Balance AI productivity gains with foundational coding knowledge

Actively explore the expanding AI development ecosystem

Prioritize ethical considerations and quality control in AI-assisted development

This continuous adaptation and learning will be crucial for navigating the evolving landscape of human-AI collaboration in software development.

4. Understanding Security Vulnerabilities in Vibe Coding

4.1 Why AI-Generated Code Isn't Inherently Secure

Despite being functionally correct, AI-generated code often omits essential security safeguards. This is not due to malice or error — it stems from the core design of LLMs and certain prompting patterns:

LLM Limitations and Pattern Completion Over Intent: LLMs primarily function by predicting the next most probable token in a sequence, rather than applying deep security engineering principles. They prioritize fulfilling functional requirements over security considerations and often lack the contextual understanding of an application's specific security requirements or an organization's established best practices. This means that AI can generate code that appears functional but omits critical security measures simply because they were not explicitly requested in the prompt.

Lack of Architectural Awareness: Current LLMs typically generate code at the function or module level without a comprehensive understanding of system-level architectural constraints, such as session state, inter-service interactions, or permission enforcement. This can lead to the introduction of vulnerabilities like broken access controls, missing state checks, or logic flaws that only become apparent when the code is integrated into a broader system.

Training Data Flaws: AI models are trained on vast datasets of existing code, which may unfortunately include inherent flaws, outdated security practices, or even biased human-created code. This means that the AI can perpetuate or inadvertently introduce known vulnerabilities present in its training data. Research indicates that LLM-generated code is "inherently insecure."A Stanford University study suggested that 36% of participants with access to AI assistants wrote solutions vulnerable to SQL injection compared to 7% of the control group [22].

Rapid Deployment vs. Security Review Capacity: The speed at which AI can generate code often outpaces the capacity of human security teams to review it thoroughly. This can lead to vulnerable code being pushed into production environments without adequate scrutiny.

Insecure Prompting Patterns: As further discussed in Section 6.1, the quality and security of AI-generated code are profoundly influenced by the prompts provided by the user. Vague instructions, the omission of explicit security requirements, implicit trust in AI outputs without human validation, and a sole focus on speed over quality significantly increase the likelihood of introducing vulnerabilities. The AI's default behavior, unless otherwise nudged, is to prioritize functional completion over security.

Security Reality Check

AI treats security like an optional feature—it won't include protections unless explicitly requested. Think of it as "security by invitation only." Every prompt is a security decision: include security requirements or accept insecure defaults.

The fact that AI prioritizes functional correctness over security and often lacks architectural awareness means it can generate code that appears to work perfectly but contains subtle, deeply embedded vulnerabilities. These can be termed "silent killer" vulnerabilities because they are difficult to detect through basic functional testing and can often bypass traditional Static Application Security Testing (SAST) tools, potentially surviving CI/CD pipelines and reaching production. The deceptive nature of these flaws, where the code functions as requested despite its underlying insecurity, creates a false sense of security, making them particularly insidious and challenging to identify until exploited. This necessitates a shift from reactive security (fixing obvious bugs) to proactive, threat-modeling-driven security reviews and advanced testing specifically designed to uncover these subtle, logic-based vulnerabilities that AI might introduce. This also underscores the irreplaceable role of human security expertise in the AI-driven development landscape.

4.2 Common Security Flaws and Attack Vectors

AI-generated code can introduce a range of common security flaws and attack vectors, often due to the AI's focus on functionality over security or its lack of contextual understanding. These include:

Data Security Vulnerabilities:

Hardcoded Credentials and Exposed Secrets: AI tools frequently suggest embedding sensitive information such as API keys, secrets, or database passwords directly within the source code. This makes credentials visible to anyone with access to the codebase and risks their persistence in version control history. The GitGuardian's State of Secrets Sprawl Report 2025 indicated that nearly 24 million secrets were inadvertently exposed on GitHub in one year, with repositories using AI coding tools showing a 40% higher rate of secret exposure [3].

Sensitive Information Exposure: Debug or error messages generated by AI might inadvertently reveal internal system details or sensitive information.

Case Study

The Exposed API Key

DataHub Connect's junior developer Alex used AI to generate code for fetching stock market data. Using the prompt "Generate Python code to fetch stock prices from 'MarketData API' for given symbols," the AI produced:

Python

```python
import requests

def get_stock_price(symbol):
    api_key = "YOUR_HARDCODED_API_KEY_12345" # AI inserted this for immediate functionality
    url = f"https://api.marketdata.com/v1/quotes/{symbol}?apiKey={api_key}"
    response = requests.get(url)
    return response.json()
```

Alex, unaware of the security implications, pushed this code to their private repository.

The Impact:

API Abuse Risk: Exposed keys could enable unauthorized calls, incurring overage charges or depleting quotas

Operational Disruption: Key rotation would require downtime for the internal tool

Reputational Damage: Security incidents erode client trust

Key Lessons:

1. **Mandatory Security Review:** Even simple AI-generated code needs human security validation
2. **Secure Prompting:** Include explicit security directives: "Generate Python code to fetch stock prices. Ensure API keys are loaded from environment variables, not hardcoded."
3. **Automated Detection:** Implement tools like GitGuardian to scan for exposed credentials before deployment

This example illustrates the "security by omission" problem—AI omits security measures unless explicitly instructed, making human oversight essential.

Unsafe Data Handling and Injection Attacks:

Missing Input Validation:
AI-generated code often lacks proper input validation, which is crucial for preventing various injection attacks.

Cross-Site Scripting (XSS):
AI tools may reflect user input unsafely in web pages, enabling attackers to inject malicious scripts that can expose sensitive data or compromise user sessions.

Command Injection:
Improper handling of system commands in AI-generated code can allow attackers to execute arbitrary commands on the server.

SQL Injection:
Direct insertion of unsanitized user input into database queries can allow attackers to manipulate or steal data from the database. A Stanford University study suggests that approximately 36% of AI-generated database queries are vulnerable to SQL injection].

Path Traversal:
This vulnerability arises when file paths are constructed from unchecked user input, potentially allowing attackers to access or manipulate arbitrary files outside the intended directory.

Weak Security Controls:

Insufficient Error Handling:
Poorly implemented error handling can inadvertently leak sensitive system information to attackers.

Outdated Cryptographic Methods:
The AI might suggest or implement weak or deprecated cryptographic algorithms (e.g., MD5, SHA1, DES), compromising data security.

Missing or Weak Authentication and Authorization:
AI-generated code may omit critical authentication and authorization checks, leading to unauthorized access to sensitive data or functionality, or allowing attackers to bypass business logic.

Timing-Based Side-Channel Attacks:
Subtle vulnerabilities, such as using non-constant-time comparisons for cryptographic operations (e.g., == for HMAC comparison), can enable attackers to gradually brute-force secrets by observing response times.

Configuration Issues:
AI-generated code might include development features enabled in production environments, overly permissive Cross-Origin Resource Sharing (CORS) settings, or unnecessary services enabled by default, creating potential attack vectors.

Prompt Injection:
This is a newer class of attack specific to LLMs, where attackers manipulate language model instructions to bypass security defenses or extract sensitive information, sometimes by "jailbreaking" the LLM to behave outside its intended parameters. This can also lead to "Prompt Leak," where the LLM inadvertently reveals its internal system instructions or proprietary logic, or "Denial of Wallet" attacks, where excessive engagement with the LLM leads to substantial resource consumption and financial implications.

Supply Chain Vulnerabilities:
AI tools may automatically add unvetted or vulnerable third-party libraries and packages, introducing supply chain risks into the codebase.

Data Poisoning Attacks:
Malicious actors could manipulate the training data used for AI models by injecting malicious samples, potentially creating backdoors or vulnerabilities in the generated code.

Feedback Loops:
Insecure AI-generated code, if used as training data for newer AI models, can create a feedback loop that perpetuates and even spreads vulnerabilities across future code generations.

Common Vibe Coding Security Vulnerabilities and Examples

Vulnerability Category	Specific Vulnerability	Description	Illustrative Example
Data Security	Hardcoded Credentials	Embedding sensitive data (API keys, passwords, tokens) directly in source code.	*password: 'admin123' in a database connection string.*
	Sensitive Info Exposure	Debug or error messages revealing internal system details.	*An error message displaying full database connection details.*
Unsafe Data Handling	Missing Input Validation	Failure to validate or sanitize user input before processing.	*Accepting any file type in an upload, leading to executable file uploads.*
	SQL Injection	Direct insertion of user input into SQL queries without proper sanitization, allowing malicious commands.	*SELECT * FROM users WHERE name = 'admin'; DROP TABLE users; --'*

	Cross-Site Scripting (XSS)	Reflecting unsanitized user input in web pages, allowing malicious scripts to execute in users' browsers.	*Displaying user-submitted <script>alert('XSS'); </script> directly.*
	Path Traversal	Constructing file paths from unchecked user input, allowing access to arbitrary files.	*fs.readFile(file. originalname) where file. originalname is ../../../etc/passwd.*
	Command Injection	Improper handling of system commands, allowing attackers to execute arbitrary commands.	*AI generating code that executes user input directly as a shell command.*
Weak Security Controls	Broken Access Control	Missing or inadequate checks to restrict user access to sensitive data or functionality.	*An API endpoint allowing any user to download any document by guessing its filename.*
	Insufficient Error Handling	Error messages revealing sensitive system information.	*A generic server error message showing stack traces or internal paths.*
	Weak Cryptography	Use of outdated or insecure cryptographic algorithms/ practices.	*Using MD5 for password hashing or reusing Initialization Vectors (IVs).*
	Timing Side-Channel Attacks	Using non-constant-time comparisons for sensitive data, allowing attackers to infer information by measuring response times.	*if (signature == expected) for HMAC verification.*
Configuration Issues	Insecure Defaults	Development features enabled in production, overly permissive settings.	*Overly permissive CORS settings or debug mode enabled in production.*

AI-Specific Vulnerabilities	Prompt Injection	Manipulating LLM instructions to bypass defenses or extract sensitive information.	*A user prompt designed to make the AI reveal its internal system prompt.*
	Supply Chain Risks	AI adding unvetted or vulnerable third-party libraries.	*AI suggesting a dependency with known CVEs.*
	Data Poisoning	Malicious manipulation of AI training data to inject vulnerabilities.	*Training data containing intentionally flawed code patterns.*

5. Emerging Standards and Governance for AI-Generated Code

5.1 Regulatory Landscape and Compliance Considerations

5.1.1 Evolving Regulatory Frameworks

The AI Act in the European Union has introduced significant compliance requirements for AI systems, with potential implications for vibe coding tools classified as high-risk AI systems, particularly when deployed in critical infrastructure, healthcare, or financial services [4].

Organizations must consider:

Risk Classification: Determining whether their vibe coding implementations fall under high-risk categories requiring conformity assessments

Transparency Requirements: Documenting AI involvement in code generation, especially for systems that impact human safety or rights

Documentation Burden: Maintaining records of prompts, generated code, human review processes, and validation procedures

In the United States, the National Institute of Standards and Technology (NIST) AI Risk Management Framework provides voluntary guidelines that organizations can adopt. The NIST framework emphasizes [5]:

Governance: Establishing clear oversight of AI systems

Mapping: Identifying and documenting contexts where AI-generated code is used

Measurement: Quantifying the performance and risks of vibe coding practices

Management: Implementing controls to address identified risks

5.1.2 Industry-Specific Compliance Considerations

Industry	Relevant Regulations	Vibe Coding Compliance Requirements
Healthcare	HIPAA [6], FDA Software as Medical Device [7]	Validation and verification documentation; Deterministic behavior proof; Human oversight evidence
Financial Services	Basel Committee on Banking Supervision AI guidelines [8]	Explicit risk management for AI-generated code; Auditability of code generation process
Critical Infrastructure	NIST Cybersecurity Framework [9]	Supply chain risk management for AI-generated components; Increased security testing requirements
Government	FedRAMP [10], CMMC [11]	Documentation of AI involvement; Enhanced review procedures for AI-generated code

5.2 Emerging Standards and Certification Approaches

5.2.1 AI Code Generation Standards Development

Several standards organizations are developing frameworks specifically addressing AI-generated code:

ISO/IEC JTC 1/SC 42 [12] is developing standards for AI systems that include specific provisions for AI code generation systems, focusing on trustworthiness, quality assessment, and bias detection.

IEEE P2864 (under development) aims to establish standard metrics for measuring the reliability and performance of AI-assisted software development tools.

OWASP AI Security and Privacy Guide [13] has expanded to include specific guidance on securing applications built with AI-generated code, including:

- AI-specific testing methodologies
- Verification procedures for AI-generated components
- Special considerations for prompt injection attacks

5.2.2 Voluntary Certification Programs

Industry-led certification programs are emerging to validate secure vibe coding practices:

AI Code Safety Certification (ACSC): A proposed industry consortium program requiring:

- Documentation of human review processes
- Proof of security testing specific to AI-generated code
- Implementation of continuous security monitoring

Secure AI Development Lifecycle (SAIDL): A framework adapting traditional secure development lifecycle practices to AI-assisted coding environments.

5.3 Governance Models for Vibe Coding Implementation

5.3.1 Organizational Governance Structures

Effective governance of vibe coding practices requires dedicated oversight roles and clear accountability structures:

AI Code Ethics Committee: Cross-functional team responsible for establishing organizational policies, reviewing high-risk implementations, and ensuring compliance with emerging regulations.

AI Security Architects: Specialized role focusing on the intersection of AI capabilities and security architecture, responsible for defining secure prompt libraries and validation protocols.

Prompt Engineering Governance: Establishing review processes for prompts used in production code generation, including mandatory security requirements.

5.3.2 Audit and Assurance Models

Emerging best practices for assurance of AI-generated code include:

AI Code Provenance Tracking: Maintaining immutable records linking generated code to specific prompts, models, and human reviewers.

Differential Testing Frameworks: Comparing outputs of multiple AI systems for the same functionality to identify potential security issues.

Security-Focused Red Teaming: Dedicated exercises where security professionals attempt to craft prompts that generate vulnerable code, helping identify weaknesses in prompt engineering practices.

6. Crafting Prompts for Secure Vibe Coding

6.1 Identifying Insecure Prompting Patterns

The quality and security of AI-generated code are profoundly influenced by the prompts provided by the user. Building on the AI limitations outlined in Section 4.1, specific prompting patterns significantly increase the likelihood of introducing vulnerabilities because current AI models focus on functional output unless specifically instructed to include security controls. This "pull-only" model means developers must actively specify protections — security won't be embedded by default.

Key insecure prompting patterns include:

Vague or Naive Instructions: Simply asking the AI to "generate code for a specific application" without any explicit security requirements often leads to insecure outputs. The AI's default behavior, unless otherwise nudged, is to prioritize functional completion over security.

Omission of Security Requirements: Failing to explicitly request crucial security measures, such as proper input validation, robust authentication, comprehensive authorization, or secure error handling, means these critical components will likely be absent from the generated code. The AI will focus on the requested functionality and may not proactively implement best practices if they are not part of the explicit directive.

Implicit Trust: A high-risk pattern involves developers who "prompt an LLM, accept the output wholesale, and proceed without validation or threat modeling." This implicit trust in the AI's output, without critical human review, is a primary pathway for vulnerabilities to enter production systems.

Speed-only Focus: Prioritizing rapid code generation without security considerations in prompts introduces numerous vulnerabilities.

Security Reality Check: Prompting without security context is like compiling without error handling, it works until it breaks. Unless you explicitly guide the LLM to consider secure patterns, it will default to functional, not defensive, code. Always assume security is opt-in, not built-in.

6.2 Strategies for Secure Prompt Engineering

To mitigate the "security by omission" problem, developers must adopt strategic prompt engineering techniques:

Explicit Security Directives Always specify security requirements within prompts, including input validation, parameterized queries, and access controls.

Example:
"Create a user authentication system using industry-standard secure practices. Store passwords using Argon2 [14] *hashing, implement multi-factor authentication, and ensure secure session management with token expiration."*

Multi-Stage Prompting Prompt the AI twice: first to implement the feature, then to review its own output for security issues.

Example Sequence:

1.
"Generate a Python Flask API endpoint for user profile updates."

2.
"Review this Flask endpoint for security vulnerabilities. Identify issues with input validation, authentication, and authorization. Suggest production-ready improvements."

Negative Constraints Explicitly prohibit insecure practices: *"Never hardcode secrets," "Avoid unsafe functions like exec or eval," or "Prohibit .env files in the codebase."*

Challenge Testing Proactively test AI responses with problematic inputs: *"How would this code handle a user input of: admin'; DROP TABLE users; --?" or "What happens if a file upload contains a .php executable?"*

Request Security Explanations Ask the AI to identify potential vulnerabilities: *"What security risks exist in this code?" or "How can we improve error handling to prevent information leakage?"*

Secure vs. Insecure Prompting	Feature/Task	Potential Vulnerability	Secure Prompt Example	Security Outcome
	File Upload **Insecure Prompt Example:** *"Build a file upload server."*	No file type validation, filename sanitization, or size limits; allows malicious uploads (RCE, Path Traversal).	*"Build a file upload server using Express and Multer. Ensure rigorous file type validation (only JPEG, PNG, GIF), sanitize filenames to prevent path traversal, and implement a max file size of 5MB. Store files securely."*	Prevents malicious file uploads, path traversal, and ensures controlled storage.
	User Authentication **Insecure Prompt Example:** *"Create a login form for my app."*	Weak password storage (plain text), no MFA, insecure session management.	*"Create a user authentication system for a web app. Store passwords using strong, salted hashes (e.g., Argon2). Implement multi-factor authentication (MFA) and secure session management with token expiration."*	Stronger password security, enhanced user identity verification, and reduced session hijacking risks.
	Database Connection **Insecure Prompt Example:** *"Connect to my PostgreSQL database."*	Hardcoded credentials directly in the code.	*"Connect to a PostgreSQL database using environment variables for credentials (DB_USER, DB_HOST, DB_NAME, DB_PASSWORD, DB_PORT). Use a connection pool."*	Prevents exposure of sensitive database credentials in source code.
	API Endpoint **Insecure Prompt Example:** *"Build an API to download documents."*	No user context, authentication, authorization, or ownership verification.	*"Build an API endpoint to allow authenticated users to download their own uploaded documents. Implement robust authentication and authorization checks to ensure only the document owner can access it."*	Enforces proper access control and prevents unauthorized data access.

Data Processing **Insecure Prompt Example:** *"Process user input for my web form."*	No input sanitization, vulnerable to XSS or SQL injection.	*"Process user input from the web form. Validate all inputs for correct format and sanitize them to prevent SQL injection and Cross-Site Scripting (XSS) attacks. Use parameterized queries for database interactions."*	Mitigates injection attacks and ensures data integrity.
Error Handling **Insecure Prompt Example:** *"Show error messages if something goes wrong."*	Error messages revealing internal system details or stack traces.	*"Implement robust error handling that provides user-friendly messages without exposing sensitive internal details or stack traces. Log detailed errors securely on the server-side only."*	Prevents information leakage that attackers could exploit.

7. Best Practices for Secure Vibe Coding Implementation

7.1 Implementation Workflow

Code Review Process	Treat all AI-generated code as potentially vulnerable	Conduct peer reviews focusing on business logic and edge cases	Refactor verbose AI output for clarity and consistency with project standards
Automated Security Integration	Integrate SAST/DAST tools (SonarQube, Snyk, Veracode) into CI/CD pipelines	Implement dependency scanning with OWASP Dependency-Check [15] or GitHub Dependabot	Deploy secrets detection tools (GitGuardian) to scan codebases and Git history
Security Testing Requirements	Write security-specific unit tests verifying unauthorized access denial	Include input sanitization tests for known attack vectors	Implement DAST methods like fuzz testing for critical endpoints

Security Reality Check	Speed without oversight is just fast failure. AI can generate a thousand lines of code in minutes, but it takes human expertise to determine if those lines should exist in production. The bottleneck isn't code generation—it's security validation.

7.2 Technical Implementation Standards	**Data Handling**	Use environment variables or dedicated secret management tools (AWS Secrets Manager [16], HashiCorp Vault [17])	Implement parameterized queries; utilize ORMs for database interactions	Encrypt sensitive data at rest; use HTTPS for all transmissions
	Access Control Implementation	Deploy robust authentication (OAuth [18], MFA) and RBAC authorization	Configure CORS settings restrictively	Implement CSRF tokens in all forms
7.3 Organizational Implementation	**Governance Structure**	Establish AI Code Ethics Committee for policy and high-risk review	Create AI Security Architect role for prompt libraries and validation protocols	Implement prompt engineering governance with mandatory security requirements
	Compliance and Legal Framework	Document AI tool usage for regulatory compliance (EU AI Act [4], NIST Framework [5]) Create transparency frameworks linking code to specific prompts and reviewers	Establish IP ownership policies for AI-generated code	Implement bias detection processes in generated outputs
	Continuous Monitoring	Deploy runtime monitoring with log analysis (Elastic Stack [19], CloudWatch [20])	Establish feedback loops from monitoring insights to prompt refinement	Conduct regular security audits of AI-generated codebases

7.4 Addressing Ethical and Legal Considerations

The adoption of AI-generated code also brings forth a complex array of ethical and legal considerations that organizations must proactively address.

Bias Mitigation: AI models are trained on historical data, which may inherently contain and perpetuate biases (e.g., gender, racial, cultural). If this biased data is used to train AI code generation systems, the resulting code could also exhibit biases, potentially leading to discrimination or unfair outcomes for certain groups of people. It is crucial to check for harmful data values, ensure data inclusivity in training datasets, and actively evaluate the generated code for biases throughout the development process.

Intellectual Property Rights and Copyright: The legal landscape surrounding the ownership and copyright of AI-generated code is complex and largely unsettled. Traditional copyright law typically requires human authorship, and AI-generated works may not be eligible for copyright protection without clear evidence of substantial human creative input. This ambiguity can lead to unclear intellectual property rights and ownership issues. Furthermore, AI-generated code frequently incorporates or references existing open-source libraries, many of which come with specific licensing requirements. This "license contamination" can inadvertently expose companies to significant legal liabilities if not properly managed. Transparency regarding the AI tools used to generate code is recommended, as it can help clarify potential sources and associated legal implications.

Accountability and Responsibility: As AI systems increasingly operate autonomously in code generation, questions arise regarding accountability for errors, security vulnerabilities, or system failures that may result from AI-generated code. To address this, developers need to be able to trace the logic and decisions that influenced the AI's outputs, ensuring a clear chain of responsibility.

Privacy and Data Protection: AI-based development tools often rely on large datasets for training and operation, raising concerns about privacy and data protection. These datasets must comply with relevant privacy regulations, such as GDPR [21]. Rigorous oversight is necessary to prevent AI systems from inadvertently exposing private information or creating vulnerabilities that could be exploited by malicious actors. Users should exercise caution when submitting content, especially sensitive or proprietary data they did not create, to AI platforms, as terms of service may grant the AI tool rights to reuse or distribute this content.

Environmental Impact: The building, training, and ongoing use of generative AI models require significant energy consumption and water for cooling, contributing to carbon emissions. Organizations should consider the environmental impact of their AI usage and strive for efficient deployment and operation of these tools.

Secure Vibe Coding Best Practices Checklist	**Category**	**Best Practice**	**Description/ Action**	**Key Benefit**
	Prompt Engineering	Explicit Security Directives	Always include specific security requirements (e.g., input validation, auth, OWASP) in prompts.	Nudges AI to generate safer code from the start.
		Multi-Stage Prompting	Prompt AI to generate code, then prompt it again to review its own output for security flaws.	Catches vulnerabilities by forcing AI to self-assess security.
		Negative Constraints	Explicitly forbid insecure practices (e.g., hardcoding secrets, eval()) in prompts.	Establishes non-negotiable security boundaries for AI.

Code Review	Critical Human Review	Assume AI-generated code is insecure; conduct thorough peer reviews for subtle vulnerabilities.	Identifies nuanced issues missed by automated tools; ensures business logic security.
	Refactoring for Clarity	Clean up verbose/ inconsistent AI code; improve variable names; align with project standards.	Enhances correctness, maintainability, and security.
Automated Tools	SAST/DAST Integration	Integrate Static (SAST) and Dynamic (DAST) Application Security Testing into CI/CD pipelines.	Flags common vulnerabilities early; tests runtime behavior.
	Dependency Scanning	Use tools to scan third-party libraries for known vulnerabilities.	Prevents supply chain attacks from insecure dependencies.
	Secrets Detection	Employ tools to scan codebases and Git history for exposed credentials.	Prevents accidental leakage of sensitive information.
Data Handling	Input Validation/ Sanitization	Rigorously validate and sanitize all user inputs to prevent injection attacks (SQL, XSS, Path Traversal).	Protects against common web application vulnerabilities.
	Secure Secrets Management	Use environment variables or dedicated secret management tools; never hardcode credentials.	Prevents catastrophic security breaches if code becomes public.
	Database Security	Protect data with encryption, parameterized queries, and least privilege access; hash and salt sensitive data.	Safeguards sensitive information in the database.

Compliance & Ethics	IP Due Diligence	Understand and manage intellectual property rights and licensing for AI-generated code and its components.	Mitigates legal risks related to ownership and license contamination.
	Bias Mitigation	Actively check for and address biases in training data and AI-generated code.	Ensures fairness and prevents perpetuation of discrimination.
	Transparency & Accountability	Document AI tool usage; ensure traceability of AI outputs; establish clear accountability frameworks.	Promotes responsible AI development and helps address issues.
General Practices	Version Control	Use Git religiously for snapshots and easy reverts; commit frequently.	Prevents data loss; enables fearless experimentation and easier debugging.
	Continuous Monitoring	Implement proactive monitoring and log analysis to detect runtime vulnerabilities and anomalies.	Identifies issues not caught during static analysis; provides real-time alerts.
	Secure API Design	Implement robust authentication (MFA, OAuth) and authorization (RBAC, least privilege) for all APIs.	Controls access to sensitive data and functionality.

8. Conclusion and Recommendations

Vibe coding represents a transformative leap in software creation — blending speed, creativity, and accessibility. Yet, as discussed throughout this guide, it introduces new risks that demand a proactive security-first mindset. AI can amplify innovation, but it cannot substitute sound engineering judgment.

8.1 Key Recommendations for Organizations:

Invest in Training and Upskilling: Prioritize continuous training for developers and security teams. This training should focus on secure prompt engineering, critical code review of AI-generated output, and a deep understanding of underlying AI limitations and potential failure modes.

Establish Robust Security Workflows: Integrate automated security testing tools, including Static Application Security Testing (SAST), Dynamic Application Security Testing (DAST), and Software Composition Analysis (SCA), into all CI/CD pipelines. Complement these automated checks with rigorous, human-led code review processes for all AI-generated code, especially for critical functionalities and edge cases.

Standardize Secure Prompting: Develop and enforce internal guidelines and potentially tools for crafting secure prompts. These guidelines should explicitly include security requirements, constraints, and forbidden behaviors to guide AI models toward generating safer code from the outset. This makes prompt engineering a critical security control point, enabling "security by design" at the earliest stage.

Implement Strong Data and Access Controls: Enforce strict secrets management practices, ensuring sensitive data is never hardcoded. Design and implement secure API endpoints with robust authentication (e.g., MFA) and authorization (e.g., Role-Based Access Control, least privilege) mechanisms.

Address Legal and Ethical Implications: Develop clear internal policies and frameworks for intellectual property ownership, license compliance, bias mitigation, and data privacy specifically related to AI-generated code. Foster transparency about AI tool usage and establish clear accountability for AI-generated outputs.

Adopt a Hybrid Development Model: Strategically leverage vibe coding for rapid prototyping, idea validation, and automation of repetitive tasks. Simultaneously, maintain and invest in traditional coding expertise for developing complex, mission-critical, and legacy systems, ensuring a seamless and secure integration between both approaches.

8.2 Key Recommendations for Developers:

Never Trust, Always Verify: Approach all AI-generated code with a critical mindset, assuming it may contain vulnerabilities. Thoroughly review and test every piece of AI-generated output before integration.

Master Prompt Engineering: Develop strong skills in crafting clear, specific, and security-aware prompts. Understand how to provide sufficient context and explicit security directives to guide the AI effectively.

Maintain Foundational Knowledge: Continuously deepen your understanding of core coding principles, secure coding best practices, and system architecture. This fundamental knowledge is crucial for identifying and rectifying issues that AI might miss or introduce.

Utilize Security Tools: Integrate and effectively use automated security testing tools (SAST, DAST, SCA) in your development workflow. Leverage AI-assisted debugging and code auditing tools where available.

Practice Secure Coding Habits: Apply principles like rigorous input validation, secure secrets management, proper error handling, and robust authentication/authorization consistently, regardless of whether the code was human- or AI-generated.

8.3 Strategies for Addressing the Accessibility-Security Paradox

8.3.1 Tiered Development Framework

Organizations can balance democratized access with security controls through structured tiers:

Implementation Framework:

	Tier 1: Supervised	Tier 2: Guided	Tier 3: Expert
User Profile	Non-technical domain experts	Technical domain experts; Citizen developers	Experienced developers; Security-trained engineers
Permitted Applications	Internal tools; Process automation	Departmental applications; Integration components	Critical systems; Customer-facing applications
Security Controls	Pre-approved prompt templates; Automated scanning; Mandatory expert review	Semi-automated validation; Security-enhanced prompts	Self-certification; Advanced security testing
Oversight	Dedicated security reviewer; Restricted deployment	Security champion pairing; Periodic reviews	Spot checks; Risk-based reviews

8.3.2 Technological Solutions

Security Guardrails:	**AI Security Co-Pilots:** Specialized LLMs trained to analyze code for vulnerabilities, serving as automated security reviewers	**Security-Enhanced Prompt Libraries:** Pre-vetted prompt collections with built-in security controls for non-experts	**Automated Security Verification:** Static and dynamic analysis tools calibrated for AI-generated code patterns
Continuous Validation Pipelines:	**Prompt-to-Production Security Gates:** Automated checkpoints validating code at each stage with risk-appropriate security complexity	**Security Drift Detection:** Monitoring systems identifying when AI code deviates from expected security patterns	**Compliance Verification:** Tools mapping AI-generated code against regulatory requirements and organizational policies

8.3.3 Organizational Implementation	**Upskilling Programs:**	**Prompt Engineering Security Certification:** Training developers on security-focused prompt design and validation	**Security Champion Networks:** Embedding security-trained individuals within development teams for guidance and first-line review	**AI-Security Fusion Roles:** New positions blending AI expertise with security knowledge
	Collaborative Models:	**Security-Developer-AI Triads:** Cross-functional teams where security experts, developers, and AI specialists collaborate	**Expert Advisory Panels:** On-demand security expert access for high-risk applications without creating development bottlenecks	**Communities of Practice:** Organization-wide knowledge sharing focused on secure vibe coding
8.3.4 Progressive Risk Management	**Risk-Based Approach:**	**Graduated Security Requirements:** Tailoring controls based on application risk level—higher-risk applications require more extensive security measures and expert involvement	**Proportional Resource Allocation:** Directing security resources based on project risk, ensuring critical applications receive appropriate attention without overburdening low-risk projects	**Continuous Feedback Integration:** Capturing security lessons learned and feeding them back into prompting practices and security controls

This framework enables organizations to harness vibe coding's democratization benefits while maintaining robust security posture through appropriate controls, training, and technological safeguards.

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