AI Agent Capabilities Periodic Table v1.0

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digital twin CONSORTIUM

Cap ID	Category	Capability Name	Definition	Key Functions	Enabled Outcomes	Illustrative Metrics/Indicators	Relevant Agent Archetypes
PK	**Perception & Knowledge**						
PK.OB		Environmental Sensing	The ability to receive and interpret input from the agent's operational environment across multiple modalities.	- Processing natural language text, voice, and multimodal inputs - Analyzing visual data (images, documents, diagrams) - Ingesting structured/unstructured data streams - Real-time event detection and pattern recognition	Contextually aware responses, environmental state awareness, timely reaction to changes	- Intent recognition accuracy (%) - Supported modalities (text/voice/image/video) - Input processing latency (ms) - Pattern detection precision/recall	All Archetypes (T1-T4)
PK.KB		Knowledge Access	The ability to connect to, retrieve from, and update internal/external knowledge sources with semantic understanding.	- Vector database semantic search and retrieval - SQL/NoSQL database querying - Knowledge graph traversal and reasoning - Real-time information synthesis from multiple sources	Informed decision-making beyond pre-trained knowledge, factual accuracy, domain expertise	- Query response time (ms) - Retrieval relevance score (0-1) - Knowledge source diversity (count) - Update/write capability (Y/N)	All Archetypes
PK.CX		Context & Memory	The ability to comprehend and maintain relevant context across interactions and time with sophisticated memory management.	- Multi-turn conversation context tracking - Long-term episodic memory formation and retrieval - Contextual entity resolution and relationship mapping - Temporal context maintenance across sessions	Coherent long-term interactions, personalized responses, learning from experience	- Context window size (tokens/turns) - Long-term memory retention (days/weeks) - Context relevance accuracy (%) - Cross-session continuity score	T2+ (Critical for workflow and cognitive)
PK.MF		Multi-Modal Fusion	The ability to integrate and reason over information from multiple modalities with cross-modal understanding.	- Combining textual descriptions with visual evidence - Audio-visual-text correlation and reasoning - Cross-modal semantic alignment - Unified multimodal representation	Richer understanding of complex situations, enhanced situational awareness, nuanced insights	- VQA (Visual Question Answering) performance - Cross-modal consistency scores - Multimodal reasoning benchmark results - Supported modality combinations	Advanced Conversational, Workflow, Cognitive
CG	**Cognition & Reasoning**						
CG.PL		Planning & Decomposition	The ability to break down complex goals into executable plans and sub-tasks with strategic foresight.	- Hierarchical task decomposition - Sequential and parallel planning strategies - Resource allocation and constraint satisfaction - Plan adaptation based on feedback	Systematic approach to complex problems, efficient resource utilization, structured execution	- Plan coherence score (0-1) - Task completion rate (%) - Plan adaptation frequency - Sub-goal feasibility assessment	T2+ (Procedural workflow and above)
CG.RS		Reasoning	The ability to apply logical inference and commonsense knowledge to draw sound conclusions.	- Deductive, inductive, and abductive reasoning - Causal relationship understanding - Mathematical and symbolic reasoning - Social and cultural context reasoning	Sound judgments, accurate inferences, human-like understanding	- Logical reasoning benchmark scores - Mathematical problem accuracy (%) - Commonsense reasoning test performance - Consistency across reasoning types	T2+ (Enhanced for T3 cognitive)
CG.DC		Decision Making	The ability to make autonomous decisions and control execution flow under uncertainty.	- Multi-criteria decision analysis - Risk assessment and uncertainty handling - Dynamic control flow management - Exception handling and recovery	Autonomous operation, robust execution, adaptive behavior	- Decision accuracy under uncertainty (%) - Response time to critical decisions (ms) - Exception recovery success rate (%) - Control flow complexity handling	T2+ (Critical for autonomous operation)
CG.PS		Problem Solving	The ability to approach novel problems systematically and develop effective solution strategies.	- Problem space analysis and representation - Solution strategy generation and evaluation - Analogical reasoning and transfer learning - Creative problem-solving approaches	Effective handling of novel challenges, innovative solutions, strategic thinking	- Novel problem solving success rate (%) - Strategy effectiveness metrics - Transfer learning performance - Creative solution quality scores	T3+ (Cognitive and MAGS)
CG.PP		Formal Planning	The ability to use formal planning languages like PDDL for domain modeling, problem specification, and automated plan generation.	- PDDL or STRIPS domain and problem definition - Automated planning algorithm integration - Hierarchical task network (HTN) planning - Plan validation and verification	Formal planning capabilities, automated task decomposition, verifiable plan generation	- PDDL problem complexity handling - Plan generation time vs. problem size - Plan optimality scores - Plan validation success rate	T3+ (Advanced Planning), L4 (Complex MAGS)
CG.PA		Plan Adaptation	The ability to adapt, version, and evolve plans based on changing conditions and feedback.	- Dynamic plan modification and adaptation - Plan versioning and rollback capabilities - Change impact analysis and propagation - Plan evolution tracking and management	Adaptive planning, resilient execution, plan evolution management	- Plan adaptation success rate - Adaptation response time to changes - Plan version management effectiveness - Change impact prediction accuracy	T3+ (Adaptive Agents), T4 (Dynamic MAGS)
LA	**Learning & Adaptation**						
LA.MM		Memory Management	The ability to store, organize, and retrieve different types of memory with sophisticated recall mechanisms.	- Short-term working memory management - Long-term episodic memory formation - Semantic knowledge structuring - Memory importance scoring and retrieval	Experience-based improvement, personalization, consistent behavior	- Memory capacity (items/duration) - Retrieval accuracy by recency/importance - Memory persistence across sessions - Supported memory types (episodic/semantic/procedural)	T1+ (Basic), T3+ (Advanced episodic)
LA.RL		Reinforcement Learning	The ability to learn optimal behaviors through environmental feedback and reward signals.	- Trial-and-error exploration strategies - Reward signal processing and policy updates - Human feedback integration (RLHF) - Multi-agent collaborative learning	Performance optimization, autonomous strategy discovery, alignment with preferences	- Learning curve improvement rate - Sample efficiency (trials to proficiency) - Transfer learning capability - Feedback integration effectiveness	T3+ (Cognitive autonomous agents)
LA.AD		Self-Optimization	The ability to modify behavior and strategies based on experience and changing conditions.	- Performance self-assessment and reflection - Strategy modification based on outcomes - Meta-learning and learning-to-learn - Dynamic goal and priority adjustment	Continuous improvement, robustness to change, meta-cognitive awareness	- Performance improvement over time (%) - Adaptation speed to new conditions - Self-correction frequency and effectiveness - Meta-learning transfer success rate	T3+ (Advanced cognitive capabilities)
LA.SL		Supervised Learning	The ability to learn from demonstrations, examples, and explicit instruction.	- Few-shot and one-shot learning from examples - Skill transfer and generalization - Human demonstration learning - Knowledge distillation and integration	Rapid skill acquisition, customization, domain adaptation	- Learning efficiency (examples needed) - Skill generalization accuracy (%) - Transfer learning success rate - Retention over time	All Archetypes (Enhanced T3+)
LA.VM		Vector Memory	The ability to manage vector-based memory representations for semantic similarity, clustering, and retrieval operations.	- Vector embedding generation and management - Semantic similarity search and clustering - Multi-provider vector database support - Vector memory optimization and indexing	Semantic memory retrieval, intelligent content association, efficient knowledge discovery	- Vector similarity search accuracy (%) - Memory retrieval latency (ms) - Supported vector dimensions and similarity metrics - Vector index optimization effectiveness	T3+ (Cognitive with Advanced Memory)
LA.MS		Memory Scoring	The ability to assess and score memory significance based on importance, surprise, relevance, and trust factors.	- Importance scoring based on relevance and frequency - Surprise detection for novel information - Trust factor evaluation and weighting - Memory consolidation based on significance scores	Intelligent memory prioritization, efficient knowledge retention, adaptive learning focus	- Memory retention accuracy by significance score - Surprise detection precision/recall - Trust factor correlation with outcomes - Memory consolidation effectiveness	T3+ (Advanced Cognitive Agents)
AE	**Action & Execution**						
AE.TX		Task Execution & Implemer	The ability to carry out planned actions and complete assigned tasks reliably.	- Instruction following and procedure execution - Quality control and validation - Progress tracking and status reporting - Error detection and correction	Reliable task completion, consistent quality, goal achievement	- Task completion rate (%) - Output quality scores - Execution time efficiency - Error detection and correction rate	All Archetypes (T1-T4)
AE.TL		Tool Usage & API Integratic	The ability to utilize external tools, services, and APIs to extend capabilities dynamically.	- Dynamic tool selection based on task needs - API authentication and secure access - Tool output interpretation and integration - Tool chaining and workflow orchestration	Extended functionality, access to specialized capabilities, system integration	- Number of supported tools/APIs - Tool selection accuracy (%) - API call success rate (%) - Tool chain execution reliability	T2+ (Critical for workflow agents)
AE.CG		Code Generation & Executi	The ability to write, execute, and debug programming code across multiple languages.	- Multi-language code generation - Secure code execution in sandboxed environments - Automated testing and validation - Code refactoring and optimization	Dynamic functionality creation, automation of complex tasks, rapid prototyping	- Code correctness rate (%) - Supported programming languages - Execution security (vulnerability scan results) - Code efficiency metrics	T2+ (Workflow and cognitive agents)
AE.CX		Content Creation & Genera	The ability to create novel content across various formats and modalities.	- Text generation (documents, reports, creative writing) - Image and visual content creation - Audio and multimedia generation - Structured data and format conversion	Creative output, documentation automation, multimodal communication	- Content quality ratings (human evaluation) - Format diversity supported - Generation speed (tokens/images per second) - Consistency and coherence metrics	T1+ (Enhanced for T3+ cognitive)
AE.TM		Tool Lifecycle Management	The ability to manage tool lifecycles, including discovery, initialization, execution, monitoring, and cleanup.	- Dynamic tool discovery and registration - Tool initialization and configuration management - Execution monitoring and performance tracking - Resource cleanup and lifecycle termination	Efficient tool utilization, resource optimization, reliable tool operations	- Tool discovery and registration success rate - Tool lifecycle management efficiency - Resource cleanup effectiveness - Tool performance monitoring coverage	T2+ (Tool-Using Agents), T4 (Complex Tool Ecosystem
AE.MC		MCP Integration	The ability to integrate with Model Context Protocol servers for extended tool and resource capabilities.	- MCP server discovery and configuration - Protocol-compliant communication and parameter validation - Extended context and capability integration - MCP session management and error handling	Extended agent capabilities, standardized tool integration, enhanced context awareness	- MCP server integration success rate - Protocol compliance validation - Extended capability utilization - Session reliability and error recovery	T3+ (Advanced Tool Integration), T4 (Enterprise MAGS)
IC	**Interaction & Collaboration**						
IC.NL		Natural Language	The ability to understand and generate natural language for effective human communication.	- Multi-language understanding and generation - Conversational context management - Intent recognition and response generation - Tone and style adaptation	Intuitive human-agent communication, accessible interfaces, natural interaction	- Language support coverage - Conversation satisfaction scores - Intent recognition accuracy (%) - Response appropriateness ratings	All Archetypes (T1-T4)
IC.DM		Dialogue Management	The ability to maintain coherent multi-turn conversations and manage dialogue flow.	- Turn-taking and conversation state tracking - Topic management and transition handling - Clarification requests and disambiguation - Conversation repair and recovery	Natural conversational experiences, effective information exchange	- Average conversation length (turns) - Conversation coherence scores - Topic transition smoothness - User engagement metrics	T1+ (Critical for conversational agents)
IC.HL		Human-in-Loop	The ability to seamlessly incorporate human oversight and intervention.	- Human approval checkpoints - Escalation and handoff mechanisms - Feedback incorporation workflows - Transparent decision boundaries	Enhanced safety, quality assurance, human-AI collaboration	- Human intervention ease score - Escalation accuracy (%) - Feedback integration effectiveness - Decision transparency ratings	All Archetypes (Critical tasks)
IC.AC		Agent Communication	The ability to communicate and coordinate with other AI agents using standardized protocols.	- Standardized communication protocols (A2A, ACP, MCP) - Message formatting and parsing - Coordination and synchronization - Conflict resolution and negotiation	Multi-agent collaboration, distributed problem solving, system scalability	- Supported communication protocols - Message delivery reliability (%) - Coordination efficiency metrics - Conflict resolution success rate	T2+ (Multi-agent systems)
IC.CL		Collaboration	The ability to work jointly with humans and agents toward common goals.	- Role-based task distribution - Progress synchronization and status sharing - Collaborative decision making - Knowledge and resource sharing	Collective intelligence, enhanced problem-solving capability, team efficiency	- Collaborative task success rate (%) - Team coordination efficiency - Knowledge sharing effectiveness - Role specialization benefits	T2+ (Workflow agents), T4 (MAGS)
IC.RB		Role Behavior	The ability to adopt specific roles, personas, and specialized behavioral patterns.	- Role profile implementation and consistency - Specialized domain knowledge application - Behavioral adaptation to role requirements - Multi-role capability switching	Specialized expertise, predictable behavior, team effectiveness	- Role consistency score (0-1) - Specialization effectiveness metrics - Role switching accuracy - Team contribution quality	T2+ (Workflow and cognitive)
IC.CS		Consensus Protocols	The ability to manage formal consensus protocols, detect conflicts, and coordinate group decision-making processes.	- Multi-round consensus protocols with timeout handling - Conflict detection across resource allocation and task dependencies - Byzantine fault tolerance in distributed decision-making - Consensus state tracking and recovery mechanisms	Coordinated multi-agent decisions, conflict-free resource allocation, robust distributed agreement	- Consensus convergence time (seconds) - Conflict detection accuracy (%) - Byzantine fault tolerance threshold - Consensus success rate under network partitions (%)	T4 (MAGS), Industrial Multi-Agent Systems
IC.CF		Conflict Resolution	The ability to detect, analyze, and resolve conflicts between agents in resource allocation, task dependencies, and decision-making.	- Resource contention detection and analysis - Task dependency conflict identification - Automated conflict resolution strategies - Escalation mechanisms for unresolvable conflicts	Smooth multi-agent coordination, efficient resource utilization, reduced system deadlocks	- Conflict detection latency (ms) - Automated resolution success rate (%) - Escalation frequency (conflicts/hour) - System deadlock prevention effectiveness	T4 (MAGS), Complex Multi-Agent Workflows
IC.SI		Industrial Integration	The ability to integrate with industrial IoT devices, SCADA systems, PLCs, and operational technology infrastructure.	- Native MQTT broker integration for industrial messaging - SCADA system connectivity and data exchange - PLC communication protocols (Modbus, OPC-UA, etc.) - Industrial network protocol support (Ethernet/IP, PROFINET)	Real-time industrial data access, operational technology integration, industrial process monitoring	- Supported industrial protocols (count) - Real-time data latency (ms) - Industrial device connectivity success rate (%) - Protocol conversion accuracy	T4 (Industrial MAGS), Manufacturing Systems
IC.ES		Enterprise Integration	The ability to integrate with enterprise APIs, protocols, and middleware systems for seamless business process integration.	- RESTful and GraphQL API integration - Enterprise service bus (ESB) connectivity - Message queue integration (RabbitMQ, ActiveMQ) - Enterprise protocol support (SOAP, EDI, AS2)	Business process automation, enterprise system integration, workflow orchestration	- Enterprise API coverage (systems integrated) - API call reliability and performance - Protocol conversion accuracy - Business process integration success rate	T3+ (Enterprise Systems), T4 (Enterprise MAGS)
IC.MB		Message Brokers	The ability to integrate with enterprise messaging infrastructure for reliable, scalable agent communication and system integration.	- MQTT integration for IoT/industrial messaging - Apache Kafka for high-throughput event streaming - RabbitMQ for enterprise message queuing - Cloud messaging services (Azure Service Bus, AWS SQS/SNS) - Event-driven architecture implementation	Real-time industrial communication, reliable message delivery, enterprise system integration, scalable pub/sub patterns	- Supported messaging protocols (MQTT, Kafka, RabbitMQ, etc.) - Message delivery reliability (%) - Throughput capacity (messages/second) - Integration with industrial systems (SCADA, PLCs) - Event processing latency (ms)	T2+ (Critical for Industrial MAGS), T4
IC.DS		Distributed Coordination	The ability to implement comprehensive telemetry, distributed tracing, and observability across multi-agent systems with lifecycle management.	- OpenTelemetry integration and trace collection - Distributed metrics aggregation and analysis - Cross-agent correlation and dependency mapping - Agent startup, state transitions, and graceful shutdown - Resource allocation and cleanup automation	System-wide visibility, performance optimization, reliable system operations, efficient resource utilization	- Telemetry data coverage (% of system components) - Trace completeness and accuracy - Agent initialization success rate - Resource cleanup effectiveness - Distributed performance correlation accuracy	T4 (Production MAGS), Enterprise Multi-Agent Systems
GS	**Governance & Safety**						
GS.DL		Deployment Management	The ability to deploy, update, and manage agent systems throughout their operational lifecycle.	- Automated deployment and provisioning - Version control and rollback capabilities - Configuration management - Retirement and decommissioning	Reliable deployments, change management, system evolution	- Deployment success rate (%) - Rollback time (minutes) - Configuration drift detection - Lifecycle stage transition efficiency	All Production Deployments (T1-T4)
GS.MO		Monitoring	The ability to monitor agent performance, behavior, and system health comprehensively.	- Real-time performance metrics collection - Behavioral anomaly detection - System health monitoring - Alert generation and escalation	Operational visibility, proactive issue detection, performance optimization	- Monitoring coverage (% system components) - Alert accuracy (true positive rate) - Mean Time to Detection (MTTD) - Dashboard usability scores	All Production Deployments (T1-T4)
GS.EV		Evaluation	The ability to evaluate agent capabilities and measure performance against defined objectives.	- Automated capability testing - Performance benchmarking - Quality assessment metrics - Comparative analysis tools	Objective capability verification, performance optimization, vendor comparison	- Benchmark coverage (% capabilities) - Assessment automation level (%) - Evaluation consistency (inter-rater reliability) - Performance trend accuracy	All Types (Critical for anti-agent washing)
GS.SC		Scaling	The ability to scale agent operations and manage computational resources efficiently.	- Dynamic scaling based on demand - Resource allocation optimization - Load balancing and distribution - Cost optimization strategies	Efficient resource utilization, cost management, performance scalability	- Scaling response time (seconds) - Resource utilization efficiency (%) - Cost per task/interaction - Performance under varying loads	T2+ (Production systems)
GS.SF		Safety	The ability to operate safely without causing harm to humans, systems, or processes.	- Risk assessment and mitigation - Safety constraint enforcement - Hazard detection and prevention - Emergency stop and recovery	Safe operation, harm prevention, regulatory compliance	- Safety incident rate (incidents/time) - Risk assessment accuracy - Constraint violation frequency - Emergency response time	All Types (Critical T3-T4 autonomous)
GS.SE		Security	The ability to protect against unauthorized access and maintain comprehensive data security.	- Authentication and authorization - Data encryption and secure communication - Threat detection and response - Security audit and compliance	Data protection, system integrity, compliance assurance	- Security vulnerability count - Authentication success rate (%) - Data breach incidents (target: 0) - Compliance audit results	All Archetypes (T1-T4)
GS.EX		Explainability	The ability to provide understandable explanations for decisions and actions.	- Decision rationale generation - Causal chain explanation - Confidence level reporting - Interpretable model outputs	User trust, accountability, debugging capability	- Explanation completeness scores - User understanding ratings - Decision traceability (%) - Explanation consistency	T2+ (Critical for autonomous decisions)
GS.RL		Reliability	The ability to perform consistently under various conditions and recover from failures.	- Fault tolerance and graceful degradation - Error detection and recovery - Performance consistency maintenance - Stress testing and validation	Dependable operation, consistent performance, business continuity	- System uptime (%) - Mean Time Between Failures (MTBF) - Recovery time from failures (MTTR) - Performance variance under load	All Production Systems (T1-T4)
GS.ET		Ethics	The ability to operate ethically and fairly across diverse populations and contexts.	- Bias detection and correction - Ethical decision framework implementation - Fairness metric monitoring - Cultural sensitivity adaptation	Fair and ethical treatment, regulatory compliance, social responsibility	- Bias detection accuracy (%) - Fairness metrics across demographics - Ethical compliance scores - Cultural adaptation effectiveness	All Archetypes (Enhanced T3+)
GS.PR		Privacy	The ability to protect user privacy and handle sensitive data appropriately.	- Personal data identification and protection - Privacy-preserving computation - Consent management and enforcement - Data minimization and anonymization	Privacy compliance, user trust, regulatory adherence	- Privacy breach incidents (target: 0) - Consent management effectiveness - Data minimization success rate (%) - Anonymization quality scores	All Archetypes (T1-T4)
GS.TC		Trust Management	The ability to assess and manage trust levels and confidence scores for decisions, memories, and agent interactions.	- Multi-factor trust assessment (reasoning, evidence, consistency, stability) - Confidence score calculation and propagation - Trust relationship modeling between agents - Confidence-based decision weighting	Reliable decision-making, trustworthy agent interactions, risk-aware operations	- Trust assessment accuracy vs. outcomes - Confidence score correlation with success rates - Trust propagation effectiveness in multi-agent systems - Decision reliability improvement with confidence weighting	T3+ (Autonomous Decision-Making), T4 (Trust-Critical