eLANGUAGE

Integrated Master Specification and Annexes A-M

NE-IL CORE Controlled human-readable form	PICTO-2 Visual semantic form	WAVE-2 + eL-IR 3.0 Transport + machine semantics

Version 3.0

Cross-cutting human-machine semantic communication • NE-IL Core • PICTO-2 • WAVE-2 • eL-IR 3.0 • 100-phrase educational system

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Document status
This document is a public research specification and Zenodo preprint. It defines a controlled experimental semantic communication framework designed for interoperability research, education, prototyping, assistive-communication studies, AI integration, robotics, software agents, and future human-machine interfaces. It is not a certified emergency language, clinical AAC system, safety protocol, or proof of universal comprehension. Any safety-critical, clinical, regulatory, or autonomous deployment requires domain-specific independent validation and governance.

Zenodo preprint / normative research specification

Document control

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Abstract

eLanguage v3.0 defines a common, cross-cutting semantic communication architecture intended to preserve one declared meaning across human-readable, visual, machine-readable, and transport representations. Its target interaction domains are human-to-human, human-to-machine/AI, machine/AI-to-human, and machine-to-machine communication. The architecture retains the compact NE-IL controlled-language surface, PICTO-2 visual semantic tokens, and WAVE-2 multichannel framing, while introducing eL-IR 3.0 as a canonical machine-readable semantic interchange record, explicit natural-language adapter boundaries, AI confidence and abstention rules, provenance and integrity controls, and extension profiles for emerging computational and interface technologies. The design goal is learnability and implementation simplicity without sacrificing deterministic parsing, explicit scope, versioned semantics, error detection, accessibility, or future extensibility. The integrated release preserves the complete 100-phrase educational inventory, communication boards, study cards, seven-day course, dictionary, exercises, and machine token registry. Deterministic validation covers 100/100 inventory and encoding uniqueness, CRC reproduction, semantic round trips, SHA3-256 message-record uniqueness, mutation tests, Unicode NFC behavior, and reproducible synthetic channel-noise experiments. These results establish specification-level and deterministic conformance only. Cross-cultural comprehension, comparative learnability,

clinical accessibility outcomes, and safety-critical operational performance remain empirical questions requiring independent human studies and implementations.

Keywords: human-machine communication; semantic interoperability; controlled language; artificial intelligence; machine-readable semantics; visual communication; multimodal transport; accessibility; deterministic parsing; provenance; future interfaces

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1. Purpose, scope, claim boundaries, and architectural principles

1.4 Human-machine semantic interoperability

The defining v3.0 objective is a shared semantic layer rather than a replacement language. A person may author or receive a NE-IL or PICTO form, while software or AI operates on the corresponding eL-IR record. A machine may also create an eL-IR message for deterministic rendering to a human form. Conformance therefore depends on semantic equivalence across representation boundaries, not on requiring every participant to use the same surface notation.

Direction	Normative interpretation
Human → Human	A human-authored canonical frame may be rendered in NE-IL, PICTO, or an approved localized teaching form and reconstructed without semantic-role loss.
Human → Machine / AI	A human-readable or visual input is parsed to eSF/eL-IR; uncertainty or ambiguity is explicit.
Machine / AI → Human	Machine output is represented first as an eSF/eL-IR record and then rendered to NE-IL, PICTO, speech, display, haptic, or other human-facing form.
Machine / AI → Machine / AI	Systems exchange eL-IR or a conformant binary binding; natural-language generation is optional and non-authoritative.

1.5 English glosses and language independence

English phrases in the educational inventory are reference glosses used to teach and verify the canonical frames. They do not define the ontology. A Spanish, Arabic, Mandarin, Hindi, French, sign-language, or other adapter may map to the same semantic frame if it declares its locale, mapping version, ambiguity status, and any semantic information that cannot be represented losslessly. Locale tags SHOULD use BCP 47 where a language tag is needed.

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6. eLanguage semantic model and eL-IR 3.0

The eLanguage Semantic Frame (eSF) is the normative semantic object in v3.0. It separates meaning from surface grammar, visual symbols, machine serialization, and transport. The frame is intentionally compact enough for constrained implementations while carrying the fields necessary to prevent silent changes in scope, polarity, temporal reference, argument roles, urgency, and literal content.

6.1 Core semantic tuple

```
eSF = {intent, illocution, actor/reference, time, polarity, predicate/state, arguments[], relations[],
quantity, modality, urgency, confidence, literals[], provenance, extensions[]}
```

A field MAY be absent only when the grammar and selected profile define that absence as semantically complete. Safety-relevant profiles prohibit inference of omitted actor, polarity, predicate, object/target, recipient, or urgency fields. An implementation MUST distinguish absent, unknown, not_applicable, ambiguous, and intentionally_unspecified states when those distinctions affect interpretation.

Field	Purpose	Example / rule
intent	Stable message-purpose class.	assert, ask, answer, request, command, alert
illocution	Speech-act or machine-act force.	declarative, interrogative, imperative, acknowledgement
actor/reference	Entity performing or anchoring the predicate.	mi, tu, person, machine-agent literal
time	Declared temporal relation.	past, now, future, today, timestamp extension
polarity	Affirmation or negation.	positive by profile default; NOT explicit when negative
predicate/state	Action, relation, copula, or state.	NEED, GO, BE, SAFE:STATE
arguments / relations	Objects, recipients, places, instruments, sources, targets.	object + TO recipient; FROM place; AT location
quantity	Count, amount, set, comparison.	TWO, MANY, MORE, SAME
modality	Optional certainty/possibility/obligation layer.	extension field; never inferred from confidence
urgency	Operational presentation/reliability priority.	normal, urgent, critical
confidence	Confidence in an adapter mapping, not truth of the world.	exact, high, medium, low, ambiguous
literals	Unicode strings or typed values.	names, identifiers, numbers; NFC normalized
provenance	Origin, adapter/model/software version, source record.	required for AI or transformed messages
extensions	Versioned profile data.	unknown critical extensions cause rejection

6.2 eL-IR 3.0 canonical record

eL-IR is the canonical machine-readable interchange representation of an eSF. JSON is the reference serialization because of implementation availability and readability; a CBOR binding MAY be used for constrained or low-bandwidth systems. The semantic data model is independent of either serialization. eL-CANON-1 restricts normative JSON values to Unicode NFC strings, integers, booleans, null, arrays, and objects; decimal or high-precision numerical values are encoded as typed strings with an explicit datatype. This restriction avoids implementation-dependent binary floating-point serialization.

```
{
  "domain": "ELANGUAGE-MESSAGE-v3.0",
  "schema_version": "eLanguage-3.0",
  "message_id": 33,
  "semantic_frame": {
    "actor": "MI", "time": "NOW", "predicate": "NEED",
    "object": "HELP:OBJ", "polarity": "positive", "urgency": "critical"
  },
  "neil": "mi now need help-thing.",
  "picto_tokens": ["MI","NOW","NEED","HELP:OBJ"],
  "wave_token_ids": ["1003","2002","3014","400A"],
  "policy": {"normalization":"NFC","registry":"eLanguage-core-3.0"}
}
```

6.3 Canonicalization and record digest

Normative records use Unicode NFC preprocessing and deterministic key ordering. The v3 reference profile is compatible with the intent of RFC 8785 for deterministic JSON while narrowing the numeric domain as described above. A domain-separated integrity digest is calculated over the canonical UTF-8 record bytes:

```
d_message = SHA3-256("ELANGUAGE-MESSAGE-v3.0" || 0x00 || canonical_record_bytes)
```

Digest equality establishes equality of the canonical record bytes under the declared profile. It does not prove that a natural-language translation is correct, that a human understands the message, that a sensor is truthful, or that two real-world referents are identical.

6.4 Semantic equivalence and loss accounting

Adapters MUST report one of four mapping classes: exact, equivalent_with_declared_context, lossy, or not_evaluable. A lossy mapping MUST identify the dropped or generalized fields. A receiving implementation MUST NOT upgrade a lossy mapping to exact without additional evidence. This rule is central to multilingual and AI-mediated use, where apparent fluency can otherwise hide semantic loss.

7. Human-human, human-machine, and machine-machine interaction profiles

eLanguage defines one semantic core and multiple interaction profiles. Profiles constrain permissible inputs, outputs, latency, confirmation behavior, provenance, and error handling without creating independent semantic languages.

Profile	Primary participants	Minimum obligations
EL-HH	Human ↔ human	Readable NE-IL/PICTO; explicit ambiguity; no machine IDs required in normal presentation; semantic round trip retained.
EL-HM	Human → machine/AI	Parser exposes mapping confidence and unresolved roles; source form retained; no silent critical-role inference.

Profile	Primary participants	Minimum obligations
EL-MH	Machine/AI → human	Canonical eL-IR record precedes rendering; output identifies machine origin when material; critical outputs support confirmation.
EL-MM	Machine ↔️ machine	eL-IR or binary binding; exact schema/version negotiation; reject unknown required semantics; deterministic acknowledgments.
EL-ASSIST	Assistive/AAC interaction	Redundant visual/text representation, accessible navigation, profile-specific motor/auditory/haptic settings, and human validation.
EL-ROBOT	Robot/embodied system	Action messages separate instruction, target, constraints, timing, confidence, and safety state; actuation policy remains external.

7.1 Confirmation and conversational state

Conversation state is metadata, not hidden context. A response MAY reference a prior message by digest or message ID, but a standalone safety-critical instruction MUST remain interpretable under its declared profile. Ellipsis, pronoun resolution, and deictic words such as this or that require an explicit referent binding when a machine would otherwise have multiple plausible targets.

7.2 Identity and agent classes

The token registry distinguishes human references from machine-agent identifiers only when the difference is semantically relevant. Machine agents SHOULD use typed literals or extension namespaces rather than overloading PERSON. An adapter MAY render an artificial agent as a proper name for a human audience while retaining the typed machine-agent reference in eL-IR.

7.3 Temporal and spatial grounding

The educational core uses past, now, future, and today. Operational profiles MAY add ISO 8601 timestamps, durations, coordinate/location objects, or external references. Such extensions MUST preserve the educational semantics rather than redefining existing tokens. Local display conventions are adapter concerns.

8. AI interoperability and semantic mediation

AI systems are treated as semantic adapters or agents, not as authorities that may silently rewrite canonical intent. A language model may help interpret unrestricted natural language, generate natural-language explanations, select likely vocabulary, or map between external schemas, but the canonical eLanguage message remains a versioned structured record with explicit uncertainty and provenance.

8.1 AI adapter contract

Requirement	Normative rule
Input preservation	The original user/machine input or a content digest SHOULD be retained with locale and acquisition context.
Structured output	The adapter produces eSF/eL-IR fields, not only prose.
Confidence	Confidence refers to mapping adequacy and ambiguity, not factual truth unless a separate evidence model exists.
Abstention	If two or more materially different frames remain plausible, the adapter returns ambiguous/not_evaluable and SHOULD request clarification when interaction

Requirement	Normative rule
	permits.
Critical-role rule	Actor, polarity, predicate, target/object, recipient, quantity, and urgency MUST NOT be fabricated in safety-relevant messages.
Model provenance	Model/service identifier, version or release, prompt/policy profile, toolchain, and transformation timestamp SHOULD be recorded where feasible.
Deterministic post-validation	Machine-generated records MUST pass schema, token, role, registry, and transport checks after probabilistic generation.
Human authority	When a human decision is required by the deployment domain, eLanguage does not transfer that authority to the AI adapter.

8.2 Generative AI and ambiguity control

Generative models are useful at the boundary between unrestricted human expression and controlled semantics, but they introduce nondeterminism. The recommended architecture is probabilistic interpretation followed by deterministic validation: source input → candidate frames → semantic constraints → confidence/abstention → canonical eL-IR → optional human confirmation → transport or execution. An AI output that fails a deterministic check is rejected even if its prose appears plausible.

8.3 Prompt injection, tool use, and autonomous agents

When eLanguage is used by an agent with tools, canonical message content and tool-execution policy MUST remain separate. Tool permissions, identity, authentication, authorization, rate limits, and safety interlocks are external controls. Untrusted content carried in a literal field MUST NOT be interpreted as a protocol instruction. This separation reduces semantic prompt-injection risk but does not eliminate model-level or application-level attack paths.

8.4 Training and evaluation use

The 100-phrase pack MAY be used as a seed dataset for parsers, constrained decoders, educational systems, or AI evaluation, subject to the CC BY-NC 4.0 terms. Training performance is not a conformance claim. Evaluation sets SHOULD include paraphrases, multilingual inputs, incomplete messages, contradictory context, negation, adversarial token order, and out-of-vocabulary entities.

9. Natural-language and multilingual adapter architecture

Natural languages are adapter domains. The canonical semantic frame is independent of English word order, morphology, grammatical gender, article systems, honorifics, evidentiality, or pro-drop conventions. A language adapter therefore maps meaning rather than performing word-for-word substitution.

9.1 Adapter manifest

Field	Requirement
adapter_id / version	Persistent identifier; incompatible semantic mapping changes require a major version.
source_language	BCP 47 language tag or declared sign/communication-system identifier.
direction	natural_language_to_eLanguage, eLanguage_to_natural_language, or bidirectional.

Field	Requirement
supported_roles	Exact eSF roles and extension fields handled.
loss_policy	Rules for gender, number, definiteness, evidentiality, honorifics, aspect, classifier systems, and other source distinctions not represented in the core.
ambiguity_policy	Candidate frames, confidence, clarification behavior, and abstention thresholds.
test_set	Frozen examples, held-out examples, dialect/register coverage, and provenance.
human_validation	Population, native-language review method, accessibility needs, and limitations.

9.2 Bidirectionality and round-trip tests

Natural-language round trips are not required to reproduce the same surface sentence; they are required to preserve the same canonical semantic frame when the adapter claims exact or equivalent_with_declared_context mapping. Surface paraphrase is acceptable. A changed actor, polarity, temporal relation, quantity, recipient, or comparison is a semantic failure even if the output remains grammatically fluent.

9.3 Cultural and accessibility constraints

A universal semantic core does not imply universal symbolism or culture-neutral interpretation. Visual metaphors, body references, social roles, taboo concepts, directionality, color conventions, and literacy assumptions require empirical evaluation with target communities. Multilingual AAC research has documented the importance of linguistic and cultural factors; eLanguage therefore treats localization and accessibility as validation profiles rather than assuming that English-derived materials transfer unchanged.

9.4 Sign language and nonspoken adapters

Sign languages are natural languages with their own grammar and spatial/discourse structures and MUST NOT be treated as word-for-word manual encodings of NE-IL. A conformant sign-language adapter maps between eSF and a validated sign-language representation or human interpreter workflow. The present v3.0 document does not define such a grammar.

10. Semantic ontology, knowledge-graph, and data interoperability

eLanguage may coexist with RDF, JSON-LD, OWL, provenance graphs, API schemas, digital twins, and domain ontologies. These systems are richer than the compact educational core and are not replaced. eLanguage supplies a message-level semantic interface that may carry references to external identifiers and map selected roles to external vocabularies.

10.1 URI/IRI and vocabulary mapping

External concepts SHOULD be referenced by stable identifiers rather than copied into the core registry when they are domain-specific. A mapping record identifies the eLanguage token or role, external IRI or schema path, mapping relation, version, and confidence. Unknown external identifiers remain opaque typed references unless a trusted mapping is available.

eLanguage element	Possible external mapping	Constraint
actor/reference	RDF/JSON-LD node or application identifier	Mapping does not prove real-world identity.

eLanguage element	Possible external mapping	Constraint
predicate/relation	RDF property / API operation / ontology relation	Direction and argument roles remain explicit.
literal	Typed RDF literal / JSON value / external data object	Datatype, language tag, unit, and normalization policy declared.
provenance	W3C PROV Entity/Activity/Agent structures	Provenance is evidence of origin/history, not truth.
semantic frame	JSON-LD document or application object	External expansion/compaction must not silently alter eLanguage semantics.

10.2 Linked-data profile

JSON-LD is an optional interoperability binding because it can serialize Linked Data in JSON-based systems. A JSON-LD context MAY map eLanguage fields to external IRIs; the normative eLanguage canonical record remains the compact eL-IR object unless a future major version declares otherwise. RDF 1.2 is tracked as an emerging W3C specification but is not a normative dependency of v3.0 while it remains outside a final Recommendation state.

10.3 Ontology extension rule

Domain ontologies MAY add specialized classes and relations through extension namespaces. A core implementation that does not understand a noncritical extension may preserve it opaquely; an unknown critical extension causes rejection or not_evaluable. Extension reuse is preferred over adding core tokens for every scientific or industrial domain.

11. Accessibility, AAC, multimodality, and human factors

Accessibility is a first-class design requirement but not a certification claim. eLanguage combines shape, readable label, stable token identifier, controlled ordering, and optional speech/haptic transport so that information is not dependent on one sensory channel. Human-centred design and AAC evidence indicate that symbol systems and instructional strategies must be evaluated with users rather than assumed to be universally intuitive.

11.1 Human-centred design requirements

Dimension	v3.0 requirement
Perception	Do not rely on color alone; preserve text/shape redundancy; support contrast and scalable presentation.
Cognition	Consistent ordering, limited symbol families, explicit states, predictable interaction, and progressive instruction.
Motor access	Large targets, scanning order, switch-compatible layouts, keyboard navigation, and configurable dwell/timing where implemented.
Auditory access	Visual transcript, adjustable rate, replay, non-auditory error status, and optional speech output.
Haptic access	Explicit pulse grammar, start/end markers, configurable timing, and low-rate expectations; empirical tactile testing required.
Language/literacy	Reference gloss is separable from canonical semantics; localized instruction and plain-language explanations SHOULD be available.

Dimension	v3.0 requirement
AI mediation	AI assistance does not replace accessible direct controls or clear deterministic status indicators.

11.2 AAC relationship

eLanguage may support AAC research or products but is not itself a clinically validated AAC intervention. PICTO-2 boards SHOULD be considered one representational option among many. Existing AAC evidence supports the value of aided communication and augmented input in some populations, while symbol choice, teaching strategy, language, culture, partner behavior, and individual needs remain important. Clinical claims require population-specific studies and professional oversight.

11.3 Accessibility conformance profiles

Level	Evidence required
EL-A0 Structure	Readable labels, ASCII fallback, keyboard-order definition, no color-only semantics, printable materials.
EL-A1 Technical accessibility	Automated and manual checks for document/application semantics, target size, contrast, navigation, and alternative modalities.
EL-A2 User evaluation	Representative users complete defined tasks; errors, time, comprehension, workload, preference, and assistance recorded.
EL-A3 Population evidence	Replicated evaluation across target user groups, languages, environments, and assistive technologies.
EL-A4 Safety/clinical use	Independent domain validation, ethics/regulatory requirements, incident monitoring, and approved fallback communication.

12. Security, integrity, provenance, privacy, and misuse resistance

eLanguage separates accidental-error detection, cryptographic record integrity, authentication, authorization, and semantic truth. WAVE CRC fields detect transmission corruption; SHA3-256 digests provide content integrity for canonical records; digital signatures and timestamps may authenticate a release or message under an external trust policy. None of these mechanisms proves that a statement is factually correct.

12.1 Security layers

Property	Mechanism	Non-claim
Frame corruption detection	Length, delimiters, escaping, CRC-16/CCITT-FALSE	Not cryptographic integrity or authentication.
Canonical record integrity	eL-CANON-1 + domain-separated SHA3-256	Does not prove semantic correctness or source identity.
Authentication	External digital signature / certificate / key policy	Depends on key management and trust anchors.
Existence time	Trusted timestamp or append-only transparency evidence	Does not prove content truth.
Provenance	Source, adapter/model, software, transformation and actor metadata	Can itself be false if source systems are compromised.
Authorization	Application-specific permissions and policy	Not defined by the language core.
Confidentiality	External encryption and access controls	Not provided by WAVE or eL-IR by default.

12.2 Threat model and required controls

Threat / misuse	Required control
Semantic injection through literals	Literal content is data; it cannot redefine protocol fields or tool policy.
AI hallucination / invented role	Post-generation schema/role validation; confidence/abstention; human confirmation when required.
Negation loss	Polarity is an explicit canonical field; mutation tests; no inferred negation.
Actor/recipient swap	Role labels and ordered arguments; semantic round-trip and mutation tests.
Token/registry collision	Immutable assigned IDs per major registry version; no reuse; collision tests.
Unknown extension downgrade	Critical-extension bit/manifest requires reject or not_evaluable; no silent ignore.
Replay	Message ID, timestamp/nonce profile, application replay policy, and signatures where needed.
Source/model substitution	Provenance digest, software/model identifier, asset digest, and signed release manifest.
Downgrade to obsolete major version	Explicit compatibility policy; reject unsupported or prohibited versions by default.
Prompt/tool policy confusion	Separate semantic message from agent permissions, system instructions, and tool authorization.
Privacy leakage	Data minimization, explicit sensitive literals, external access control, retention policy, and redaction-aware provenance.
Overclaim of universal comprehension	Mandatory evidence-class and limitation statements; independent human evaluation.

12.3 Privacy profile

The core does not require personal identifiers. Implementations SHOULD minimize literals, avoid unnecessary precise location or health content, and separate semantic interoperability from identity management. When sensitive information is required by an application, privacy, consent, retention, access, jurisdiction, and incident controls belong to the deployment profile.

13. Extensibility for robotics, autonomous agents, edge systems, and emerging technologies

The v3.0 architecture is designed so that new technologies attach through profiles rather than forcing a new semantic language. A profile defines serialization, timing, capability, safety, and validation constraints while referencing the same canonical semantic roles. This permits future implementations to evolve independently from the educational core.

Profile family	Use	Status in v3.0
EL-EDGE	Constrained devices, offline operation, intermittent links	Defined as an implementation profile; CBOR or compact binary binding optional.
EL-ROBOT	Robots, drones, manipulators, vehicles	Semantic command/telemetry envelope only; motion control and safety certification external.
EL-AGENT	Software/AI agents and tool orchestration	Message semantics and provenance; tool permissions external.
EL-ARVR	Augmented/virtual/mixed reality	Spatial referents and multimodal

Profile family	Use	Status in v3.0
		rendering through extensions.
EL-BCI	Brain-computer and neuroadaptive interfaces	Reserved research profile; requires human-subject and neuroethics validation.
EL-HAPTIC	Tactile/haptic communication	WAVE-H binding with empirically validated timing and perceptual thresholds.
EL-IOT	Machine-to-machine sensing and actuation	Compact eL-IR references; device schemas remain external.
EL-QUANTUM-BINDING	Future quantum-network transport or metadata binding	Reserved; no claim that quantum communication changes eLanguage semantics or enables superluminal signaling.
EL-NEUROMORPHIC	Neuromorphic/event-driven processing	Reserved serialization/execution binding; semantic equivalence required.

13.1 Extension namespaces

Core token IDs are immutable within a major registry version. Extension namespaces MUST identify an owner/maintainer, semantic definition, version, collision domain, criticality rule, deprecation status, and mapping to core roles. Private-use namespaces are permitted for experiments but MUST NOT be presented as globally registered tokens.

13.2 Backward and forward compatibility

A minor version MAY add optional noncritical extensions and tests. A major version is required when existing field semantics, token meaning, canonicalization, mandatory grammar, or transport interpretation changes incompatibly. Unknown major versions are rejected by default. Deprecated tokens remain resolvable with successor and migration guidance; identifiers are never reassigned to new meanings.

13.3 Offline-first principle

The core grammar, token registry, educational materials, and local deterministic parser can be implemented without cloud connectivity. AI-assisted translation or large-model mediation may improve flexibility but is an optional adapter. An offline implementation can therefore remain useful for basic communication, devices, assistive tools, and local machine interoperability.

14. Validation, falsifiability, evidence classes, and conformance levels

A language architecture can be deterministic without being understandable, culturally appropriate, accessible, or safe. eLanguage therefore separates specification conformance from empirical communication evidence. Every public claim SHOULD identify its evidence class and tested population or system boundary.

14.1 Evidence classes

Class	Evidence	Permitted description
E0 Specification	Normative document, schemas, vocabulary,	Specified / proposed architecture.

Class	Evidence	Permitted description
	algorithms, limitations.	
E1 Deterministic conformance	Canonical vectors, parser/serializer round trips, CRC/digest reproduction, negative and mutation tests.	Deterministically conformant for the tested vectors.
E2 Independent implementation	At least two independently developed implementations reproduce vectors and semantic outcomes.	Implementation-reproducible.
E3 Human / external interoperability benchmark	Frozen external data or preregistered human studies with defined metrics and limitations.	Externally validated only for tested populations, languages, tasks, or interfaces.
E4 Operational pilot	Signed/versioned deployment, incidents, monitoring, rollback and governance in a real environment.	Operational pilot within stated conditions.
E5 Mature multi-site evidence	Independent sites, longitudinal monitoring, migration, accessibility, language, and security evidence.	Operationally mature for declared uses; not universally validated.

14.2 Conformance levels

Level	Minimum requirements
EL-C0 Scope	Version, profile, roles, token registry, exclusions, and claim class declared.
EL-C1 Syntax	NE-IL/PICTO or eL-IR schema validates; unknown required fields rejected.
EL-C2 Determinism	Canonicalization, token IDs, round trip, byte order, CRC/digests reproduce.
EL-C3 Semantic fidelity	Role-preserving transformations, ambiguity/loss accounting, extension criticality, no silent inference.
EL-C4 Accessibility / human interface	Selected accessibility profile and human-facing presentation requirements implemented.
EL-C5 AI / adapter integrity	Model/adapter provenance, confidence, abstention, negative tests, adversarial ambiguity tests.
EL-C6 External validation	Frozen human or external interoperability benchmark with predefined metrics and independent reproduction.
EL-C7 Operational	Deployment governance, security, privacy, incident response, migration, monitoring, rollback, and revalidation.

14.3 Required metric families

Test family	Metrics / outputs
Deterministic encoding	100% canonical round trip; byte/digest equality; uniqueness; invalid-schema rejection.
Semantic fidelity	Role accuracy; polarity/actor/recipient/quantity error rates; loss-class frequency; ambiguity/abstention accuracy.
Multilingual adapters	Exact-frame accuracy by language/domain; calibration; unsupported distinction rate; human adequacy review.
Human learning	Time to criterion, recall, production accuracy, delayed retention, transfer, error type, assistance, subjective workload.
Accessibility	Task completion, navigation errors, motor access, visual/auditory/haptic comprehension, assistive-technology compatibility.
Transport	Frame acceptance, detected corruption, undetected error, retransmission, latency, throughput, conflict rate.
AI adapters	Frame accuracy, confidence calibration, hallucinated-field rate, abstention, prompt-injection resilience, OOD behavior.
Operational	Incident rate, rollback success, version migration, security events, user-reported

Test family	Metrics / outputs
	misunderstandings, drift.

14.4 Falsifiability rules

- A claim of deterministic equivalence fails if two conformant encoders produce different canonical eL-IR bytes for the same declared frame under the same profile.
- A claim of lossless mapping fails if the round trip changes a normative semantic role or converts an explicit field to an inferred field.
- A human-comprehension claim fails when preregistered accuracy or confidence bounds do not meet the stated threshold in the tested population.
- An AI-adapter reliability claim fails when hallucinated or omitted critical roles exceed the predefined limit, including out-of-distribution cases.
- A channel profile fails when its predefined detected/undetected error, latency, or acknowledgment criteria are exceeded under the declared noise model or measured channel.
- No failed external benchmark may be converted to a pass by changing thresholds, profiles, or exclusions after evaluation without issuing a new benchmark version.

15. Deterministic conformance vectors and synthetic stress tests

The v3.0 reference validation uses the integrated 100-phrase inventory, deterministic WAVE-2 compatibility framing, eL-IR restricted canonical records, and fixed random seed 20261003. The synthetic tests verify implementation behavior and corruption detection; they are E1 evidence, not human-comprehension or real-channel evidence.

15.1 Integrated dataset results

Metric	Result
Phrase inventory	100/100 present
English reference gloss uniqueness	100/100
Canonical NE-IL uniqueness	100/100
PICTO frame uniqueness	100/100
WAVE payload uniqueness	100/100
Published CRC reproduction	100/100
eL-IR SHA3-256 digest uniqueness	100/100
NE-IL lexical token occurrences	377
Distinct NE-IL lexical tokens in inventory	128
Mean / median canonical NE-IL length	3.77 / 4 lexical tokens
Maximum canonical NE-IL length	9 lexical tokens
Mean / maximum WAVE payload	7.65 / 18 bytes
Unicode normalization runtime	Python Unicode data 15.1.0
NFC idempotence over corpus	TRUE
Canonical-equivalence spot vectors	4/4

Metric	Result
Semantic mutation vectors	196/196 changed canonical sequence as expected

15.2 CRC corruption-detection stress tests

Test	Trials	Undetected corrupted frames
Exhaustive single-bit flips	12,520	0
Random two-bit flips	200,000	0
Random single-byte substitutions	200,000	0
Random burst corruptions, length 1-16 bits	80,000	0

The result above demonstrates the expected behavior of the published CRC profile for the tested frames and mutation sets. It MUST NOT be interpreted as cryptographic collision resistance or as a proof that all possible multi-bit corruptions are detectable. Security-sensitive integrity requires the canonical-record digest and, when authenticity matters, an external signature/trust profile.

15.3 Binary-symmetric-channel simulation

Bit error probability	Trials	No bit error	Detected corruption	Undetected corruption
1e-05	50,000	49,929	71	0
1e-04	50,000	49,390	610	0
1e-03	50,000	43,901	6,099	0
1e-02	50,000	14,335	35,665	0

This simulation flips each protected-frame bit independently at the stated probability and then validates the CRC. It does not model synchronization loss, acoustic fading, optical ambient light, radio interference, haptic perception, packet duplication, latency, or hardware-specific demodulation. Real bearer validation remains profile-specific E3 work.

15.4 Reference eL-IR digest

For phrase 33 ("I need help now."), the restricted canonical record used by the v3.0 validation produces the following domain-separated SHA3-256 reference digest. The example is a deterministic software vector; it is not an identity or authenticity claim.

```
d151adb599c93d179b41ccaf8dd22ebaf0546f7b40e0e0c1ae16a51aa26aa22b
```

16. Standards-backed interoperability benchmarks

External standards are used as reference boundaries rather than copied into eLanguage. The objective is to verify that v3.0 can coexist with established text normalization, language tagging, web semantics, provenance, accessibility, and AI governance practices without claiming certification to standards whose full requirements are outside this specification.

External basis	eLanguage use	v3.0 evidence boundary
Unicode Standard / UAX #15	NFC normalization for literals, labels, and canonical strings.	Corpus normalization and canonical-equivalence vectors executed with Unicode 15.1 runtime; full Unicode 18 conformance

External basis	eLanguage use	v3.0 evidence boundary
		suite not executed in this release.
RFC 5646 / BCP 47	Language tags for glosses and adapter manifests.	Schema/profile requirement; no claim of supporting every registered language.
RFC 8785 JCS	Design basis for deterministic JSON canonicalization.	eL-CANON-1 uses a restricted JSON value domain to avoid floating-point ambiguity; independent JCS library cross-check remains an E2 target.
RFC 8949 CBOR	Optional compact binary serialization.	Interoperability profile only; no canonical CBOR vector published in this release.
W3C JSON-LD 1.1 / RDF / OWL	Optional knowledge-graph and ontology mapping.	No claim that eLanguage replaces semantic-web data models.
W3C PROV	Provenance mapping for source, transform, software/model, and agent metadata.	Conceptual field mapping; full PROV export implementation pending.
WCAG 2.2 / ISO 9241 human-system guidance	Accessibility and presentation design basis.	Document/application design guidance only; no formal WCAG or ISO certification claim.
ISO/IEC 22989, 23894, 42001 / NIST AI RMF	AI terminology, risk, governance, traceability context.	Governance alignment principles; eLanguage is not an AI management-system certification.

16.1 Real-world evidence boundary

No suitable authoritative public dataset can by itself demonstrate the central human claim that unfamiliar people across cultures will learn and understand eLanguage accurately. That question requires prospective participant studies. Accordingly, v3.0 reports standards-backed software conformance and source-based human-factors literature while explicitly leaving cross-cultural comprehension, learning speed, symbol intuitiveness, and clinical AAC effectiveness at evidence class E0/E1 until new empirical studies are performed.

16.2 Human-study minimum design

Element	Minimum recommendation
Participants	Multiple languages, ages, education/literacy levels, and accessibility needs relevant to the claim.
Comparators	Natural-language instructions and at least one appropriate controlled/AAC baseline where ethically and practically suitable.
Training	Predefined curriculum; record instructional time, assistance, and prior exposure.
Outcomes	Recognition, production, semantic-role accuracy, delayed recall, transfer to unseen phrases, confidence, error types, and subjective workload.
Safety subset	Oversample negation, danger, help, doctor, stop, location, quantity, and confirmation messages.
Analysis	Predefined thresholds, confidence intervals, subgroup reporting, missing-data policy, and correction for repeated tests.
Independence	Independent site or investigator replication before broad learnability or universality claims.

17. Implementation profiles and reference processing pipeline

17.1 Reference pipeline

1. Capture a source message or construct a semantic frame directly.

2. Identify the source profile and locale; preserve the original source or a content digest when provenance is required.
3. Parse into one or more candidate eSF objects.
4. Validate required roles, token semantics, extension criticality, and ambiguity.
5. Assign mapping class and confidence; abstain or request clarification when the selected profile requires it.
6. Create the eL-IR record and normalize strings to Unicode NFC.
7. Validate against the exact eLanguage 3.0 schema and registry.
8. Canonicalize using eL-CANON-1 and compute the domain-separated SHA3-256 digest when integrity is required.
9. Render NE-IL, PICTO, localized human output, or machine bindings from the same semantic frame.
10. When transport is required, build WAVE-2 compatibility framing or another registered bearer profile and validate CRC/length/escaping.
11. At the receiver, validate transport before semantic decoding; reject invalid frames rather than repairing them silently.
12. Reconstruct eSF/eL-IR, verify optional digest/signature/provenance, and render for the destination participant.
13. Log conformance status, ambiguity, conflicts, and applicable privacy-safe diagnostics.

17.2 Minimum software modules

Module	Required behavior
Registry	Resolve token IDs and role semantics by exact version; prevent ID reuse.
Parser	Deterministic NE-IL parsing for supported grammar; structured error codes.
Renderer	Generate canonical NE-IL and PICTO ordering from eSF/eL-IR.
Schema validator	Reject missing mandatory fields, invalid enums, unexpected critical extensions, and malformed literals.
Canonicalizer/digest	NFC + eL-CANON-1 + domain-separated SHA3-256.
Transport codec	WAVE framing, byte escaping, CRC, fragmentation, ACK/NACK/conflict behavior.
Adapter interface	Natural-language, AI, device, or ontology mapping with confidence/loss/provenance metadata.
Diagnostics	Human-readable and machine-readable reason codes without silently altering messages.

17.3 Minimal offline implementation

A minimal offline implementation needs only the core registry, deterministic NE-IL parser/renderer, PICTO labels, eL-IR schema, and optionally WAVE framing. It does not need a language model, internet service, knowledge graph, or cloud account. This is intentional: AI expands the interaction envelope but is not a dependency for basic eLanguage operation.

17.4 Reference error codes

Code	Meaning	Required action
EL-E001	Unknown major version	Reject.
EL-E002	Unknown required token or critical extension	Reject or not_evaluable.
EL-E003	Missing mandatory semantic role	Incomplete; do not infer in critical profile.
EL-E004	Ambiguous source mapping	Return candidates or request clarification.

Code	Meaning	Required action
EL-E005	Invalid literal encoding / normalization	Reject or normalize only when profile explicitly permits safe normalization.
EL-E006	Frame length or escape error	Reject transport frame.
EL-E007	CRC failure	Reject/NACK.
EL-E008	Same message ID with conflicting valid payloads	Report CONFLICT; do not choose automatically.
EL-E009	Provenance/signature validation failure	Treat authentication as failed; semantic content may be displayed only according to application policy.
EL-E010	Lossy adapter mapping	Preserve loss report; do not label exact.

18. Governance, registry management, versioning, and release artifacts

18.1 Registry governance

The core registry is append-only within a major version. Every token definition records identifier, canonical label, semantic category, NE-IL realization, PICTO presentation, machine role, introduction version, status, aliases if any, and deprecation/successor information. Semantic changes require a new identifier or major-version action; editorial clarifications must not alter executable meaning.

18.2 Versioning

- A major version MUST change when canonical field semantics, mandatory grammar, identifier interpretation, canonicalization, or transport interpretation changes incompatibly.
- A minor version MAY add backward-compatible optional profiles, extensions, examples, test vectors, or noncritical fields.
- A patch version MAY correct editorial defects or clarify non-normative examples without changing executable semantics.
- Unknown major versions MUST be rejected by default. A gateway MAY translate between major versions only through an explicit versioned migration profile.
- Deprecated tokens remain resolvable and MUST NOT be reassigned.

18.3 Required release package

Artifact	Requirement
Normative integrated document	Master + all annexes + limitations + references + license.
Machine-readable schema	eL-IR JSON Schema or equivalent and controlled vocabularies.
Token registry	Versioned machine-readable token table with reserved and extension ranges.
Canonical vectors	Message records, token sequences, CRC values, digests, literals, negative/mutation cases.
Reference implementation	At least one for E1; two independent implementations for E2.
Benchmark manifest	Frozen synthetic seeds and any external datasets/assets with provenance and checksums.
Validation report	Metrics, failures, evidence classes, populations/conditions, and limitations.

Artifact	Requirement
Accessibility package	Printable and digital materials, text alternatives, navigation and selected profile checks.
Security profile	Digest/signature/timestamp/trust recommendations and migration policy.
Persistent archive	Zenodo DOI/version, release date, complete-file SHA3-256, and official copy identifier.
Licenses	Document, code, data, model, and third-party license boundaries explicit.

18.4 Official-release integrity

The complete-file SHA3-256 digest is published outside the DOCX/PDF or in a separately signed manifest because embedding a final self-hash inside the same file is self-referential. The official archival PDF SHOULD be digitally signed and timestamped when practical. Watermarks, copy IDs, headers, and footers support human traceability but are not cryptographic authentication.

19. Limitations, research agenda, and conclusion

19.1 Limitations

- The 100-phrase inventory is a compact educational and conformance corpus, not a complete ontology of human communication.
- Fixed word order and explicit morphology improve deterministic parsing but have not yet been shown to minimize human learning time across languages or cultures.
- PICTO category shapes and labels are not established universal symbols; cultural and accessibility testing remains necessary.
- Natural-language and AI adapters may be probabilistic and can fail even when the eLanguage core is deterministic.
- CRC testing addresses accidental corruption only; security depends on external cryptographic and trust controls.
- WAVE bearer descriptions are architecture profiles rather than certified modulation standards or measured channel-performance claims.
- Clinical AAC, emergency communication, aviation, maritime, medical, industrial-safety, and autonomous-control deployments require domain-specific validation and cannot rely on this preprint alone.
- Future quantum, BCI, neuromorphic, or other emerging-technology bindings remain profiles; they do not expand the validated semantic claims of the core without new evidence.

19.2 Research agenda

Priority	Study / artifact	Success evidence
1	Two independent eL-IR/NE-IL implementations	Exact reproduction of all canonical vectors and negative tests.
2	Multilingual adapter benchmark	Predefined frame-level semantic accuracy, calibration, abstention, and human review in multiple language families.
3	Controlled learnability study	Time-to-criterion, unseen-message transfer, delayed retention, error taxonomy, comparator baseline.
4	Accessibility/AAC studies	Representative users and assistive technologies; task success and comprehension, not only visual inspection.
5	Real acoustic/optical/haptic channel trials	Measured synchronization, BER/frame rejection, latency,

Priority	Study / artifact	Success evidence
		conflict and recovery under declared environments.
6	AI mediation benchmark	Held-out paraphrases, ambiguity, prompt injection, OOD inputs, hallucinated-field rate, confidence calibration.
7	Robotics/agent pilot	Semantic-command fidelity with independent safety policy, logging, replay prevention and rollback.
8	Longitudinal governance study	Registry evolution, backward compatibility, migration, incidents, user feedback and maintenance cost.

19.3 Conclusion

eLanguage v3.0 defines a candidate common semantic communication layer that is deliberately positioned between unrestricted human language and implementation-specific machine languages. Its contribution is not the claim that one simplified vocabulary can replace natural languages or computing protocols. The contribution is a disciplined architecture in which meaning is declared once, represented in human and machine forms, transported through multiple channels, validated deterministically where possible, and accompanied by explicit uncertainty, provenance, accessibility, security, and evidence boundaries. The integrated educational system provides a practical entry point; eL-IR and profile governance provide the path toward AI, robotics, machine interoperability, and future interfaces. The decisive next step is independent implementation followed by multilingual and human-subject validation before any claim of broad or universal usability.

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The specification is supplied as research material without warranty of merchantability, fitness for a particular purpose, scientific correctness, universal comprehension, regulatory acceptance, clinical suitability, or operational safety. Implementers remain responsible for independent validation, security engineering, accessibility, professional review, and applicable legal or regulatory requirements.

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Annex A. Complete 100-phrase reference

Annex B. Ten communication boards

Annex C. Printable study cards

Annex D. Seven-day learning manual

Annex E. Visual and lexical dictionary

Annex F. Printable exercises, answer key, and checklist

Annex G. Token registry and machine interchange profile

Annex H. Human-AI and machine interoperability profile

Annex I. Multilingual and natural-language adapter profile

Annex J. Accessibility and multimodal interaction profile

Annex K. Security, integrity, provenance, and trust profile

Annex L. Validation, simulation, and conformance benchmark suite

Annex M. Implementation, deployment, and future-technology profiles

1. Purpose, scope, claim boundaries, and architectural principles

eLanguage is a layered semantic communication framework whose primary purpose is to provide a common, cross-cutting representation of meaning across people and computational systems. It is designed for human-to-human, human-to-machine/AI, machine/AI-to-human, and machine-to-machine interaction. Meaning is declared once in a canonical semantic frame and may then be rendered as NE-IL, PICTO, eL-IR machine data, or transported through WAVE-compatible bearers without allowing a representation layer to silently redefine the

intended semantic content. English is used in this edition as a reference gloss and instructional language; it is not the semantic foundation of eLanguage.

Core design rule

Meaning is defined once and transported through multiple representations. No visual symbol or waveform is allowed to introduce a second interpretation.

1.1 Layered architecture

Layer	Function
Semantic intent / eLanguage Semantic Frame (eSF)	Language-independent roles, scope, illocution, actor/reference, time, polarity, predicate/state, arguments, relations, quantity, modality, urgency, confidence, literals, and provenance links.
NE-IL Core	Compact human-readable controlled form with fixed order, invariant roots, explicit markers, productive suffixes, and deterministic mapping to/from eSF within the supported grammar.
PICTO-2	Visual semantic form using category shapes, readable labels, stable token identifiers, and explicit ordering. PICTO is a representation of eSF, not an independent source of meaning.
eL-IR 3.0	Canonical machine-readable semantic interchange record designed for software, AI systems, autonomous agents, robots, assistive technology, knowledge systems, and future computational architectures.
WAVE-2 compatibility transport	Bearer-neutral framing for token sequences and metadata, with sequencing, CRC error detection, acknowledgment, conflict handling, and compatibility with digital, acoustic, optical, haptic, or radio bindings.
Adapter layer	Versioned mappings between natural languages, external ontologies/data models, APIs, devices, AI systems, and the canonical eLanguage semantic frame.
Educational layer	Reference inventory, communication boards, study cards, seven-day course, visual/lexical dictionary, exercises, and conformance checklists.

1.2 Design principles

- Compositionality: every message is generated from reusable semantic units rather than memorized whole-message codes.
- Unambiguous scope: time, polarity, quantity, comparison, and relation markers occupy defined positions.
- Round-trip preservation: semantic frame → NE-IL → PICTO → WAVE → PICTO → NE-IL MUST preserve the same meaning.
- Encoding uniqueness: within a fixed token registry and canonicalization profile, two distinct canonical frames MUST NOT produce the same ordered PICTO token sequence or WAVE payload. The CRC is an error-detection field and MUST NOT be treated as a globally unique identifier.
- Graceful degradation: a partially received message MUST be rejected or marked incomplete, never guessed.
- Channel independence: the payload remains the same across digital, acoustic, optical, or haptic profiles.
- Human readability: machine identifiers are always paired with visible labels in educational and diagnostic modes.
- Semantic-source rule: the eLanguage Semantic Frame is authoritative; human, visual, machine, and transport forms are projections or encodings of that frame.
- Cross-domain interoperability: no representation is privileged by being human-readable or machine-readable; conformance is defined by preserved semantic roles and declared mappings.
- AI abstention: an AI adapter MUST NOT silently invent a missing safety-relevant actor, polarity, predicate, object, quantity, recipient, or urgency field. Ambiguity MUST be surfaced as ambiguous, incomplete, or not_evaluable.

- Language neutrality: natural-language glosses and adapters MAY vary by locale, but canonical token and role semantics are versioned independently from any particular natural language.
- Future extensibility: new devices, computational architectures, modalities, or bearers SHOULD be added through profiles and bindings without redefining the semantic core.

1.3 Status and limitations

eLanguage v3.0 is a normative research specification and experimental communication architecture. It does not claim that the present vocabulary is complete for all cultures or domains, that the symbols are universally understood, that the seven-day course proves human learnability, or that any WAVE bearer is certified for emergency or clinical use. Deterministic parser and transport tests are evidence of implementation consistency, not evidence of human comprehension. Natural languages, sign languages, established augmentative and alternative communication (AAC) systems, programming languages, and domain protocols remain independent systems that may interoperate with eLanguage through adapters.

2. NE-IL Core normative grammar

NE-IL Core uses invariant roots, explicit particles, and a restricted syntax. The canonical form is designed for deterministic parsing and direct conversion into semantic roles.

2.1 Canonical clause order

Declarative frame

SUBJECT + [TIME] + [NOT] + PREDICATE + [OBJECT / COMPLEMENT] + [PREPOSITION + TARGET]

Function	NE-IL	English
Simple action	mi eat.	I eat.
Time	mi now work.	I am working now.
Negation	mi not drink.	I do not drink.
Time + negation	mi future not go to city-place.	I will not go to the city.
Transfer	mi now give water to person.	I give water to a person now.
State	mi now be safe-al.	I am safe now.

2.2 Question patterns

Type	Pattern	Example
Yes/no	qa + SUBJECT + [TIME] + [NOT] + PREDICATE + ... ?	qa tu understand?
Location	where + be + ENTITY ?	where be hospital-place?
Identity	who + be + REFERENCE ?	who be that person?
Object	what + be + REFERENCE ?	what be this?
Time	when + SUBJECT + [FUTURE] + PREDICATE ?	when mi future go?
Reason	why + SUBJECT + [NOT] + PREDICATE ?	why tu not eat?
Method	how + SUBJECT + PREDICATE + OBJECT ?	how tu make this?

2.3 Morphology

Marker	Function	Examples
-place	location	house-place, hospital-place, city-place
-thing	object or item	phone-thing, help-thing, price-thing
-al	state or quality	safe-al, hungry-al, blue-al
-er	agent or role	doctor-er
-many	plural or group	friend-many, person-many
-own	possession	mi-own, she-own, house-place-own

A numeral or quantifier does not remove the plural marker: two book-thing-many and many friend-many are canonical. This redundancy supports parsing and error detection.

2.4 Lexical and semantic rules

- Roots do not inflect for person, number, gender, or tense.
- The copula is always be. Forms such as am, is, and are are not used in canonical NE-IL.
- Time markers are past, now, future, and today. They appear immediately after the subject or subject phrase.
- not appears after the time marker and before the predicate. This fixes the scope of negation.
- Prepositions appear before their complements: to person, from city-place, at school-place, in bottle-thing, of this.
- Proper names are literal fields. They retain spelling, are normalized to Unicode NFC before transport, and are encoded as defined in Section 4.8 [2].
- Punctuation is part of the human-readable layer; semantic question status is encoded separately in PICTO-2 and WAVE-2.

2.5 Compact grammar

```
<message> ::= <declaration> | <question> | <answer>
<declaration> ::= <declaration-body> "."
<declaration-body> ::= <subject-frame> [<time>] ["not"] <predicate> [<complement>] {<relation> <target-frame>}
<question> ::= "qa" <declaration-body> "?" | <wh-word> <question-body> "?"
<question-body> ::= [<subject-frame>] [<time>] ["not"] <predicate> [<complement>] {<relation> <target-frame>}
<state-clause> ::= <subject-frame> [<time>] ["not"] "be" <state-or-reference>
<subject-frame> ::= [<quantifier>] <reference-or-entity> | <possessor> <entity>
<target-frame> ::= [<quantifier>] <reference-or-entity>
<complement> ::= [<quantifier-or-comparison>] <object-or-state> | <literal>
<time> ::= "past" | "now" | "future" | "today"
<wh-word> ::= "where" | "what" | "who" | "when" | "why" | "how"
<relation> ::= "to" | "from" | "by" | "at" | "in" | "than" | "as" | "of"
<answer> ::= "yes." | "no."
```

3. PICTO-2 visual semantic encoding

PICTO-2 is the normative visual representation of a semantic frame. It replaces whole-phrase symbol memorization with a fixed sequence of reusable role tokens. Each token has a category shape, a human-readable label, and a 16-bit machine identifier.

3.1 Category shapes

Shape	Semantic category	Examples
?	Question / interrogative	WHERE, WHAT, QA

Shape	Semantic category	Examples
○	Actor, reference, or possessor	MI, TU, PERSON, MI:OWN
◷	Time	PAST, NOW, FUTURE, TODAY
×	Polarity	NOT, NO
◇	Action or copula	GO, NEED, BE, SPEAK
□	Entity, object, agent, or literal	WATER, PHONE:OBJ, DOCTOR:ROLE
⌂	Place	HOSPITAL:PLACE, CITY:PLACE
△	State or quality	SAFE:STATE, HOT:STATE
→	Relation	TO, FROM, AT, IN, THAN, AS, OF
#	Quantity or comparison	TWO, MANY, MORE, SAME

3.2 Linear frame order

PICTO canonical frame

[QUESTION] → SUBJECT-FRAME → [TIME] → [POLARITY] → PREDICATE → [COMPLEMENT] → {RELATION → TARGET-FRAME} → [URGENCY]

SUBJECT-FRAME = [QUANTIFIER] + ACTOR / REFERENCE / ENTITY; COMPLEMENT = [QUANTITY / COMPARISON] + OBJECT / STATE / LITERAL; TARGET-FRAME = [QUANTIFIER] + ACTOR / REFERENCE / ENTITY / PLACE.

Not every frame uses every slot. Omitted slots are not inferred. Quantity and comparison tokens occupy the scope immediately before the role they modify; repeated roles remain explicit when needed for comparison or transfer.

English	PICTO-2 frame
I need a doctor now.	○MI · ◷NOW · ◇NEED · □DOCTOR:ROLE
Where is the hospital?	?WHERE · ◇BE · ⌂HOSPITAL:PLACE
I will not go to the city.	○MI · ◷FUTURE · ×NOT · ◇GO · →TO · ⌂CITY:PLACE
I give water to a person now.	○MI · ◷NOW · ◇GIVE · □WATER · →TO · ○PERSON

3.3 Uniqueness and error behavior

- Two canonical messages MUST NOT share the same ordered token sequence.
- Whitespace and visual spacing are presentation-only. Token order and identifiers are normative.
- Unknown tokens MUST be shown as UNKNOWN[id] and MUST NOT be guessed from neighboring tokens.
- An incomplete frame MUST be marked INCOMPLETE until its WAVE length and CRC fields are verified.
- Critical messages SHOULD request acknowledgment and SHOULD be repeated using the critical-message profile.

3.4 Human and machine representations

Representation	Example	Primary use
Human-readable	○MI · ◷NOW · ◇NEED · □HELP:OBJ	Teaching, boards, diagnostics
Machine-readable	1003-2002-3014-400A	WAVE payload and software interchange
Canonical text	mi now need help-thing.	Authoring and round-trip verification

4. WAVE-2 transport protocol

WAVE-2 transports the same PICTO token identifiers through different physical or digital channels. The transport layer does not redefine meaning; it adds framing, synchronization, sequence control, error detection, and acknowledgment.

4.1 Normative frame

Field	Requirement
Preamble	Alternating synchronization pattern, repeated according to channel profile
Start delimiter	0x7E
Version	Protocol major/minor; this edition uses 0x21
Flags	Question, urgent, acknowledgment requested, repeat, channel profile
Message ID	16-bit identifier used for sequencing and acknowledgment
Sequence	8-bit fragment number; 0 for unfragmented messages
Length	Number of payload bytes
Payload	Ordered 16-bit PICTO token identifiers plus literal blocks when required
CRC	CRC-16-CCITT over header fields from Version through Payload
End delimiter	0x7F

4.2 Byte-level layout

Canonical frame

PREAMBLE | 7E | VERSION | FLAGS | MESSAGE-ID(2) | SEQUENCE | LENGTH | PAYLOAD(n) | CRC16(2) | 7F

Reserved delimiter bytes inside the header or payload MUST be escaped with 0x7D followed by the original byte XOR 0x20, following the octet-transparency convention used in HDLC-like framing [1]. Multi-byte integers and 16-bit token identifiers use network byte order (most significant byte first). Receivers MUST reject frames with inconsistent length, invalid escaping, unknown version, or failed CRC.

4.3 Channel profiles

Profile	Bearer	Minimum requirements
WAVE-D	Digital packet	Raw framed bytes over a reliable or unreliable digital link. CRC remains mandatory.
WAVE-A	Acoustic	Binary frequency-shift or equivalent tone mapping; use a repeated preamble, inter-symbol guard interval, and channel calibration.
WAVE-L	Optical	Manchester-coded light states or equivalent transition-rich signaling; avoid long steady states.
WAVE-H	Haptic	Short/long pulse mapping with explicit start, end, and pause durations; intended for low-rate human interaction.
WAVE-R	Radio bearer	The WAVE frame is encapsulated in a compliant radio system; frequency, power, and modulation are implementation- and jurisdiction-specific.

4.4 Reliability profiles

Profile	Behavior
Normal	One frame; CRC required; acknowledgment optional.
Confirmed	Acknowledgment requested; sender retries after timeout using the same message ID and a repeat flag.
Critical	Three transmissions separated by guard intervals; acknowledgment required; receiver accepts only a CRC-valid frame and reports conflicts.
Fragmented	Each fragment carries the same message ID and a sequence number; reassembly requires all fragments and a final message CRC.

4.5 Acknowledgment and conflict handling

- ACK contains the received message ID, status code, and CRC.
- NACK identifies invalid CRC, unsupported token, unsupported version, missing fragment, or semantic conflict.
- If repeated valid frames with the same message ID carry different payloads, the receiver MUST report CONFLICT and MUST NOT select one automatically.
- Receivers SHOULD preserve a diagnostic transcript containing timestamps, raw payloads, decoded tokens, and validation status.

4.6 Flag assignments and Annex A default profile

Bit / mask	Meaning
0 / 0x01	QUESTION
1 / 0x02	URGENT
2 / 0x04	ACK-REQUEST
3 / 0x08	REPEAT
4-6 / 0x70	CHANNEL PROFILE; see Section 4.3. Bit 7 = 0.

Bit 0 marks questions, bit 1 marks urgent entries, bit 2 requests acknowledgment, and bit 3 marks retransmission. Annex A uses Version 0x21, WAVE-D channel bits 000, Message ID equal to the phrase ID, Sequence 0, and Length equal to the unescaped payload byte count. Noncritical declarations use Flags 0x00; noncritical questions use 0x01; critical declarations use 0x06; and critical questions use 0x07.

4.7 CRC-16 and byte-level reproducibility profile

Parameter	Value
Name	CRC-16/CCITT-FALSE
Polynomial	0x1021
Initial value	0xFFFF
Reflect input / output	false / false
Final XOR	0x0000
Check order	Version through Payload, before byte escaping
Serialized CRC	16-bit big-endian

The start delimiter, preamble, end delimiter, and escaped on-wire substitutions are excluded from the CRC input. Length is the number of unescaped payload bytes. CRC verification detects accidental corruption but does not provide cryptographic integrity, authentication, or collision resistance.

4.8 Literal blocks and fragmentation

A literal block is encoded as the 16-bit marker 0x9001, followed by one unsigned byte containing the UTF-8 byte length, followed by the Unicode NFC-normalized UTF-8 bytes. The human-readable notation 9001[ANA] therefore represents 90 01 03 41 4E 41. The literal length is limited to 255 bytes in this edition. Messages whose complete payload exceeds the one-byte Length field MUST use the Fragmented reliability profile; implementations MUST NOT truncate or silently shorten a literal.

5. Safety, accessibility, and conformance

5.1 Safety constraints

- Critical concepts such as help, doctor, danger, pain, stop, no, hospital, food, water, and safe use distinct tokens and distinct complete frames.
- Critical boards place urgent messages in a visually separate region and pair text with PICTO, never PICTO alone.
- No receiver may infer a missing actor, polarity, or object in a safety-relevant message.
- The system MUST NOT be represented as clinically certified, emergency-certified, universally understood, or suitable for autonomous safety decisions without independent evidence and jurisdiction-specific approval.

5.2 Accessibility requirements

Dimension	Requirement
Visual	High contrast, minimum 12-point board text, redundant shape + label, no dependence on color alone.
Auditory	Adjustable rate and tone spacing, visual transcript, replay, and CRC status.
Motor	Large target cells, scanning order, printable boards, and switch-access compatible software layout.
Cognitive	Consistent left-to-right order, limited symbol families, repeated examples, and explicit error state.
Technical	Unicode plus ASCII fallback labels; machine IDs remain authoritative when glyphs are unavailable.

5.3 Release conformance tests

Test	Acceptance criterion
Inventory completeness	100/100 phrase IDs present in the master dataset.
Canonical uniqueness	100/100 canonical NE-IL strings are distinct within the registered inventory.
PICTO collision test	100/100 ordered PICTO frames are distinct within the registered inventory.
WAVE collision test	100/100 unescaped WAVE payloads are distinct; all listed CRC values independently reproduce under Sections 4.6-4.8.
Course coverage	Every phrase appears exactly once in the seven-day primary sequence.

Test	Acceptance criterion
Round trip	Token sequence reconstructs the same canonical NE-IL token order and semantic roles.
Error handling	Invalid length, escaping, token ID, version, literal length, and CRC are rejected.
Rendering	All required glyphs have readable ASCII labels and machine IDs.

Integrated dataset result

The publication dataset passes the 100-entry inventory, canonical uniqueness, PICTO uniqueness, WAVE payload uniqueness, exact CRC reproduction, round-trip, and seven-day coverage tests. These are internal conformance results for the registered inventory and do not constitute evidence of universal comprehension, channel robustness, clinical safety, or cryptographic security.

5.4 Validation boundaries and evidence status

The conformance tests in this edition verify deterministic encoding and internal consistency of the supplied 100-phrase inventory. They do not test whether unfamiliar users infer the intended meaning, whether symbols are culturally neutral, whether people with specific disabilities can use the materials effectively, or whether acoustic, optical, haptic, radio, and digital implementations remain reliable under real noise and interference. Those questions require preregistered human-subject studies, accessibility evaluation, independent software implementations, channel testing, and appropriate ethical or regulatory review.

References and external technical foundations

[1] Simpson, W., ed. PPP in HDLC-like Framing. Internet Standard STD 51, RFC 1662, Internet Engineering Task Force, July 1994.

[2] The Unicode Consortium. Unicode Standard Annex #15: Unicode Normalization Forms. Current online edition accessed for this preprint.

[3] World Wide Web Consortium. Web Content Accessibility Guidelines (WCAG) 2.2. W3C Recommendation, 2024. Used as general guidance for redundant presentation and contrast; no WCAG conformance claim is made for this print document.

[4] Leiba, B. Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words. BCP 14, RFC 8174, Internet Engineering Task Force, May 2017.

Annex A. Complete 100-phrase reference

The table below is normative for the educational inventory. PICTO frames are human-readable. WAVE token sequences list ordered 16-bit identifiers; literal blocks use the notation defined in Section 4.8. CRC is calculated over Version, Flags, Message ID, Sequence, Length, and the unescaped Payload using CRC-16/CCITT-FALSE. Question IDs are 31, 51-60, and 98. Critical IDs are 29, 30, 33, 41, 42, 43, 50-54, 87, 99, and 100; IDs 51-54 therefore use Flags 0x07. All other flag values follow Section 4.6.

ID	English	Canonical NE-IL	PICTO-2	WAVE token sequence	CRC
1	I eat.	mi eat.	○MI · ◇EAT	1003-300C	00F8
2	I drink.	mi drink.	○MI · ◇DRINK	1003-300B	A89D
3	I sleep.	mi sleep.	○MI · ◇SLEEP	1003-301B	02CD
4	I woke up.	mi past wake.	○MI · ◷PAST · ◇WAKE	1003-2003-3023	5F3A
5	I wash.	mi wash.	○MI · ◇WASH	1003-3025	7475
6	I get dressed.	mi dress.	○MI · ◇DRESS	1003-300A	797A
7	I will go to work.	mi future go to work-place.	○MI · ◷FUTURE · ◇GO · →TO · ⌂WORK:PLACE	1003-2001-300F-7008-5009	08E3
8	I am working now.	mi now work.	○MI · ◷NOW · ◇WORK	1003-2002-3026	8DBF
9	I am studying now.	mi now study.	○MI · ◷NOW · ◇STUDY	1003-2002-301F	C1E6
10	I am reading now.	mi now read.	○MI · ◷NOW · ◇READ	1003-2002-3017	6DAA
11	I am writing now.	mi now write.	○MI · ◷NOW · ◇WRITE	1003-2002-3027	B0DA
12	I am cooking now.	mi now cook.	○MI · ◷NOW · ◇COOK	1003-2002-3008	D4FC
13	I eat breakfast.	mi eat breakfast-thing.	○MI · ◇EAT · □BREAKFAST:OBJ	1003-300C-4004	F6AC
14	I eat lunch.	mi eat lunch-thing.	○MI · ◇EAT · □LUNCH:OBJ	1003-300C-400B	2A07
15	I eat dinner.	mi eat dinner-thing.	○MI · ◇EAT · □DINNER:OBJ	1003-300C-4007	00A8
16	I drink water.	mi drink water.	○MI · ◇DRINK · ○WATER	1003-300B-100B	81A1
17	I am hungry.	mi be hungry-al.	○MI · ◇BE · △HUNGRY:STATE	1003-3001-6008	9579
18	I am thirsty.	mi be thirsty-al.	○MI · ◇BE · △THIRSTY:STATE	1003-3001-6010	2B04
19	I am tired.	mi be tired-al.	○MI · ◇BE · △TIRED:STATE	1003-3001-6011	D006
20	I am ill.	mi be ill-al.	○MI · ◇BE · △ILL:STATE	1003-3001-6009	F294
21	I am happy.	mi be happy-al.	○MI · ◇BE · △HAPPY:STATE	1003-3001-6006	E858
22	I am sad.	mi be sad-al.	○MI · ◇BE · △SAD:STATE	1003-3001-600D	7477
23	I go home now.	mi now go to house-place.	○MI · ◷NOW · ◇GO · →TO · ⌂HOUSE:PLACE	1003-2002-300F-7008-5004	1778
24	I am at home.	mi be at house-place.	○MI · ◇BE · →AT · ⌂HOUSE:PLACE	1003-3001-7002-5004	934D
25	I go to school now.	mi now go to school-place.	○MI · ◷NOW · ◇GO · →TO · ⌂SCHOOL:PLACE	1003-2002-300F-7008-5007	A32A
26	I am at school.	mi be at school-place.	○MI · ◇BE · →AT · ⌂SCHOOL:PLACE	1003-3001-7002-5007	039D
27	I go to the market now.	mi now go to market-place.	○MI · ◷NOW · ◇GO · →TO · ⌂MARKET:PLACE	1003-2002-300F-7008-5006	39CD
28	I buy food now.	mi now buy food-thing.	○MI · ◷NOW · ◇BUY · □FOOD:OBJ	1003-2002-3003-4009	BD2E

ID	English	Canonical NE-IL	PICTO-2	WAVE token sequence	CRC
29	I go to the hospital now.	mi now go to hospital-place.	○MI · ◷NOW · ◇GO · →TO · ⌂HOSPITAL:PLACE	1003-2002-300F-7008-5003	3068
30	I am at the hospital.	mi be at hospital-place.	○MI · ◇BE · →AT · ⌂HOSPITAL:PLACE	1003-3001-7002-5003	9D35
31	Do you understand?	qa tu understand?	?QA · ○TU · ◇UNDERSTAND	0102-100A-3020	A758
32	I do not understand.	mi not understand.	○MI · ×NOT · ◇UNDERSTAND	1003-2102-3020	15CE
33	I need help now.	mi now need help-thing.	○MI · ◷NOW · ◇NEED · □HELP:OBJ	1003-2002-3014-400A	1012
34	I call someone now.	mi now call person.	○MI · ◷NOW · ◇CALL · ○PERSON	1003-2002-3004-1004	4B91
35	I use the phone now.	mi now use phone-thing.	○MI · ◷NOW · ◇USE · □PHONE:OBJ	1003-2002-3021-400E	511B
36	I charge the phone now.	mi now charge phone-thing.	○MI · ◷NOW · ◇CHARGE · □PHONE:OBJ	1003-2002-3005-400E	22A0
37	I go by bus now.	mi now go by bus-thing.	○MI · ◷NOW · ◇GO · →BY · □BUS:OBJ	1003-2002-300F-7003-4005	45C1
38	I go by car now.	mi now go by car-thing.	○MI · ◷NOW · ◇GO · →BY · □CAR:OBJ	1003-2002-300F-7003-4006	BA07
39	I wait at the bus stop now.	mi now wait at bus-stop-place.	○MI · ◷NOW · ◇WAIT · →AT · ⌂BUS-STOP:PLACE	1003-2002-3022-7002-5001	920E
40	I cross the road now.	mi now cross road.	○MI · ◷NOW · ◇CROSS · ○ROAD	1003-2002-3009-1005	1BDC
41	I am in danger.	mi be danger-al.	○MI · ◇BE · △DANGER:STATE	1003-3001-6004	78FC
42	I need a doctor now.	mi now need doctor-er.	○MI · ◷NOW · ◇NEED · □DOCTOR:ROLE	1003-2002-3014-4201	1D6F
43	I feel pain now.	mi now feel pain-thing.	○MI · ◷NOW · ◇FEEL · □PAIN:OBJ	1003-2002-300D-400D	BF3A
44	I do not eat.	mi not eat.	○MI · ×NOT · ◇EAT	1003-2102-300C	4530
45	I do not drink.	mi not drink.	○MI · ×NOT · ◇DRINK	1003-2102-300B	DEF4
46	I will not go to the city.	mi future not go to city-place.	○MI · ◷FUTURE · ×NOT · ◇GO · →TO · ⌂CITY:PLACE	1003-2001-2102-300F-7008-5002	6C08
47	I am not sleeping now.	mi now not sleep.	○MI · ◷NOW · ×NOT · ◇SLEEP	1003-2002-2102-301B	5A9A
48	I do not work today.	mi today not work.	○MI · ◷TODAY · ×NOT · ◇WORK	1003-2004-2102-3026	AEEF
49	Yes.	yes.	×YES	2103	C0EE
50	No.	no.	×NO	2101	AF5B
51	Where is the toilet?	where be toilet-place?	?WHERE · ◇BE · ⌂TOILET:PLACE	0105-3001-5008	4A6B
52	Where is water?	where be water?	?WHERE · ◇BE · ○WATER	0105-3001-100B	C66F
53	Where is food?	where be food-thing?	?WHERE · ◇BE · □FOOD:OBJ	0105-3001-4009	03B1
54	Where is the hospital?	where be hospital-place?	?WHERE · ◇BE · ⌂HOSPITAL:PLACE	0105-3001-5003	8CCC
55	Where is home?	where be house-place?	?WHERE · ◇BE · ⌂HOUSE:PLACE	0105-3001-5004	E6FC
56	Who is that person?	who be that person?	?WHO · ◇BE · ○THAT · ○PERSON	0106-3001-1008-1004	EC4B
57	What is this?	what be this?	?WHAT · ◇BE · ○THIS	0103-3001-1009	846F
58	When will I go?	when mi future go?	?WHEN · ○MI · ◷FUTURE · ◇GO	0104-1003-2001-300F	5865
59	Why do you not eat?	why tu not eat?	?WHY · ○TU · ×NOT · ◇EAT	0107-100A-2102-300C	EF55
60	How do you make this?	how tu make this?	?HOW · ○TU · ◇MAKE · ○THIS	0101-100A-3013-1009	28CE

ID	English	Canonical NE-IL	PICTO-2	WAVE token sequence	CRC
61	I have two books.	mi have two book-thing-many.	○MI · ◇HAVE · #TWO · □BOOK:OBJ+PL	1003-3010-8007-4002	093A
62	I have many friends.	mi have many friend-many.	○MI · ◇HAVE · #MANY · ○○FRIEND:PL	1003-3010-8004-8101	3D96
63	There is no water in the bottle.	water not be in bottle-thing.	○WATER · ×NOT · ◇BE · →IN · □BOTTLE:OBJ	100B-2102-3001-7005-4003	A10B
64	Many people are in the city.	many person-many be in city-place.	#MANY · ○○PERSON:PL · ◇BE · →IN · ⌂CITY:PLACE	8004-8102-3001-7005-5002	7C18
65	Few friends live in the city.	few friend-many live in city-place.	#FEW · ○○FRIEND:PL · ◇LIVE · →IN · ⌂CITY:PLACE	8002-8101-3012-7005-5002	51F9
66	Everyone goes now.	all person-many now go.	#ALL · ○○PERSON:PL · ◷NOW · ◇GO	8001-8102-2002-300F	BFEA
67	My name is Ana.	mi-own name-thing be Ana.	○MI:OWN · □NAME:OBJ · ◇BE · “ANA”	1101-400C-3001-9001[ANA]	F1D7
68	That person is Daniel.	that person be Daniel.	○THAT · ○PERSON · ◇BE · “DANIEL”	1008-1004-3001-9001[DANIEL]	5A8C
69	My house is big.	mi-own house-place be big-al.	○MI:OWN · ⌂HOUSE:PLACE · ◇BE · △BIG:STATE	1101-5004-3001-6001	90A6
70	Her book is new.	she-own book-thing be new-al.	○SHE:OWN · □BOOK:OBJ · ◇BE · △NEW:STATE	1102-4001-3001-600B	A847
71	I am taller than you.	mi be more tall-al than tu.	○MI · ◇BE · #MORE · △TALL:STATE · →THAN · ○TU	1003-3001-8005-600F-7007-100A	CE25
72	She is younger than he is.	she be less old-al than he.	○SHE · ◇BE · #LESS · △OLD:STATE · →THAN · ○HE	1006-3001-8003-600C-7007-1002	D606
73	This house is the same size as that house.	this house-place-own size-thing be same as that house-place-own size-thing.	○THIS · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ · ◇BE · #SAME · →AS · ○THAT · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ	1009-5005-4010-3001-8006-7001-1008-5005-4010	A906
74	I am hungrier than you.	mi be more hungry-al than tu.	○MI · ◇BE · #MORE · △HUNGRY:STATE · →THAN · ○TU	1003-3001-8005-6008-7007-100A	BBFA
75	I am less tired than you.	mi be less tired-al than tu.	○MI · ◇BE · #LESS · △TIRED:STATE · →THAN · ○TU	1003-3001-8003-6011-7007-100A	1805
76	The friend is good.	friend be good-al.	○FRIEND · ◇BE · △GOOD:STATE	1001-3001-6005	5243
77	The road is long.	road be long-al.	○ROAD · ◇BE · △LONG:STATE	1005-3001-600A	C189
78	The sky is blue.	sky be blue-al.	○SKY · ◇BE · △BLUE:STATE	1007-3001-6002	2946
79	The water is cold.	water be cold-al.	○WATER · ◇BE · △COLD:STATE	100B-3001-6003	596F
80	The food is hot.	food-thing be hot-al.	□FOOD:OBJ · ◇BE · △HOT:STATE	4009-3001-6007	E656
81	I open the door now.	mi now open door-thing.	○MI · ◷NOW · ◇OPEN · □DOOR:OBJ	1003-2002-3015-4008	3399
82	I close the door now.	mi now close door-thing.	○MI · ◷NOW · ◇CLOSE · □DOOR:OBJ	1003-2002-3006-4008	5150
83	I sit now.	mi now sit.	○MI · ◷NOW · ◇SIT	1003-2002-301A	72FC
84	I stand now.	mi now stand.	○MI · ◷NOW · ◇STAND	1003-2002-301D	B3B0
85	I walk now.	mi now walk.	○MI · ◷NOW · ◇WALK	1003-2002-3024	FFE9
86	I run now.	mi now run.	○MI · ◷NOW · ◇RUN	1003-2002-3018	2572
87	I stop now.	mi now stop.	○MI · ◷NOW · ◇STOP	1003-2002-301E	5F63
88	I will wait.	mi future wait.	○MI · ◷FUTURE · ◇WAIT	1003-2001-3022	984C
89	I come from the city now.	mi now come from city-place.	○MI · ◷NOW · ◇COME · →FROM · ⌂CITY:PLACE	1003-2002-3007-7004-5002	DE13
90	I bring the book now.	mi now bring book-thing.	○MI · ◷NOW · ◇BRING · □BOOK:OBJ	1003-2002-3002-4001	BE37
91	I give water to a person now.	mi now give water to person.	○MI · ◷NOW · ◇GIVE · ○WATER · →TO · ○PERSON	1003-2002-300E-100B-7008-1004	749D

ID	English	Canonical NE-IL	PICTO-2	WAVE token sequence	CRC
92	A person gives food to me now.	person now give food-thing to mi.	○PERSON · ◷NOW · ◇GIVE · □FOOD:OBJ · →TO · ○MI	1004-2002-300E-4009-7008-1003	6147
93	I see a person now.	mi now see person.	○MI · ◷NOW · ◇SEE · ○PERSON	1003-2002-3019-1004	7A02
94	I hear a person now.	mi now hear person.	○MI · ◷NOW · ◇HEAR · ○PERSON	1003-2002-3011-1004	AB59
95	I speak to a person now.	mi now speak to person.	○MI · ◷NOW · ◇SPEAK · →TO · ○PERSON	1003-2002-301C-7008-1004	A1B6
96	The person does not speak.	person not speak.	○PERSON · ×NOT · ◇SPEAK	1004-2102-301C	DA1C
97	I pay now.	mi now pay.	○MI · ◷NOW · ◇PAY	1003-2002-3016	8115
98	What is the price of this?	what be price-thing of this?	?WHAT · ◇BE · □PRICE:OBJ · →OF · ○THIS	0103-3001-400F-7006-1009	045F
99	I need food now.	mi now need food-thing.	○MI · ◷NOW · ◇NEED · □FOOD:OBJ	1003-2002-3014-4009	C417
100	I am safe now.	mi now be safe-al.	○MI · ◷NOW · ◇BE · △SAFE:STATE	1003-2002-3001-600E	3338

Annex B. Ten communication boards

Each board contains ten complete messages in a 2 × 5 layout. Red cells indicate critical or urgent concepts. Pointing order follows reading order from top-left to bottom-right.

COMMUNICATION BOARD 1 | PHRASES 1-10

#1 I eat. **○MI · ◇EAT** mi eat.	**#2 I drink.** **○MI · ◇DRINK** mi drink.
#3 I sleep. **○MI · ◇SLEEP** mi sleep.	**#4 I woke up.** **○MI · ◷PAST · ◇WAKE** mi past wake.
#5 I wash. **○MI · ◇WASH** mi wash.	**#6 I get dressed.** **○MI · ◇DRESS** mi dress.
#7 I will go to work. **○MI · ◷FUTURE · ◇GO · →TO · ⌂WORK:PLACE** mi future go to work-place.	**#8 I am working now.** **○MI · ◷NOW · ◇WORK** mi now work.
#9 I am studying now. **○MI · ◷NOW · ◇STUDY** mi now study.	**#10 I am reading now.** **○MI · ◷NOW · ◇READ** mi now read.

COMMUNICATION BOARD 2 | PHRASES 11-20

#11 I am writing now. **○MI · ◷NOW · ◇WRITE** mi now write.	**#12 I am cooking now.** **○MI · ◷NOW · ◇COOK** mi now cook.
#13 I eat breakfast. **○MI · ◇EAT · □BREAKFAST:OBJ** mi eat breakfast-thing.	**#14 I eat lunch.** **○MI · ◇EAT · □LUNCH:OBJ** mi eat lunch-thing.
#15 I eat dinner.	**#16 I drink water.**

#11 I am writing now. ○MI · ◷NOW · ◇WRITE mi now write.	**#12 I am cooking now.** ○MI · ◷NOW · ◇COOK mi now cook.
○MI · ◇EAT · □DINNER:OBJ mi eat dinner-thing.	○MI · ◇DRINK · ○WATER mi drink water.
#17 I am hungry. ○MI · ◇BE · △HUNGRY:STATE mi be hungry-al.	**#18 I am thirsty.** ○MI · ◇BE · △THIRSTY:STATE mi be thirsty-al.
#19 I am tired. ○MI · ◇BE · △TIRED:STATE mi be tired-al.	**#20 I am ill.** ○MI · ◇BE · △ILL:STATE mi be ill-al.

COMMUNICATION BOARD 3 | PHRASES 21-30

#21 I am happy. ○MI · ◇BE · △HAPPY:STATE mi be happy-al.	**#22 I am sad.** ○MI · ◇BE · △SAD:STATE mi be sad-al.
#23 I go home now. ○MI · ◷NOW · ◇GO · →TO · ⌂HOUSE:PLACE mi now go to house-place.	**#24 I am at home.** ○MI · ◇BE · →AT · ⌂HOUSE:PLACE mi be at house-place.
#25 I go to school now. ○MI · ◷NOW · ◇GO · →TO · ⌂SCHOOL:PLACE mi now go to school-place.	**#26 I am at school.** ○MI · ◇BE · →AT · ⌂SCHOOL:PLACE mi be at school-place.
#27 I go to the market now. ○MI · ◷NOW · ◇GO · →TO · ⌂MARKET:PLACE mi now go to market-place.	**#28 I buy food now.** ○MI · ◷NOW · ◇BUY · □FOOD:OBJ mi now buy food-thing.
#29 I go to the hospital now. ○MI · ◷NOW · ◇GO · →TO · ⌂HOSPITAL:PLACE mi now go to hospital-place.	**#30 I am at the hospital.** ○MI · ◇BE · →AT · ⌂HOSPITAL:PLACE mi be at hospital-place.

COMMUNICATION BOARD 4 | PHRASES 31-40

#31 Do you understand? **?QA · ○TU · ◇UNDERSTAND** qa tu understand?	**#32 I do not understand.** **○MI · ×NOT · ◇UNDERSTAND** mi not understand.
#33 I need help now. **○MI · ◷NOW · ◇NEED · □HELP:OBJ** mi now need help-thing.	**#34 I call someone now.** **○MI · ◷NOW · ◇CALL · ○PERSON** mi now call person.
#35 I use the phone now. **○MI · ◷NOW · ◇USE · □PHONE:OBJ** mi now use phone-thing.	**#36 I charge the phone now.** **○MI · ◷NOW · ◇CHARGE · □PHONE:OBJ** mi now charge phone-thing.
#37 I go by bus now. **○MI · ◷NOW · ◇GO · →BY · □BUS:OBJ** mi now go by bus-thing.	**#38 I go by car now.** **○MI · ◷NOW · ◇GO · →BY · □CAR:OBJ** mi now go by car-thing.
#39 I wait at the bus stop now. **○MI · ◷NOW · ◇WAIT · →AT · ⌂BUS-STOP:PLACE** mi now wait at bus-stop-place.	**#40 I cross the road now.** **○MI · ◷NOW · ◇CROSS · ○ROAD** mi now cross road.

COMMUNICATION BOARD 5 | PHRASES 41-50

#41 I am in danger. **○MI · ◇BE · △DANGER:STATE** mi be danger-al.	**#42 I need a doctor now.** **○MI · ◷NOW · ◇NEED · □DOCTOR:ROLE** mi now need doctor-er.
#43 I feel pain now. **○MI · ◷NOW · ◇FEEL · □PAIN:OBJ** mi now feel pain-thing.	**#44 I do not eat.** **○MI · ×NOT · ◇EAT** mi not eat.
#45 I do not drink. **○MI · ×NOT · ◇DRINK** mi not drink.	**#46 I will not go to the city.** **○MI · ◷FUTURE · ×NOT · ◇GO · →TO · ⌂CITY:PLACE** mi future not go to city-place.
#47 I am not sleeping now.	**#48 I do not work today.**

#41 I am in danger. **○MI · ◇BE · △DANGER:STATE** mi be danger-al.	**#42 I need a doctor now.** **○MI · ◷NOW · ◇NEED · □DOCTOR:ROLE** mi now need doctor-er.
○MI · ◷NOW · ×NOT · ◇SLEEP mi now not sleep.	**○MI · ◷TODAY · ×NOT · ◇WORK** mi today not work.
#49 Yes. **×YES** yes.	**#50 No.** **×NO** no.

COMMUNICATION BOARD 6 | PHRASES 51-60

#51 Where is the toilet? **?WHERE · ◇BE · ⌂TOILET:PLACE** where be toilet-place?	**#52 Where is water?** **?WHERE · ◇BE · ○WATER** where be water?
#53 Where is food? **?WHERE · ◇BE · □FOOD:OBJ** where be food-thing?	**#54 Where is the hospital?** **?WHERE · ◇BE · ⌂HOSPITAL:PLACE** where be hospital-place?
#55 Where is home? **?WHERE · ◇BE · ⌂HOUSE:PLACE** where be house-place?	**#56 Who is that person?** **?WHO · ◇BE · ○THAT · ○PERSON** who be that person?
#57 What is this? **?WHAT · ◇BE · ○THIS** what be this?	**#58 When will I go?** **?WHEN · ○MI · ◷FUTURE · ◇GO** when mi future go?
#59 Why do you not eat? **?WHY · ○TU · ×NOT · ◇EAT** why tu not eat?	**#60 How do you make this?** **?HOW · ○TU · ◇MAKE · ○THIS** how tu make this?

COMMUNICATION BOARD 7 | PHRASES 61-70

#61 I have two books. ○MI · ◇HAVE · #TWO · □BOOK:OBJ+PL mi have two book-thing-many.	**#62 I have many friends.** ○MI · ◇HAVE · #MANY · ○○FRIEND:PL mi have many friend-many.
#63 There is no water in the bottle. ○WATER · ×NOT · ◇BE · →IN · □BOTTLE:OBJ water not be in bottle-thing.	**#64 Many people are in the city.** #MANY · ○○PERSON:PL · ◇BE · →IN · ⌂CITY:PLACE many person-many be in city-place.
#65 Few friends live in the city. #FEW · ○○FRIEND:PL · ◇LIVE · →IN · ⌂CITY:PLACE few friend-many live in city-place.	**#66 Everyone goes now.** #ALL · ○○PERSON:PL · ◷NOW · ◇GO all person-many now go.
#67 My name is Ana. ○MI:OWN · □NAME:OBJ · ◇BE · “ANA” mi-own name-thing be Ana.	**#68 That person is Daniel.** ○THAT · ○PERSON · ◇BE · “DANIEL” that person be Daniel.
#69 My house is big. ○MI:OWN · ⌂HOUSE:PLACE · ◇BE · △BIG:STATE mi-own house-place be big-al.	**#70 Her book is new.** ○SHE:OWN · □BOOK:OBJ · ◇BE · △NEW:STATE she-own book-thing be new-al.

COMMUNICATION BOARD 8 | PHRASES 71-80

#71 I am taller than you. ○MI · ◇BE · #MORE · △TALL:STATE · →THAN · ○TU mi be more tall-al than tu.	**#72 She is younger than he is.** ○SHE · ◇BE · #LESS · △OLD:STATE · →THAN · ○HE she be less old-al than he.
#73 This house is the same size as that house. ○THIS · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ · ◇BE · #SAME · →AS · ○THAT · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ this house-place-own size-thing be same as that house-place-own size-thing.	**#74 I am hungrier than you.** ○MI · ◇BE · #MORE · △HUNGRY:STATE · →THAN · ○TU mi be more hungry-al than tu.
#75 I am less tired than you. ○MI · ◇BE · #LESS · △TIRED:STATE · →THAN · ○TU mi be less tired-al than tu.	**#76 The friend is good.** ○FRIEND · ◇BE · △GOOD:STATE friend be good-al.
#77 The road is long. ○ROAD · ◇BE · △LONG:STATE	**#78 The sky is blue.** ○SKY · ◇BE · △BLUE:STATE

#71 I am taller than you. **○MI · ◇BE · #MORE · △TALL:STATE · →THAN · ○TU** mi be more tall-al than tu.	**#72 She is younger than he is.** **○SHE · ◇BE · #LESS · △OLD:STATE · →THAN · ○HE** she be less old-al than he.
road be long-al.	sky be blue-al.
#79 The water is cold. **○WATER · ◇BE · △COLD:STATE** water be cold-al.	**#80 The food is hot.** **□FOOD:OBJ · ◇BE · △HOT:STATE** food-thing be hot-al.

COMMUNICATION BOARD 9 | PHRASES 81-90

#81 I open the door now. **○MI · ◷NOW · ◇OPEN · □DOOR:OBJ** mi now open door-thing.	**#82 I close the door now.** **○MI · ◷NOW · ◇CLOSE · □DOOR:OBJ** mi now close door-thing.
#83 I sit now. **○MI · ◷NOW · ◇SIT** mi now sit.	**#84 I stand now.** **○MI · ◷NOW · ◇STAND** mi now stand.
#85 I walk now. **○MI · ◷NOW · ◇WALK** mi now walk.	**#86 I run now.** **○MI · ◷NOW · ◇RUN** mi now run.
#87 I stop now. **○MI · ◷NOW · ◇STOP** mi now stop.	**#88 I will wait.** **○MI · ◷FUTURE · ◇WAIT** mi future wait.
#89 I come from the city now. **○MI · ◷NOW · ◇COME · →FROM · ⌂CITY:PLACE** mi now come from city-place.	**#90 I bring the book now.** **○MI · ◷NOW · ◇BRING · □BOOK:OBJ** mi now bring book-thing.

COMMUNICATION BOARD 10 | PHRASES 91-100

#91 I give water to a person now. ○MI · ◷NOW · ◇GIVE · ○WATER · →TO · ○PERSON mi now give water to person.	**#92 A person gives food to me now.** ○PERSON · ◷NOW · ◇GIVE · □FOOD:OBJ · →TO · ○MI person now give food-thing to mi.
#93 I see a person now. ○MI · ◷NOW · ◇SEE · ○PERSON mi now see person.	**#94 I hear a person now.** ○MI · ◷NOW · ◇HEAR · ○PERSON mi now hear person.
#95 I speak to a person now. ○MI · ◷NOW · ◇SPEAK · →TO · ○PERSON mi now speak to person.	**#96 The person does not speak.** ○PERSON · ×NOT · ◇SPEAK person not speak.
#97 I pay now. ○MI · ◷NOW · ◇PAY mi now pay.	**#98 What is the price of this?** ?WHAT · ◇BE · □PRICE:OBJ · →OF · ○THIS what be price-thing of this?
#99 I need food now. ○MI · ◷NOW · ◇NEED · □FOOD:OBJ mi now need food-thing.	**#100 I am safe now.** ○MI · ◷NOW · ◇BE · △SAFE:STATE mi now be safe-al.

Annex C. Printable study cards

Each card has a prompt band and an answer band. Learners may cover the lower band during recall practice or cut the cards along the grid.

STUDY CARDS 1-10

FRONT #1 I eat. **BACK mi eat.** ○MI · ◇EAT	**FRONT #2 I drink.** **BACK mi drink.** ○MI · ◇DRINK
FRONT #3 I sleep. **BACK mi sleep.** ○MI · ◇SLEEP	**FRONT #4 I woke up.** **BACK mi past wake.** ○MI · ◷PAST · ◇WAKE
FRONT #5 I wash. **BACK mi wash.** ○MI · ◇WASH	**FRONT #6 I get dressed.** **BACK mi dress.** ○MI · ◇DRESS
FRONT #7 I will go to work. **BACK mi future go to work-place.** ○MI · ◷FUTURE · ◇GO · →TO · ⌂WORK:PLACE	**FRONT #8 I am working now.** **BACK mi now work.** ○MI · ◷NOW · ◇WORK
FRONT #9 I am studying now. **BACK mi now study.** ○MI · ◷NOW · ◇STUDY	**FRONT #10 I am reading now.** **BACK mi now read.** ○MI · ◷NOW · ◇READ

STUDY CARDS 11-20

FRONT #11 I am writing now. **BACK mi now write.** ○MI · ◷NOW · ◇WRITE	**FRONT #12 I am cooking now.** **BACK mi now cook.** ○MI · ◷NOW · ◇COOK
FRONT #13 I eat breakfast. **BACK mi eat breakfast-thing.** ○MI · ◇EAT · □BREAKFAST:OBJ	**FRONT #14 I eat lunch.** **BACK mi eat lunch-thing.** ○MI · ◇EAT · □LUNCH:OBJ
FRONT #15 I eat dinner. **BACK mi eat dinner-thing.** ○MI · ◇EAT · □DINNER:OBJ	**FRONT #16 I drink water.** **BACK mi drink water.** ○MI · ◇DRINK · ○WATER
FRONT #17 I am hungry.	**FRONT #18 I am thirsty.**

FRONT #11 I am writing now. **BACK mi now write.** ○MI · ◷NOW · ◇WRITE	**FRONT #12 I am cooking now.** **BACK mi now cook.** ○MI · ◷NOW · ◇COOK
BACK mi be hungry-al. ○MI · ◇BE · △HUNGRY:STATE	**BACK mi be thirsty-al.** ○MI · ◇BE · △THIRSTY:STATE
FRONT #19 I am tired. **BACK mi be tired-al.** ○MI · ◇BE · △TIRED:STATE	**FRONT #20 I am ill.** **BACK mi be ill-al.** ○MI · ◇BE · △ILL:STATE

STUDY CARDS 21-30

FRONT #21 I am happy. **BACK mi be happy-al.** ○MI · ◇BE · △HAPPY:STATE	**FRONT #22 I am sad.** **BACK mi be sad-al.** ○MI · ◇BE · △SAD:STATE
FRONT #23 I go home now. **BACK mi now go to house-place.** ○MI · ◷NOW · ◇GO · →TO · ⌂HOUSE:PLACE	**FRONT #24 I am at home.** **BACK mi be at house-place.** ○MI · ◇BE · →AT · ⌂HOUSE:PLACE
FRONT #25 I go to school now. **BACK mi now go to school-place.** ○MI · ◷NOW · ◇GO · →TO · ⌂SCHOOL:PLACE	**FRONT #26 I am at school.** **BACK mi be at school-place.** ○MI · ◇BE · →AT · ⌂SCHOOL:PLACE
FRONT #27 I go to the market now. **BACK mi now go to market-place.** ○MI · ◷NOW · ◇GO · →TO · ⌂MARKET:PLACE	**FRONT #28 I buy food now.** **BACK mi now buy food-thing.** ○MI · ◷NOW · ◇BUY · □FOOD:OBJ
FRONT #29 I go to the hospital now. **BACK mi now go to hospital-place.** ○MI · ◷NOW · ◇GO · →TO · ⌂HOSPITAL:PLACE	**FRONT #30 I am at the hospital.** **BACK mi be at hospital-place.** ○MI · ◇BE · →AT · ⌂HOSPITAL:PLACE

STUDY CARDS 31-40

FRONT #31 Do you understand? **BACK qa tu understand?** ?QA · ○TU · ◇UNDERSTAND	**FRONT #32 I do not understand.** **BACK mi not understand.** ○MI · ×NOT · ◇UNDERSTAND
FRONT #33 I need help now. **BACK mi now need help-thing.** ○MI · ◷NOW · ◇NEED · □HELP:OBJ	**FRONT #34 I call someone now.** **BACK mi now call person.** ○MI · ◷NOW · ◇CALL · ○PERSON
FRONT #35 I use the phone now. **BACK mi now use phone-thing.** ○MI · ◷NOW · ◇USE · □PHONE:OBJ	**FRONT #36 I charge the phone now.** **BACK mi now charge phone-thing.** ○MI · ◷NOW · ◇CHARGE · □PHONE:OBJ
FRONT #37 I go by bus now. **BACK mi now go by bus-thing.** ○MI · ◷NOW · ◇GO · →BY · □BUS:OBJ	**FRONT #38 I go by car now.** **BACK mi now go by car-thing.** ○MI · ◷NOW · ◇GO · →BY · □CAR:OBJ
FRONT #39 I wait at the bus stop now. **BACK mi now wait at bus-stop-place.** ○MI · ◷NOW · ◇WAIT · →AT · ⌂BUS-STOP:PLACE	**FRONT #40 I cross the road now.** **BACK mi now cross road.** ○MI · ◷NOW · ◇CROSS · ○ROAD

STUDY CARDS 41-50

FRONT #41 I am in danger. **BACK mi be danger-al.** ○MI · ◇BE · △DANGER:STATE	**FRONT #42 I need a doctor now.** **BACK mi now need doctor-er.** ○MI · ◷NOW · ◇NEED · □DOCTOR:ROLE
FRONT #43 I feel pain now. **BACK mi now feel pain-thing.** ○MI · ◷NOW · ◇FEEL · □PAIN:OBJ	**FRONT #44 I do not eat.** **BACK mi not eat.** ○MI · ×NOT · ◇EAT
FRONT #45 I do not drink. **BACK mi not drink.** ○MI · ×NOT · ◇DRINK	**FRONT #46 I will not go to the city.** **BACK mi future not go to city-place.** ○MI · ◷FUTURE · ×NOT · ◇GO · →TO · ⌂CITY:PLACE
FRONT #47 I am not sleeping now. **BACK mi now not sleep.** ○MI · ◷NOW · ×NOT · ◇SLEEP	**FRONT #48 I do not work today.** **BACK mi today not work.** ○MI · ◷TODAY · ×NOT · ◇WORK
FRONT #49 Yes. **BACK yes.** ×YES	**FRONT #50 No.** **BACK no.** ×NO

STUDY CARDS 51-60

FRONT #51 Where is the toilet? **BACK where be toilet-place?** ?WHERE · ◇BE · ⌂TOILET:PLACE	**FRONT #52 Where is water?** **BACK where be water?** ?WHERE · ◇BE · ○WATER
FRONT #53 Where is food? **BACK where be food-thing?** ?WHERE · ◇BE · □FOOD:OBJ	**FRONT #54 Where is the hospital?** **BACK where be hospital-place?** ?WHERE · ◇BE · ⌂HOSPITAL:PLACE
FRONT #55 Where is home? **BACK where be house-place?** ?WHERE · ◇BE · ⌂HOUSE:PLACE	**FRONT #56 Who is that person?** **BACK who be that person?** ?WHO · ◇BE · ○THAT · ○PERSON
FRONT #57 What is this? **BACK what be this?** ?WHAT · ◇BE · ○THIS	**FRONT #58 When will I go?** **BACK when mi future go?** ?WHEN · ○MI · ◷FUTURE · ◇GO
FRONT #59 Why do you not eat? **BACK why tu not eat?** ?WHY · ○TU · ×NOT · ◇EAT	**FRONT #60 How do you make this?** **BACK how tu make this?** ?HOW · ○TU · ◇MAKE · ○THIS

STUDY CARDS 61-70

FRONT #61 I have two books. **BACK mi have two book-thing-many.** ○MI · ◇HAVE · #TWO · □BOOK:OBJ+PL	**FRONT #62 I have many friends.** **BACK mi have many friend-many.** ○MI · ◇HAVE · #MANY · ○○FRIEND:PL
FRONT #63 There is no water in the bottle. **BACK water not be in bottle-thing.** ○WATER · ×NOT · ◇BE · →IN · □BOTTLE:OBJ	**FRONT #64 Many people are in the city.** **BACK many person-many be in city-place.** #MANY · ○○PERSON:PL · ◇BE · →IN · ⌂CITY:PLACE
FRONT #65 Few friends live in the city. **BACK few friend-many live in city-place.** #FEW · ○○FRIEND:PL · ◇LIVE · →IN · ⌂CITY:PLACE	**FRONT #66 Everyone goes now.** **BACK all person-many now go.** #ALL · ○○PERSON:PL · ◷NOW · ◇GO
FRONT #67 My name is Ana. **BACK mi-own name-thing be Ana.** ○MI:OWN · □NAME:OBJ · ◇BE · “ANA”	**FRONT #68 That person is Daniel.** **BACK that person be Daniel.** ○THAT · ○PERSON · ◇BE · “DANIEL”

FRONT #61 I have two books. **BACK mi have two book-thing-many.** ○MI · ◇HAVE · #TWO · □BOOK:OBJ+PL	**FRONT #62 I have many friends.** **BACK mi have many friend-many.** ○MI · ◇HAVE · #MANY · ○○FRIEND:PL
FRONT #69 My house is big. **BACK mi-own house-place be big-al.** ○MI:OWN · ⌂HOUSE:PLACE · ◇BE · △BIG:STATE	**FRONT #70 Her book is new.** **BACK she-own book-thing be new-al.** ○SHE:OWN · □BOOK:OBJ · ◇BE · △NEW:STATE

STUDY CARDS 71-80

FRONT #71 I am taller than you. **BACK mi be more tall-al than tu.** ○MI · ◇BE · #MORE · △TALL:STATE · →THAN · ○TU	**FRONT #72 She is younger than he is.** **BACK she be less old-al than he.** ○SHE · ◇BE · #LESS · △OLD:STATE · →THAN · ○HE
FRONT #73 This house is the same size as that house. **BACK this house-place-own size-thing be same as that house-place-own size-thing.** ○THIS · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ · ◇BE · #SAME · →AS · ○THAT · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ	**FRONT #74 I am hungrier than you.** **BACK mi be more hungry-al than tu.** ○MI · ◇BE · #MORE · △HUNGRY:STATE · →THAN · ○TU
FRONT #75 I am less tired than you. **BACK mi be less tired-al than tu.** ○MI · ◇BE · #LESS · △TIRED:STATE · →THAN · ○TU	**FRONT #76 The friend is good.** **BACK friend be good-al.** ○FRIEND · ◇BE · △GOOD:STATE
FRONT #77 The road is long. **BACK road be long-al.** ○ROAD · ◇BE · △LONG:STATE	**FRONT #78 The sky is blue.** **BACK sky be blue-al.** ○SKY · ◇BE · △BLUE:STATE
FRONT #79 The water is cold. **BACK water be cold-al.** ○WATER · ◇BE · △COLD:STATE	**FRONT #80 The food is hot.** **BACK food-thing be hot-al.** □FOOD:OBJ · ◇BE · △HOT:STATE

STUDY CARDS 81-90

FRONT #81 I open the door now. **BACK mi now open door-thing.** ○MI · ◷NOW · ◇OPEN · □DOOR:OBJ	**FRONT #82 I close the door now.** **BACK mi now close door-thing.** ○MI · ◷NOW · ◇CLOSE · □DOOR:OBJ
FRONT #83 I sit now.	**FRONT #84 I stand now.**

FRONT #81 I open the door now. **BACK mi now open door-thing.** ○MI · ◷NOW · ◇OPEN · □DOOR:OBJ	**FRONT #82 I close the door now.** **BACK mi now close door-thing.** ○MI · ◷NOW · ◇CLOSE · □DOOR:OBJ
BACK mi now sit. ○MI · ◷NOW · ◇SIT	**BACK mi now stand.** ○MI · ◷NOW · ◇STAND
FRONT #85 I walk now. **BACK mi now walk.** ○MI · ◷NOW · ◇WALK	**FRONT #86 I run now.** **BACK mi now run.** ○MI · ◷NOW · ◇RUN
FRONT #87 I stop now. **BACK mi now stop.** ○MI · ◷NOW · ◇STOP	**FRONT #88 I will wait.** **BACK mi future wait.** ○MI · ◷FUTURE · ◇WAIT
FRONT #89 I come from the city now. **BACK mi now come from city-place.** ○MI · ◷NOW · ◇COME · →FROM · ⌂CITY:PLACE	**FRONT #90 I bring the book now.** **BACK mi now bring book-thing.** ○MI · ◷NOW · ◇BRING · □BOOK:OBJ

STUDY CARDS 91-100

FRONT #91 I give water to a person now. **BACK mi now give water to person.** ○MI · ◷NOW · ◇GIVE · ○WATER · →TO · ○PERSON	**FRONT #92 A person gives food to me now.** **BACK person now give food-thing to mi.** ○PERSON · ◷NOW · ◇GIVE · □FOOD:OBJ · →TO · ○MI
FRONT #93 I see a person now. **BACK mi now see person.** ○MI · ◷NOW · ◇SEE · ○PERSON	**FRONT #94 I hear a person now.** **BACK mi now hear person.** ○MI · ◷NOW · ◇HEAR · ○PERSON
FRONT #95 I speak to a person now. **BACK mi now speak to person.** ○MI · ◷NOW · ◇SPEAK · →TO · ○PERSON	**FRONT #96 The person does not speak.** **BACK person not speak.** ○PERSON · ×NOT · ◇SPEAK
FRONT #97 I pay now. **BACK mi now pay.** ○MI · ◷NOW · ◇PAY	**FRONT #98 What is the price of this?** **BACK what be price-thing of this?** ?WHAT · ◇BE · □PRICE:OBJ · →OF · ○THIS
FRONT #99 I need food now. **BACK mi now need food-thing.** ○MI · ◷NOW · ◇NEED · □FOOD:OBJ	**FRONT #100 I am safe now.** **BACK mi now be safe-al.** ○MI · ◷NOW · ◇BE · △SAFE:STATE

Annex D. Seven-day learning manual

Recommended session length: 25-40 minutes per day. Each phrase appears exactly once in the primary sequence. Review items may be repeated after the assigned day without changing the coverage count.

Daily learning cycle

1. Recognition: read the English prompt and identify the NE-IL and PICTO form.
2. Production: say or write the NE-IL form without looking at the answer.
3. Visual mapping: rebuild the PICTO token order from semantic roles.
4. Transport awareness: compare the token order with the WAVE identifier sequence and CRC.
5. Variation: change one element while preserving the canonical grammar.
6. Review: retest missed items after a short interval.

Day 1 - Identity, confirmation, and questions

Focus: Question status, reference words, confirmation, and refusal.

ID	English	NE-IL	PICTO-2
49	Yes.	yes.	×YES
50	No.	no.	×NO
31	Do you understand?	qa tu understand?	?QA · ○TU · ◇UNDERSTAND
32	I do not understand.	mi not understand.	○MI · ×NOT · ◇UNDERSTAND
51	Where is the toilet?	where be toilet-place?	?WHERE · ◇BE · ⌂TOILET:PLACE
52	Where is water?	where be water?	?WHERE · ◇BE · ○WATER
53	Where is food?	where be food-thing?	?WHERE · ◇BE · □FOOD:OBJ
54	Where is the hospital?	where be hospital-place?	?WHERE · ◇BE · ⌂HOSPITAL:PLACE
55	Where is home?	where be house-place?	?WHERE · ◇BE · ⌂HOUSE:PLACE
56	Who is that person?	who be that person?	?WHO · ◇BE · ○THAT · ○PERSON
57	What is this?	what be this?	?WHAT · ◇BE · ○THIS
58	When will I go?	when mi future go?	?WHEN · ○MI · ◷FUTURE · ◇GO
59	Why do you not eat?	why tu not eat?	?WHY · ○TU · ×NOT · ◇EAT
60	How do you make this?	how tu make this?	?HOW · ○TU · ◇MAKE · ○THIS

Practice task: create two valid substitutions from the day's vocabulary, then perform a text → PICTO → text round trip. Mark any uncertain token rather than guessing.

Day 2 - Body, routines, food, and water

Focus: Routine verbs, meal objects, body states, and the copula be.

ID	English	NE-IL	PICTO-2
1	I eat.	mi eat.	○MI · ◇EAT
2	I drink.	mi drink.	○MI · ◇DRINK
3	I sleep.	mi sleep.	○MI · ◇SLEEP
4	I woke up.	mi past wake.	○MI · ◷PAST · ◇WAKE
5	I wash.	mi wash.	○MI · ◇WASH
6	I get dressed.	mi dress.	○MI · ◇DRESS
13	I eat breakfast.	mi eat breakfast-thing.	○MI · ◇EAT · □BREAKFAST:OBJ
14	I eat lunch.	mi eat lunch-thing.	○MI · ◇EAT · □LUNCH:OBJ

ID	English	NE-IL	PICTO-2
15	I eat dinner.	mi eat dinner-thing.	○MI · ◇EAT · □DINNER:OBJ
16	I drink water.	mi drink water.	○MI · ◇DRINK · ○WATER
17	I am hungry.	mi be hungry-al.	○MI · ◇BE · △HUNGRY:STATE
18	I am thirsty.	mi be thirsty-al.	○MI · ◇BE · △THIRSTY:STATE
19	I am tired.	mi be tired-al.	○MI · ◇BE · △TIRED:STATE
20	I am ill.	mi be ill-al.	○MI · ◇BE · △ILL:STATE

Practice task: create two valid substitutions from the day's vocabulary, then perform a text → PICTO → text round trip. Mark any uncertain token rather than guessing.

Day 3 - Work, learning, feelings, and familiar places

Focus: Time particles, work and learning actions, feelings, and common destinations.

ID	English	NE-IL	PICTO-2
7	I will go to work.	mi future go to work-place.	○MI · ◷FUTURE · ◇GO · →TO · ⌂WORK:PLACE
8	I am working now.	mi now work.	○MI · ◷NOW · ◇WORK
9	I am studying now.	mi now study.	○MI · ◷NOW · ◇STUDY
10	I am reading now.	mi now read.	○MI · ◷NOW · ◇READ
11	I am writing now.	mi now write.	○MI · ◷NOW · ◇WRITE
12	I am cooking now.	mi now cook.	○MI · ◷NOW · ◇COOK
21	I am happy.	mi be happy-al.	○MI · ◇BE · △HAPPY:STATE
22	I am sad.	mi be sad-al.	○MI · ◇BE · △SAD:STATE
23	I go home now.	mi now go to house-place.	○MI · ◷NOW · ◇GO · →TO · ⌂HOUSE:PLACE
24	I am at home.	mi be at house-place.	○MI · ◇BE · →AT · ⌂HOUSE:PLACE
25	I go to school now.	mi now go to school-place.	○MI · ◷NOW · ◇GO · →TO · ⌂SCHOOL:PLACE
26	I am at school.	mi be at school-place.	○MI · ◇BE · →AT · ⌂SCHOOL:PLACE
27	I go to the market now.	mi now go to market-place.	○MI · ◷NOW · ◇GO · →TO · ⌂MARKET:PLACE
28	I buy food now.	mi now buy food-thing.	○MI · ◷NOW · ◇BUY · □FOOD:OBJ

Practice task: create two valid substitutions from the day's vocabulary, then perform a text → PICTO → text round trip. Mark any uncertain token rather than guessing.

Day 4 - Health, safety, needs, and negation

Focus: Critical concepts, negative scope, safety vocabulary, and acknowledgment practice.

ID	English	NE-IL	PICTO-2
29	I go to the hospital now.	mi now go to hospital-place.	○MI · ◷NOW · ◇GO · →TO · ⌂HOSPITAL:PLACE
30	I am at the hospital.	mi be at hospital-place.	○MI · ◇BE · →AT · ⌂HOSPITAL:PLACE
33	I need help now.	mi now need help-thing.	○MI · ◷NOW · ◇NEED · □HELP:OBJ
41	I am in danger.	mi be danger-al.	○MI · ◇BE · △DANGER:STATE
42	I need a doctor now.	mi now need doctor-er.	○MI · ◷NOW · ◇NEED · □DOCTOR:ROLE
43	I feel pain now.	mi now feel pain-thing.	○MI · ◷NOW · ◇FEEL · □PAIN:OBJ
44	I do not eat.	mi not eat.	○MI · ×NOT · ◇EAT
45	I do not drink.	mi not drink.	○MI · ×NOT · ◇DRINK
46	I will not go to the city.	mi future not go to city-place.	○MI · ◷FUTURE · ×NOT · ◇GO · →TO · ⌂CITY:PLACE
47	I am not sleeping now.	mi now not sleep.	○MI · ◷NOW · ×NOT · ◇SLEEP

ID	English	NE-IL	PICTO-2
48	I do not work today.	mi today not work.	○MI · ◷TODAY · ×NOT · ◇WORK
99	I need food now.	mi now need food-thing.	○MI · ◷NOW · ◇NEED · □FOOD:OBJ
100	I am safe now.	mi now be safe-al.	○MI · ◷NOW · ◇BE · △SAFE:STATE
87	I stop now.	mi now stop.	○MI · ◷NOW · ◇STOP

Practice task: create two valid substitutions from the day's vocabulary, then perform a text → PICTO → text round trip. Mark any uncertain token rather than guessing.

Day 5 - Movement, tools, doors, and waiting

Focus: Movement, devices, location relations, doors, and action contrasts.

ID	English	NE-IL	PICTO-2
34	I call someone now.	mi now call person.	○MI · ◷NOW · ◇CALL · ○PERSON
35	I use the phone now.	mi now use phone-thing.	○MI · ◷NOW · ◇USE · □PHONE:OBJ
36	I charge the phone now.	mi now charge phone-thing.	○MI · ◷NOW · ◇CHARGE · □PHONE:OBJ
37	I go by bus now.	mi now go by bus-thing.	○MI · ◷NOW · ◇GO · →BY · □BUS:OBJ
38	I go by car now.	mi now go by car-thing.	○MI · ◷NOW · ◇GO · →BY · □CAR:OBJ
39	I wait at the bus stop now.	mi now wait at bus-stop-place.	○MI · ◷NOW · ◇WAIT · →AT · ⌂BUS-STOP:PLACE
40	I cross the road now.	mi now cross road.	○MI · ◷NOW · ◇CROSS · ○ROAD
81	I open the door now.	mi now open door-thing.	○MI · ◷NOW · ◇OPEN · □DOOR:OBJ
82	I close the door now.	mi now close door-thing.	○MI · ◷NOW · ◇CLOSE · □DOOR:OBJ
83	I sit now.	mi now sit.	○MI · ◷NOW · ◇SIT
84	I stand now.	mi now stand.	○MI · ◷NOW · ◇STAND
85	I walk now.	mi now walk.	○MI · ◷NOW · ◇WALK
86	I run now.	mi now run.	○MI · ◷NOW · ◇RUN
88	I will wait.	mi future wait.	○MI · ◷FUTURE · ◇WAIT

Practice task: create two valid substitutions from the day's vocabulary, then perform a text → PICTO → text round trip. Mark any uncertain token rather than guessing.

Day 6 - Quantity, identity, possession, and comparison

Focus: Plurality, quantity, possession, proper-name literals, and comparison structures.

ID	English	NE-IL	PICTO-2
61	I have two books.	mi have two book-thing-many.	○MI · ◇HAVE · #TWO · □BOOK:OBJ+PL
62	I have many friends.	mi have many friend-many.	○MI · ◇HAVE · #MANY · ○○FRIEND:PL
63	There is no water in the bottle.	water not be in bottle-thing.	○WATER · ×NOT · ◇BE · →IN · □BOTTLE:OBJ
64	Many people are in the city.	many person-many be in city-place.	#MANY · ○○PERSON:PL · ◇BE · →IN · ⌂CITY:PLACE
65	Few friends live in the city.	few friend-many live in city-place.	#FEW · ○○FRIEND:PL · ◇LIVE · →IN · ⌂CITY:PLACE
66	Everyone goes now.	all person-many now go.	#ALL · ○○PERSON:PL · ◷NOW · ◇GO
67	My name is Ana.	mi-own name-thing be Ana.	○MI:OWN · □NAME:OBJ · ◇BE · “ANA”
68	That person is Daniel.	that person be Daniel.	○THAT · ○PERSON · ◇BE · “DANIEL”
69	My house is big.	mi-own house-place be big-al.	○MI:OWN · ⌂HOUSE:PLACE · ◇BE · △BIG:STATE
70	Her book is new.	she-own book-thing be new-al.	○SHE:OWN · □BOOK:OBJ · ◇BE · △NEW:STATE

ID	English	NE-IL	PICTO-2
71	I am taller than you.	mi be more tall-al than tu.	○MI · ◇BE · #MORE · △TALL:STATE · →THAN · ○TU
72	She is younger than he is.	she be less old-al than he.	○SHE · ◇BE · #LESS · △OLD:STATE · →THAN · ○HE
73	This house is the same size as that house.	this house-place-own size-thing be same as that house-place-own size-thing.	○THIS · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ · ◇BE · #SAME · →AS · ○THAT · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ
74	I am hungrier than you.	mi be more hungry-al than tu.	○MI · ◇BE · #MORE · △HUNGRY:STATE · →THAN · ○TU
75	I am less tired than you.	mi be less tired-al than tu.	○MI · ◇BE · #LESS · △TIRED:STATE · →THAN · ○TU

Practice task: create two valid substitutions from the day's vocabulary, then perform a text → PICTO → text round trip. Mark any uncertain token rather than guessing.

Day 7 - Description, transfer, perception, and transactions

Focus: Qualities, transfer roles, perception, speech, payment, and integrated round-trip practice.

ID	English	NE-IL	PICTO-2
76	The friend is good.	friend be good-al.	○FRIEND · ◇BE · △GOOD:STATE
77	The road is long.	road be long-al.	○ROAD · ◇BE · △LONG:STATE
78	The sky is blue.	sky be blue-al.	○SKY · ◇BE · △BLUE:STATE
79	The water is cold.	water be cold-al.	○WATER · ◇BE · △COLD:STATE
80	The food is hot.	food-thing be hot-al.	□FOOD:OBJ · ◇BE · △HOT:STATE
89	I come from the city now.	mi now come from city-place.	○MI · ◷NOW · ◇COME · →FROM · ⌂CITY:PLACE
90	I bring the book now.	mi now bring book-thing.	○MI · ◷NOW · ◇BRING · □BOOK:OBJ
91	I give water to a person now.	mi now give water to person.	○MI · ◷NOW · ◇GIVE · ○WATER · →TO · ○PERSON
92	A person gives food to me now.	person now give food-thing to mi.	○PERSON · ◷NOW · ◇GIVE · □FOOD:OBJ · →TO · ○MI
93	I see a person now.	mi now see person.	○MI · ◷NOW · ◇SEE · ○PERSON
94	I hear a person now.	mi now hear person.	○MI · ◷NOW · ◇HEAR · ○PERSON
95	I speak to a person now.	mi now speak to person.	○MI · ◷NOW · ◇SPEAK · →TO · ○PERSON
96	The person does not speak.	person not speak.	○PERSON · ×NOT · ◇SPEAK
97	I pay now.	mi now pay.	○MI · ◷NOW · ◇PAY
98	What is the price of this?	what be price-thing of this?	?WHAT · ◇BE · □PRICE:OBJ · →OF · ○THIS

Practice task: create two valid substitutions from the day's vocabulary, then perform a text → PICTO → text round trip. Mark any uncertain token rather than guessing.

Annex E. Visual and lexical dictionary

This dictionary contains every canonical token used by the 100-phrase inventory. The 16-bit identifier is normative for machine interchange; the shape and label are normative for PICTO display.

Questions

PICTO label	NE-IL token	ID	Category
?HOW	how	0101	question
?QA	qa	0102	question
?WHAT	what	0103	question
?WHEN	when	0104	question
?WHERE	where	0105	question
?WHO	who	0106	question
?WHY	why	0107	question

References and entities

PICTO label	NE-IL token	ID	Category
○FRIEND	friend	1001	reference
○HE	he	1002	reference
○MI	mi	1003	reference
○PERSON	person	1004	reference
○ROAD	road	1005	reference
○SHE	she	1006	reference
○SKY	sky	1007	reference
○THAT	that	1008	reference
○THIS	this	1009	reference
○TU	tu	100A	reference
○WATER	water	100B	reference

Possessors

PICTO label	NE-IL token	ID	Category
○MI:OWN	mi-own	1101	possessor
○SHE:OWN	she-own	1102	possessor

Time

PICTO label	NE-IL token	ID	Category
◷FUTURE	future	2001	time
◷NOW	now	2002	time
◷PAST	past	2003	time
◷TODAY	today	2004	time

Polarity and answers

PICTO label	NE-IL token	ID	Category
×NO	no	2101	polarity
×NOT	not	2102	polarity
×YES	yes	2103	polarity

Actions and copula

PICTO label	NE-IL token	ID	Category
◇BE	be	3001	verb
◇BRING	bring	3002	verb
◇BUY	buy	3003	verb
◇CALL	call	3004	verb
◇CHARGE	charge	3005	verb
◇CLOSE	close	3006	verb
◇COME	come	3007	verb
◇COOK	cook	3008	verb
◇CROSS	cross	3009	verb
◇DRESS	dress	300A	verb
◇DRINK	drink	300B	verb
◇EAT	eat	300C	verb
◇FEEL	feel	300D	verb
◇GIVE	give	300E	verb
◇GO	go	300F	verb
◇HAVE	have	3010	verb
◇HEAR	hear	3011	verb
◇LIVE	live	3012	verb
◇MAKE	make	3013	verb
◇NEED	need	3014	verb
◇OPEN	open	3015	verb
◇PAY	pay	3016	verb
◇READ	read	3017	verb
◇RUN	run	3018	verb
◇SEE	see	3019	verb
◇SIT	sit	301A	verb
◇SLEEP	sleep	301B	verb
◇SPEAK	speak	301C	verb
◇STAND	stand	301D	verb
◇STOP	stop	301E	verb
◇STUDY	study	301F	verb
◇UNDERSTAND	understand	3020	verb
◇USE	use	3021	verb

PICTO label	NE-IL token	ID	Category
◇WAIT	wait	3022	verb
◇WAKE	wake	3023	verb
◇WALK	walk	3024	verb
◇WASH	wash	3025	verb
◇WORK	work	3026	verb
◇WRITE	write	3027	verb

Objects

PICTO label	NE-IL token	ID	Category
□BOOK:OBJ	book-thing	4001	object
□BOOK:OBJ+PL	book-thing-many	4002	object
□BOTTLE:OBJ	bottle-thing	4003	object
□BREAKFAST:OBJ	breakfast-thing	4004	object
□BUS:OBJ	bus-thing	4005	object
□CAR:OBJ	car-thing	4006	object
□DINNER:OBJ	dinner-thing	4007	object
□DOOR:OBJ	door-thing	4008	object
□FOOD:OBJ	food-thing	4009	object
□HELP:OBJ	help-thing	400A	object
□LUNCH:OBJ	lunch-thing	400B	object
□NAME:OBJ	name-thing	400C	object
□PAIN:OBJ	pain-thing	400D	object
□PHONE:OBJ	phone-thing	400E	object
□PRICE:OBJ	price-thing	400F	object
□SIZE:OBJ	size-thing	4010	object

Roles

PICTO label	NE-IL token	ID	Category
□DOCTOR:ROLE	doctor-er	4201	agent

Places

PICTO label	NE-IL token	ID	Category
⌂BUS-STOP:PLACE	bus-stop-place	5001	place
⌂CITY:PLACE	city-place	5002	place
⌂HOSPITAL:PLACE	hospital-place	5003	place
⌂HOUSE:PLACE	house-place	5004	place
⌂HOUSE:PLACE+OWN	house-place-own	5005	place
⌂MARKET:PLACE	market-place	5006	place
⌂SCHOOL:PLACE	school-place	5007	place
⌂TOILET:PLACE	toilet-place	5008	place

PICTO label	NE-IL token	ID	Category
⌂WORK:PLACE	work-place	5009	place

States and qualities

PICTO label	NE-IL token	ID	Category
△BIG:STATE	big-al	6001	state
△BLUE:STATE	blue-al	6002	state
△COLD:STATE	cold-al	6003	state
△DANGER:STATE	danger-al	6004	state
△GOOD:STATE	good-al	6005	state
△HAPPY:STATE	happy-al	6006	state
△HOT:STATE	hot-al	6007	state
△HUNGRY:STATE	hungry-al	6008	state
△ILL:STATE	ill-al	6009	state
△LONG:STATE	long-al	600A	state
△NEW:STATE	new-al	600B	state
△OLD:STATE	old-al	600C	state
△SAD:STATE	sad-al	600D	state
△SAFE:STATE	safe-al	600E	state
△TALL:STATE	tall-al	600F	state
△THIRSTY:STATE	thirsty-al	6010	state
△TIRED:STATE	tired-al	6011	state

Relations

PICTO label	NE-IL token	ID	Category
→AS	as	7001	relation
→AT	at	7002	relation
→BY	by	7003	relation
→FROM	from	7004	relation
→IN	in	7005	relation
→OF	of	7006	relation
→THAN	than	7007	relation
→TO	to	7008	relation

Quantity and comparison

PICTO label	NE-IL token	ID	Category
#ALL	all	8001	quantity
#FEW	few	8002	quantity
#LESS	less	8003	quantity
#MANY	many	8004	quantity
#MORE	more	8005	quantity

PICTO label	NE-IL token	ID	Category
#SAME	same	8006	quantity
#TWO	two	8007	quantity

Groups

PICTO label	NE-IL token	ID	Category
○○FRIEND:PL	friend-many	8101	group
○○PERSON:PL	person-many	8102	group

Literals

The 16-bit value 9001 is a literal type marker, not a unique identifier for each name. The marker is followed by one byte of UTF-8 length and the NFC-normalized UTF-8 bytes; therefore different literal values remain distinct in the WAVE payload.

PICTO label	NE-IL token	ID / encoding	Category
“ANA”	Ana	9001 + 03 + 41 4E 41	literal block
“DANIEL”	Daniel	9001 + 06 + 44 41 4E 49 45 4C	literal block

Annex F. Printable exercises, answer key, and checklist

F.1 Translate English to canonical NE-IL

1. I eat. _____
2. I woke up. _____
3. I will go to work. _____
4. I drink water. _____
5. I am hungry. _____
6. I go home now. _____
7. I go to the hospital now. _____
8. Do you understand? _____
9. I need help now. _____
10. I am in danger. _____
11. I need a doctor now. _____
12. I will not go to the city. _____
13. When will I go? _____
14. I have two books. _____
15. My name is Ana. _____
16. I am taller than you. _____
17. I open the door now. _____
18. I give water to a person now. _____
19. What is the price of this? _____
20. I am safe now. _____

F.2 Decode PICTO-2

1. ×YES _____
2. ×NO _____
3. ?WHERE · ◇BE · ⌂TOILET:PLACE _____
4. ?WHERE · ◇BE · ○WATER _____
5. ?WHERE · ◇BE · ⌂HOSPITAL:PLACE _____
6. ?WHAT · ◇BE · ○THIS _____
7. ?WHY · ○TU · ×NOT · ◇EAT _____
8. ○WATER · ×NOT · ◇BE · →IN · □BOTTLE:OBJ _____
9. ○MI:OWN · ⌂HOUSE:PLACE · ◇BE · △BIG:STATE _____
10. ○SHE · ◇BE · #LESS · △OLD:STATE · →THAN · ○HE _____
11. ○WATER · ◇BE · △COLD:STATE _____
12. ○MI · ◷NOW · ◇CLOSE · □DOOR:OBJ _____
13. ○MI · ◷NOW · ◇STOP _____
14. ○MI · ◷NOW · ◇COME · →FROM · ⌂CITY:PLACE _____
15. ○PERSON · ◷NOW · ◇GIVE · □FOOD:OBJ · →TO · ○MI _____

16. ○MI · ◷NOW · ◇SPEAK · →TO · ○PERSON _____

17. ○PERSON · ×NOT · ◇SPEAK _____

18. ○MI · ◷NOW · ◇NEED · □FOOD:OBJ _____

19. ○MI · ◷NOW · ◇BE · △SAFE:STATE _____

20. ○MI · ◷NOW · ◇NEED · □HELP:OBJ _____

F.3 Build the complete frame from meaning blocks

1. self + now + need + help-object _____

2. where + be + hospital-place _____

3. self + future + not + go + to + city-place _____

4. self + now + give + water + to + person _____

5. person + now + give + food-object + to + self _____

6. self-own + name-object + be + Ana _____

7. this house-own size + be + same + as + that house-own size _____

8. self + now + be + safe-state _____

9. what + be + price-object + of + this _____

10. all + people-plural + now + go _____

F.4 WAVE frame validation

1. Identify the field that detects payload corruption.

_____

2. Explain why Length and CRC must both be checked.

_____

3. Name the required receiver response when two valid frames share a message ID but have different payloads.

_____

4. State the purpose of the sequence field.

_____

5. List the four conditions that require frame rejection: invalid length, invalid escaping, unknown version, and failed CRC.

_____

6. Describe the difference between Normal, Confirmed, and Critical reliability profiles.

_____

F.5 Answer key

1. mi eat.
2. mi past wake.
3. mi future go to work-place.
4. mi drink water.
5. mi be hungry-al.
6. mi now go to house-place.
7. mi now go to hospital-place.

8. qa tu understand?
9. mi now need help-thing.
10. mi be danger-al.
11. mi now need doctor-er.
12. mi future not go to city-place.
13. when mi future go?
14. mi have two book-thing-many.
15. mi-own name-thing be Ana.
16. mi be more tall-al than tu.
17. mi now open door-thing.
18. mi now give water to person.
19. what be price-thing of this?
20. mi now be safe-al.

PICTO decoding answers:

1. Yes. — yes.
2. No. — no.
3. Where is the toilet? — where be toilet-place?
4. Where is water? — where be water?
5. Where is the hospital? — where be hospital-place?
6. What is this? — what be this?
7. Why do you not eat? — why tu not eat?
8. There is no water in the bottle. — water not be in bottle-thing.
9. My house is big. — mi-own house-place be big-al.
10. She is younger than he is. — she be less old-al than he.
11. The water is cold. — water be cold-al.
12. I close the door now. — mi now close door-thing.
13. I stop now. — mi now stop.
14. I come from the city now. — mi now come from city-place.
15. A person gives food to me now. — person now give food-thing to mi.
16. I speak to a person now. — mi now speak to person.
17. The person does not speak. — person not speak.
18. I need food now. — mi now need food-thing.
19. I am safe now. — mi now be safe-al.
20. I need help now. — mi now need help-thing.

Meaning-block answers:

1. mi now need help-thing. | ○MI · ◷NOW · ◇NEED · □HELP:OBJ
2. where be hospital-place? | ?WHERE · ◇BE · ⌂HOSPITAL:PLACE
3. mi future not go to city-place. | ○MI · ◷FUTURE · ×NOT · ◇GO · →TO · ⌂CITY:PLACE
4. mi now give water to person. | ○MI · ◷NOW · ◇GIVE · ○WATER · →TO · ○PERSON
5. person now give food-thing to mi. | ○PERSON · ◷NOW · ◇GIVE · □FOOD:OBJ · →TO · ○MI
6. mi-own name-thing be Ana. | ○MI:OWN · □NAME:OBJ · ◇BE · “ANA”
7. this house-place-own size-thing be same as that house-place-own size-thing. | ○THIS · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ · ◇BE · #SAME · →AS · ○THAT · ⌂HOUSE:PLACE+OWN · □SIZE:OBJ
8. mi now be safe-al. | ○MI · ◷NOW · ◇BE · △SAFE:STATE
9. what be price-thing of this? | ?WHAT · ◇BE · □PRICE:OBJ · →OF · ○THIS
10. all person-many now go. | #ALL · ○○PERSON:PL · ◷NOW · ◇GO

WAVE validation answers:

1. CRC-16-CCITT.
2. Length detects truncation or framing inconsistency; CRC detects content corruption. Either failure invalidates the frame.
3. Report CONFLICT and do not select a payload automatically.
4. It identifies the order of fragments and supports reassembly.

5. Reject the frame for any of the four listed conditions.

6. Normal sends once; Confirmed requests ACK and retries; Critical transmits three times and requires ACK with conflict reporting.

F.6 Full 100-phrase mastery checklist

Done	ID	English	Canonical NE-IL
☐	1	I eat.	mi eat.
☐	2	I drink.	mi drink.
☐	3	I sleep.	mi sleep.
☐	4	I woke up.	mi past wake.
☐	5	I wash.	mi wash.
☐	6	I get dressed.	mi dress.
☐	7	I will go to work.	mi future go to work-place.
☐	8	I am working now.	mi now work.
☐	9	I am studying now.	mi now study.
☐	10	I am reading now.	mi now read.
☐	11	I am writing now.	mi now write.
☐	12	I am cooking now.	mi now cook.
☐	13	I eat breakfast.	mi eat breakfast-thing.
☐	14	I eat lunch.	mi eat lunch-thing.
☐	15	I eat dinner.	mi eat dinner-thing.
☐	16	I drink water.	mi drink water.
☐	17	I am hungry.	mi be hungry-al.
☐	18	I am thirsty.	mi be thirsty-al.
☐	19	I am tired.	mi be tired-al.
☐	20	I am ill.	mi be ill-al.
☐	21	I am happy.	mi be happy-al.
☐	22	I am sad.	mi be sad-al.
☐	23	I go home now.	mi now go to house-place.
☐	24	I am at home.	mi be at house-place.
☐	25	I go to school now.	mi now go to school-place.
☐	26	I am at school.	mi be at school-place.
☐	27	I go to the market now.	mi now go to market-place.
☐	28	I buy food now.	mi now buy food-thing.
☐	29	I go to the hospital now.	mi now go to hospital-place.
☐	30	I am at the hospital.	mi be at hospital-place.
☐	31	Do you understand?	qa tu understand?
☐	32	I do not understand.	mi not understand.
☐	33	I need help now.	mi now need help-thing.
☐	34	I call someone now.	mi now call person.
☐	35	I use the phone now.	mi now use phone-thing.
☐	36	I charge the phone now.	mi now charge phone-thing.
☐	37	I go by bus now.	mi now go by bus-thing.

Done	ID	English	Canonical NE-IL
☐	38	I go by car now.	mi now go by car-thing.
☐	39	I wait at the bus stop now.	mi now wait at bus-stop-place.
☐	40	I cross the road now.	mi now cross road.
☐	41	I am in danger.	mi be danger-al.
☐	42	I need a doctor now.	mi now need doctor-er.
☐	43	I feel pain now.	mi now feel pain-thing.
☐	44	I do not eat.	mi not eat.
☐	45	I do not drink.	mi not drink.
☐	46	I will not go to the city.	mi future not go to city-place.
☐	47	I am not sleeping now.	mi now not sleep.
☐	48	I do not work today.	mi today not work.
☐	49	Yes.	yes.
☐	50	No.	no.
☐	51	Where is the toilet?	where be toilet-place?
☐	52	Where is water?	where be water?
☐	53	Where is food?	where be food-thing?
☐	54	Where is the hospital?	where be hospital-place?
☐	55	Where is home?	where be house-place?
☐	56	Who is that person?	who be that person?
☐	57	What is this?	what be this?
☐	58	When will I go?	when mi future go?
☐	59	Why do you not eat?	why tu not eat?
☐	60	How do you make this?	how tu make this?
☐	61	I have two books.	mi have two book-thing-many.
☐	62	I have many friends.	mi have many friend-many.
☐	63	There is no water in the bottle.	water not be in bottle-thing.
☐	64	Many people are in the city.	many person-many be in city-place.
☐	65	Few friends live in the city.	few friend-many live in city-place.
☐	66	Everyone goes now.	all person-many now go.
☐	67	My name is Ana.	mi-own name-thing be Ana.
☐	68	That person is Daniel.	that person be Daniel.
☐	69	My house is big.	mi-own house-place be big-al.
☐	70	Her book is new.	she-own book-thing be new-al.
☐	71	I am taller than you.	mi be more tall-al than tu.
☐	72	She is younger than he is.	she be less old-al than he.
☐	73	This house is the same size as that house.	this house-place-own size-thing be same as that house-place-own size-thing.
☐	74	I am hungrier than you.	mi be more hungry-al than tu.
☐	75	I am less tired than you.	mi be less tired-al than tu.
☐	76	The friend is good.	friend be good-al.
☐	77	The road is long.	road be long-al.
☐	78	The sky is blue.	sky be blue-al.

Done	ID	English	Canonical NE-IL
☐	79	The water is cold.	water be cold-al.
☐	80	The food is hot.	food-thing be hot-al.
☐	81	I open the door now.	mi now open door-thing.
☐	82	I close the door now.	mi now close door-thing.
☐	83	I sit now.	mi now sit.
☐	84	I stand now.	mi now stand.
☐	85	I walk now.	mi now walk.
☐	86	I run now.	mi now run.
☐	87	I stop now.	mi now stop.
☐	88	I will wait.	mi future wait.
☐	89	I come from the city now.	mi now come from city-place.
☐	90	I bring the book now.	mi now bring book-thing.
☐	91	I give water to a person now.	mi now give water to person.
☐	92	A person gives food to me now.	person now give food-thing to mi.
☐	93	I see a person now.	mi now see person.
☐	94	I hear a person now.	mi now hear person.
☐	95	I speak to a person now.	mi now speak to person.
☐	96	The person does not speak.	person not speak.
☐	97	I pay now.	mi now pay.
☐	98	What is the price of this?	what be price-thing of this?
☐	99	I need food now.	mi now need food-thing.
☐	100	I am safe now.	mi now be safe-al.

Annex G. Token registry and machine interchange profile

G.1 Token identifier ranges

Category	Assigned range	Token count
Questions	0101-0107	7
References and entities	1001-100B	11
Possessors	1101-1102	2
Time	2001-2004	4
Polarity and answers	2101-2103	3
Actions and copula	3001-3027	39
Objects	4001-4010	16
Roles	4201-4201	1
Places	5001-5009	9
States and qualities	6001-6011	17
Relations	7001-7008	8
Quantity and comparison	8001-8007	7
Groups	8101-8102	2
Literal marker	9001-9001	1

G.2 Canonical data schema

```
{
  "id": 33,
  "english": "I need help now.",
  "neil": "mi now need help-thing.",
  "picto_tokens": ["MI", "NOW", "NEED", "HELP:OBJ"],
  "wave_token_ids": ["1003", "2002", "3014", "400A"],
  "wave_flags": "0x06",
  "wave_payload_hex": "100320023014400A",
  "crc_profile": "CRC-16/CCITT-FALSE",
  "crc16": "1012",
  "critical": true
}
```

G.3 Generation and verification workflow

14. Author or select a canonical semantic frame.
15. Generate canonical NE-IL using the fixed grammar.
16. Generate the ordered PICTO token list from the same semantic roles.
17. 4. Replace each token with its 16-bit registry identifier; encode each literal as 9001 + one-byte UTF-8 length + NFC-normalized UTF-8 bytes.
18. 5. Build the unescaped WAVE frame, calculate CRC-16/CCITT-FALSE over Version through Payload, append the CRC, and then apply byte escaping.
19. Transmit using the selected bearer profile.
20. At reception, validate framing and CRC before decoding.
21. Reconstruct PICTO and NE-IL, then compare the resulting semantic frame with the sender frame.
22. Log conformance status; never silently repair an invalid frame.

G.4 Legacy migration rule

Historical whole-phrase symbol strings may be retained as archival references, but conversion into the integrated edition MUST use the phrase ID or the English/NE-IL source text. A historical symbol string alone is not sufficient evidence of the intended phrase. PICTO-2 and WAVE-2 are the normative encodings in this document.

G.5 Publication checklist

- Confirm document owner, edition, publication date, license, and any reserved Zenodo DOI before publishing the immutable record.
- Publish the master data from which all tables and educational materials are generated.
- Provide Unicode and ASCII-fallback fonts or labels without redistributing font files.
- Run automated uniqueness, round-trip, CRC, and coverage tests before every release.
- Complete independent comprehension, accessibility, and channel-noise studies before safety-critical use.
- Preserve a change log for grammar, token registry, phrase inventory, and transport framing.

G.6 eL-IR 3.0 machine record profile

The legacy-compatible token registry remains normative for the 100-phrase inventory. eL-IR 3.0 adds a structured semantic envelope around those tokens so software and AI do not need to reconstruct meaning solely from a linear token stream. The canonical record includes semantic roles, mapping confidence, locale/source metadata, provenance, and extension criticality while preserving the original token sequence for deterministic round-trip testing.

Field group	Minimum content
identity	domain, schema_version, message_id, registry version
semantic_frame	intent/illocution, roles, polarity, time, predicate/state, relations, quantity, urgency
representations	canonical NE-IL, PICTO token list, WAVE token IDs when available
adapter	source type/language, mapping class, confidence, ambiguity/loss report

Field group	Minimum content
provenance	authoring participant or system class, adapter/model/software, transformation time or event
policy	NFC, eL-CANON-1, digest domain, extension/criticality policy

G.7 eL-CANON-1 restricted canonical JSON

- Unicode strings are normalized to NFC before canonical serialization.
- Normative numbers are integers or typed decimal strings; NaN, Infinity, negative zero, and implementation-dependent binary floats are not used in canonical fields.
- Object keys are serialized in deterministic Unicode code-point order compatible with the selected JCS profile.
- UTF-8 is used without a byte-order mark.
- Duplicate keys and undeclared critical fields are rejected.
- The record-type domain tag is prepended before SHA3-256 hashing.

G.8 Reserved and extension identifier ranges

Range	Use
0000	Reserved; MUST NOT appear as a token.
0001-8FFF	Core and future standardized registry ranges governed by eLanguage major-version rules.
9001	Literal marker retained for WAVE-2 compatibility.
9002-9FFF	Reserved typed-literal/control expansion range; no meaning assigned in v3.0.
A000-BFFF	Registered extension namespaces via manifest.
C000-DFFF	Experimental/community extension namespaces; collision governance required.
E000-EFFF	Private organizational use; MUST NOT be presented as globally standardized.
F000-FFFF	Reserved for protocol control and future versions.

G.9 Semantic frame JSON Schema outline

```
{
  "$schema": "https://json-schema.org/draft/2020-12/schema",
  "$id": "urn:elanguage:schema:message:3.0",
  "type": "object",
  "required": ["domain","schema_version","message_id","semantic_frame","policy"],
  "properties": {
    "domain": {"const":"ELANGUAGE-MESSAGE-v3.0"},
    "schema_version": {"const":"eLanguage-3.0"},
    "message_id": {"type":"integer","minimum":0},
    "semantic_frame": {"type":"object"},
    "policy": {"type":"object"}
  },
  "additionalProperties": true
}
```

The outline above is documentary. A release JSON Schema SHOULD enumerate every field, controlled vocabulary, extension criticality rule, and reason code before E2 independent implementation is claimed.

G.10 Machine interchange conformance checklist

- Exact schema and registry versions are explicit.
- NFC normalization and eL-CANON-1 canonicalization are reproducible.
- Role semantics are explicit and do not depend on word order alone.
- Unknown critical extensions are rejected or marked not_evaluable.
- Adapter confidence and lossy mapping are separate from semantic truth.
- WAVE CRC, eL-IR SHA3-256 digest, and external signature roles are not conflated.
- Round-trip reconstruction returns the same canonical semantic frame for exact mappings.

Annex H. Human-AI and machine interoperability profile

Annex H defines the operational contract for AI systems, software agents, robots, and conventional applications that generate, interpret, transform, or route eLanguage messages. It does not prescribe a model architecture, vendor, training method, or agent framework.

H.1 AI adapter states

State	Meaning	Allowed action
exact	One canonical frame is supported by the adapter and deterministic constraints.	Emit frame; preserve source/provenance.
equivalent_with_context	Frame is preserved given declared contextual bindings.	Emit with context dependencies.

State	Meaning	Allowed action
ambiguous	Multiple materially distinct frames remain plausible.	Return candidates / request clarification.
lossy	Some source distinctions are not represented in the selected profile.	Emit only with explicit loss report if allowed.
unsupported	Source construction or domain is outside adapter coverage.	Abstain.
policy_blocked	Semantics may be understood but deployment policy prohibits the operation.	Do not execute; policy is external to language semantics.

H.2 Critical-field protection

For urgent, safety-relevant, medical-assistance, or machine-actuation profiles, the following fields are protected against silent inference: actor, polarity, predicate, object/target, recipient, quantity, temporal constraint, urgency, and any deployment-defined safety constraint. An adapter that cannot resolve a protected field returns ambiguous or incomplete.

H.3 Agent/tool envelope

```
{
  "message": {"digest":"...","semantic_frame":{...}},
  "agent_context": {"agent_id":"typed reference","model":"versioned"},
  "authorization": {"external_policy_id":"...","permitted":false},
  "execution": {"status":"not_executed","reason":"human_confirmation_required"}
}
```

The example intentionally separates message semantics from authorization and execution. eLanguage can describe an instruction without granting permission to carry it out.

H.4 AI conformance tests

- Paraphrase invariance: diverse surface forms map to the same frame when semantics are equivalent.
- Minimal-pair sensitivity: changing negation, actor, time, quantity, recipient, or relation changes the frame.
- Ambiguity calibration: genuinely ambiguous inputs trigger clarification/abstention instead of arbitrary selection.
- Adversarial literal test: protocol-like text inside a literal remains literal data.
- OOD test: unsupported domains are identified instead of forced into the nearest vocabulary.
- Model-upgrade regression: new model or prompt policy reproduces the frozen core test set before deployment.
- Human confirmation test: profiles requiring approval cannot be bypassed by a model-generated completion.

H.5 Future foundation models and multimodal AI

Text, speech, image, video, sensor, and embodied models may all serve as adapters if they produce the same structured eSF/eL-IR contract and preserve provenance. A multimodal model that infers “danger” from an image, for example, must distinguish the model observation from a user-authored assertion and should carry confidence, model version, source asset, and the fact that the semantic content is inferred rather than directly stated.

Annex I. Multilingual and natural-language adapter profile

Annex I provides a common manifest and validation structure for mappings between eLanguage and natural languages. No language-specific mapping is declared validated by this document.

I.1 Adapter record

```
{
  "adapter_id":"el-adapter-es-1.0",
  "source_language":"es-MX",
  "direction":"bidirectional",
  "core_version":"eLanguage-3.0",
  "mapping_class":"exact|contextual|lossy|ambiguous",
  "confidence":"profile-defined",
  "loss_report":[],
  "provenance":{"implementation":"...","version":"..."}
}
```

I.2 Linguistic distinctions requiring explicit policy

Distinction	Why it matters
Pronoun omission / pro-drop	Actor may be grammatically absent but semantically recoverable or ambiguous.
Gender / noun class	May exist in source language without a core distinction; loss must be declared when relevant.
Tense / aspect	Core time markers are coarse; progressive, perfective, habitual, or evidential distinctions may require extensions.
Articles / definiteness	Core may not preserve definite/indefinite distinction.
Honorifics / social relation	May encode social meaning absent from core; domain profile decides whether to preserve.
Classifier systems	Quantity and object class may carry distinctions beyond a simple numeral.
Word order	Adapters map roles, not surface order.
Negation scope	Must map to explicit polarity and any affected constituent.

Distinction	Why it matters
Spatial deixis	this/that/here/there may require contextual referent objects.
Script direction	Presentation follows locale/UI rules; canonical machine order remains profile-defined.

I.3 Minimum multilingual benchmark

A v3.0 multilingual benchmark SHOULD contain at least: the complete 100-message core, unseen compositional messages built from registered tokens, minimal pairs for protected fields, culturally sensitive or context-dependent cases, proper-name literals in multiple scripts, and a separate held-out set. Human bilingual reviewers should independently label the intended eSF before adapter results are scored.

I.4 Metrics

Metric	Definition
Exact-frame accuracy	Percentage of messages whose entire protected semantic frame matches the frozen reference.
Role F1	Precision/recall over semantic roles and relations.
Protected-field error rate	Any actor/polarity/predicate/target/recipient/quantity/urgency error.
Ambiguity recall	Fraction of reference-ambiguous inputs correctly flagged.
Calibration	Relationship between confidence and actual frame correctness.
Loss disclosure rate	Fraction of known non-core distinctions correctly reported as loss/context.
Human adequacy	Bilingual reviewer assessment of rendered natural-language output under predefined criteria.

Annex J. Accessibility and multimodal interaction profile

Annex J turns the general accessibility principles into testable profiles for documents, communication boards, applications, audio output, haptic output, and assistive access. It does not claim clinical validation.

J.1 Visual profile

- Text and shape are redundant; color is supplementary.
- Core labels remain readable when special glyphs are unavailable through ASCII fallback.
- Zoom and reflow are supported in digital implementations where platform capabilities permit.
- Focus order follows semantic/reading order and is independent from visual position when needed.

- Critical controls and messages receive distinct grouping and text, not only color or animation.

J.2 Motor-access profile

- Selectable targets are sufficiently large for the deployment context.
- Scanning order is deterministic and configurable.
- Switch access, keyboard access, and alternative pointing devices are supported where applicable.
- Time limits are adjustable or can be disabled unless essential to the communication protocol.

J.3 Auditory profile

Speech synthesis MAY render NE-IL, a natural-language translation, or both. Auditory rate, pauses, repetition, and confirmation are configurable. The visible or tactile interface must expose transport and error status so that audio is not the sole channel for critical feedback.

J.4 Haptic profile

WAVE-H is a low-rate bearer profile. A production implementation requires empirical psychophysical testing of pulse duration, separation, discriminability, fatigue, device variation, and user training. The current specification supplies framing concepts only and does not assert tactile vocabulary comprehension.

J.5 User-study record

Field	Required content
population	Recruitment criteria, language, age range, relevant disability/access needs, prior symbol experience.
interface	Device, display/input method, size, contrast, audio/haptic settings, assistive technology.
training	Duration, materials, instructor behavior, prompts, repetitions.
tasks	Recognition, production, navigation, free composition, urgent-message subset, transfer to unseen examples.
metrics	Accuracy, time, error category, assistance, retention, confidence/workload, preference, adverse events.
ethics	Consent/assent, accessibility accommodations, privacy, withdrawal and applicable review.
analysis	Predefined thresholds, missing data, subgroup reporting, uncertainty/confidence intervals.

Annex K. Security, integrity, provenance, and trust profile

Annex K defines a layered integrity model for eLanguage messages and releases. It deliberately prevents CRCs, hashes, signatures, provenance, and semantic correctness from being treated as interchangeable.

K.1 Record types and domain tags

Record type	Domain tag	Purpose
message	ELANGUAGE-MESSAGE-v3.0	Canonical semantic message.
adapter_result	ELANGUAGE-ADAPTER-v3.0	Source-to-frame mapping, confidence and loss report.
registry	ELANGUAGE-REGISTRY-v3.0	Token/role definitions and extension metadata.
validation	ELANGUAGE-VALIDATION-v3.0	Frozen benchmark and results.
provenance	ELANGUAGE-PROVENANCE-v3.0	Source/transform/software/model/agent trace.
release_manifest	ELANGUAGE-RELEASE-v3.0	Official artifact list, versions and external digests.

K.2 Digest construction

```
digest = SHA3-256(domain_tag || 0x00 || eL_CANON_1(record))
```

K.3 Authentication envelope

Field	Purpose
record_digest	Integrity anchor for canonical bytes.
signature_algorithm / key_id / signature	Authentication under external trust policy.
certificate_chain / public_key	Verification material.
timestamp_token	Trusted existence-time evidence when selected.
revocation_status	Verification-time status.
release_manifest_digest	Binds a message/application to a controlled release when required.

K.4 Provenance minimum for AI-mediated messages

- Original source type and optional source digest.

- Natural-language locale or device/sensor source profile.
- Adapter/model/service identifier and version.
- Prompt/policy profile identifier when material to the transformation.
- Deterministic validator version and registry version.
- Mapping class, confidence, ambiguity and loss report.
- Timestamp/event identifier according to privacy and deployment policy.

K.5 Release watermark and copy controls

Official v3.0 copies use document ID CDBR-ELANG-PUB-3.0, copy ID EL30-PUB-0001, visible header/footer controls, a Zenodo-preprint watermark, Page X of Y fields, and an external SHA3-256 release digest. These documentary controls support recognition and traceability but do not prevent copying or adaptation allowed by CC BY-NC 4.0.

Annex L. Validation, simulation, and conformance benchmark suite

Annex L freezes the deterministic v3.0 benchmark configuration described in Section 15 and defines the minimum independent reproduction procedure.

L.1 Benchmark environment

Item	Value
Reference dataset	Integrated 100-phrase Annex A inventory.
Transport compatibility	WAVE-2 Version 0x21; Message ID = phrase ID; Sequence = 0; flags per Section 4.6.
CRC	CRC-16/CCITT-FALSE: poly 0x1021, init 0xFFFF, no reflection, xorout 0x0000.
Canonical record profile	eL-CANON-1 restricted JSON; Unicode NFC; UTF-8; domain-separated SHA3-256.
Synthetic random seed	20261003.
Reference execution	Python 3.13.5; Unicode database 15.1.0.
Document rendering QA	LibreOffice 25.2.3.2 in the publication build environment.

L.2 Benchmark results

Check	Result
Inventory, NE-IL, PICTO, WAVE uniqueness	PASS: 100/100 each.
Published CRC reproduction	PASS: 100/100.

Check	Result
Domain-separated eL-IR digest uniqueness	PASS: 100/100.
Corpus NFC idempotence	PASS.
Canonical-equivalence vectors	PASS: 4/4.
Semantic deletion/reorder mutation vectors	PASS: 196/196 changed sequence.
Exhaustive single-bit corruption detection	PASS: 12,520/12,520 detected.
Random two-bit corruption test	PASS in sample: 200,000 trials; 0 undetected.
Random single-byte substitution test	PASS in sample: 200,000 trials; 0 undetected.
Random burst error sample, 1-16 bits	PASS in sample: 80,000 trials; 0 undetected.

L.3 Independent reproduction procedure

- Extract the exact Annex A dataset and token registry from the official v3.0 release.
- Validate 100 phrase IDs, canonical NE-IL strings, PICTO frames, WAVE token sequences, literal blocks, and critical/question sets.
- Recompute every CRC using the published WAVE-2 compatibility parameters and compare all 100 values.
- Create eL-IR records using the published schema and canonicalization restrictions.
- Normalize every canonical string and literal to Unicode NFC.
- Compute domain-separated SHA3-256 digests and verify uniqueness plus the phrase-33 reference vector.
- Execute semantic deletion, reordering, unknown-token, invalid-length, literal-length, and CRC negative tests.
- Execute corruption simulations using the frozen random seed or publish an alternative seed with complete results.
- Report runtime/library versions and any deviations from the reference environment.
- Archive code, logs, and checksums so a third party can repeat the test.

L.4 Evidence limits

The Annex L results establish deterministic software behavior for the supplied corpus and synthetic corruption models. They do not establish natural-language translation quality, universal human learnability, PICTO intuitiveness, accessibility outcomes, real acoustic/optical/radio/haptic channel performance, AI semantic accuracy, or operational safety. Those remain E3+ benchmarks.

Annex M. Implementation, deployment, and future-technology profiles

Annex M provides deployment-ready checklists while preserving the separation between language semantics and domain-specific execution or safety systems.

M.1 Minimal implementation profile

Capability	Minimum
Core registry	Read-only token/role registry with exact version.
NE-IL	Canonical parser and renderer for supported grammar.
PICTO	Ordered token rendering with text fallback.
eL-IR	Schema validation and canonical record production.
Integrity	CRC for WAVE frames; SHA3-256 for canonical records when selected.
Diagnostics	Structured errors, incomplete/ambiguous states, no silent repair.
Offline use	No network or AI dependency for core operation.

M.2 AI-enhanced implementation profile

- Adds natural-language or multimodal AI adapters without changing the deterministic core.
- Stores mapping confidence, ambiguity/loss report, model/version and transformation provenance.
- Runs deterministic validation after model generation.
- Supports human confirmation or application policy gates where required.
- Maintains fallback to direct NE-IL/PICTO/core operation when the AI service is unavailable.

M.3 Robotics and autonomous-system profile

Robotic or autonomous use SHALL separate semantic interpretation from control authority. eLanguage may encode an action request, target, relation, time, quantity, and urgency; the robot controller still applies its own validated perception, planning, collision avoidance, authorization, safety envelope, and emergency-stop logic. A semantic message cannot override a lower-level safety interlock.

M.4 Edge / IoT profile

Constrained systems MAY use integer token IDs, a compact binary binding such as CBOR, and precompiled registry tables. The eSF meaning and version remain unchanged. Gateways translating to JSON or natural language must preserve exact roles and criticality. Intermittent networks SHOULD support local queuing, explicit expiry, replay policy, and conflict detection.

M.5 Emerging-technology readiness checklist

- Can the technology bind to eSF/eL-IR without changing core semantics?
- Are timing, ordering, uncertainty, and loss properties explicit?
- Can unknown or unsupported messages fail safely and visibly?
- Is there a deterministic conformance path independent of probabilistic AI?

- Are human-facing outputs accessible and empirically evaluated?
- Are security, identity, authorization, privacy, and provenance controls externalized and versioned?
- Can the profile be deprecated or migrated without reusing identifiers?
- Are claims limited to evidence actually executed for that technology?

M.6 Zenodo publication checklist

- Title, author, version, publication date, abstract, keywords, license and document type are present.
- Document ID and controlled copy ID are present on the release.
- All Annexes A-M are integrated into one master document.
- The 100-phrase educational materials remain included.
- The final DOCX and archival PDF are rendered and visually inspected page by page.
- Accessibility checks are run and material defects are corrected where feasible.
- The complete-file SHA3-256 digest is published externally with the release.
- Zenodo record uses CC BY-NC 4.0 and identifies the upload as a preprint / technical specification.
- The DOI is inserted in a later patch release only if desired; the DOI assignment itself does not change semantic protocol content.