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b3u.dev X12 — The Good, the Bad, and the Ugly

A technical report on maintaining X12 EDI software as a product family on the CCS platform — one grammar, one parse, five runtimes, an obfuscation layer, and a compliance-clean answer to X12's licensing rules.

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1. Why this report

If you build or maintain X12 EDI software — a clearinghouse, a billing or remittance system, a practice-management product, an EDI toolkit, a supply-chain or logistics integration — your stack is polyglot whether you chose that or not:

transaction processing, claims logic	JAVA / C++
analytics / reconciliation / ETL	PYTHON
operator consoles, portals	JAVASCRIPT
hot paths, gateways, appliances	C++ / RUST

every language boundary re-parses the same interchange today

Each layer parses the same interchange again, into its own object model, with its own copy of every trading partner's quirks. That duplication is where companion-guide drift, version skew, and a large share of EDI maintenance cost live — and in US healthcare it sits on the **money side**: HIPAA mandates X12 at the billing boundary, so every claim, remittance, and eligibility check crosses this exact machinery.

CCS removes the duplication at the architecture level:

ONE PARSE. FIVE RUNTIMES. NO RE-PARSING AT ANY LANGUAGE BOUNDARY.

An interchange is parsed **once**, by a parser generated from a grammar, into an SCB — a *Syntax-Controlled Binary*: the parsed structure itself, persisted as bytes. Java, Python, JavaScript, Rust,

and C++ each read that same artifact through a native SCB API and reconstruct the interchange **byte-identically**. The same artifact passes through an obfuscation layer (XTEA and ECIES/AES-GCM) for storage and transport.

This is the second demonstration of that claim. The first — a complete HL7 v2 pipeline with the full code and JVM benchmarks — is published at b3u.dev/docs/ccs_java_hl7.pdf, and this report deliberately does not repeat it. X12 and HL7 are cousins — delimited, segment-oriented, self-declaring separators — and in US healthcare they are two halves of the *same* encounter: clinical messages inside the provider systems, an X12 claim at the billing boundary, handled by the same vendors. One platform, two language frontends, one substrate underneath.

What this report adds is X12-specific: a working X12 tokenizer and envelope pipeline across all five runtimes, the demonstration that the five-runtime layer **transposes to a second format in one working day**, and — because X12 is a licensed standard with unusually strict rules about AI tooling — a chapter on how CCS engagements stay on the right side of those rules by construction.

Ground rules this work inherits from our engineering policy: all content is synthetic, and — stated precisely in §3 — **no X12 specification content was consumed anywhere in building what this report shows**.

2. CCS fundamentals, in brief

(The full treatment — generated artifacts shown in-source, the five SCB APIs, in-process compilation from Java, and JVM/C++ benchmarks — is §2–§3 of the published HL7 report. This section is the minimum a standalone reader needs.)

CCS is a grammar-driven data platform, protected by US Patent 8,464,232. You write a grammar in SGDL (a compact EBNF-class grammar language); the b3u.dev toolchain generates the format's parser/compiler frontend (CLI + shared library with a small C ABI), the grammar's keyword tables in five languages, and the SCB layout. An SCB exists in two on-disk forms with identical content:

form	what it is	when to use it
.fgr	decimal-text record stream	portable interchange,

			diffable, human-auditable	
	.bfgr		raw binary image, native	
			byte order	
			production load path –	
			20-30× faster to load	

Five native SCB APIs (C++, Python, JavaScript, Rust, Java) read the same artifact and are held together by a standing byte-identity oracle. The APIs are **consumers** — parser generation never ships to a client runtime; that boundary is a product invariant.

The obfuscation layer transforms SCB images buffer-to-buffer: algo 1 is seed-keyed XTEA; algo 2 is ECIES over secp256k1 with AES-GCM authentication (wrong key or tampered blob is refused at the tag); algo 3 is a wire-compatible independent implementation of algo 2, cross-decoding with it in both directions.

Performance anchors, measured in the HL7 report on this same substrate: on the JVM, loading a parsed binary costs about one Jackson parse of the equivalent JSON, and the binary form loads 12–16× faster than its text form; in C++ the factor is 20–30×, landing within ~2× of simdjson's DOM parse. Parse cost is paid once per message, at one node; every subsequent consumer pays a binary load.

3. X12's licensing rules, and why our method is clean by construction

X12 is not a free standard. The specification — implementation guides (TR3s) and the machine-readable Table Data — is licensed by X12 Incorporated, and X12's published IP policy adds a rule that matters enormously in 2026: it **prohibits entering X12 standards and related X12 IP into AI tools**, and forbids creating derivatives of X12 IP using AI without express written consent.

Most vendors experimenting with AI-assisted EDI tooling have a problem there. We do not, for a structural reason: the CCS pipeline never wanted an AI in that position in the first place.

✓ CCS method	a DETERMINISTIC toolchain processes licensed spec content into grammars and parsers – software processing licensed material, under licence. No model reads a TR3. No model writes the grammar from spec content.
⊖ the trap	an LLM summarizes an implementation guide into a

parser or mapping – an AI-created derivative of licensed IP. Exactly what the policy prohibits.

The grammar layer was designed deterministic for engineering reasons — generated parsers must be exactly reproducible and mechanically verifiable — and that design decision turns out to be the compliance posture X12's rules require.

What this report's demonstration is built on. Everything in §4 uses only the public-commons *syntax layer* of X12 — the segment/element/component shape, the conventional * : ~ separators, the interchange envelope segment IDs (ISA GS ST ... SE GE IEA) — plus payload segments with invented IDs and deliberately meaningless synthetic content. No TR3, no Table Data, no companion-guide content was consulted, quoted, or encoded. That is also why the demonstration is envelope-only (§6.2 keeps that honest): transaction-set structure *is* the licensed material, and it enters the pipeline only inside a licensed engagement.

What an engagement looks like under the rules. X12 software providers already hold X12 licences — it is the price of being in the business. A CCS engagement works from *your* licensed specification and *your* companion guides, processed by the deterministic toolchain into your grammar variants and generated components. The AI-era compliance question your counsel will ask — "did any of our licensed X12 material train or prompt a model?" — has a clean answer: no, and the architecture is why.

4. The X12 demonstration

A complete, gated pipeline: an X12 tokenizer in the compiler, an interchange-envelope grammar, a generated parser delivered as a shared library, a Java pipeline that compiles in-process and carries the interchange through the obfuscation cycle, and four more readers — Python, JavaScript, Rust, C++ — that all load the *same* compiled SCB and render it byte-identically. One command runs every gate.

4.1 The X12 tokenizer

X12's wire shape is its own dialect: * separates elements, : separates components, and — unlike line-oriented formats — the segment terminator is a **character**, ~. A file with one segment per line and a file that is a single unbroken stream are the same interchange. Everything between separators is data: spaces (ISA's fixed-width fields are space-padded), dots, dashes, dates like

20260826 — and X12 has no escape mechanism, so what is in the element is in the token, byte for byte.

The compiler carries a dedicated X12 tokenizer as a first-class language mode (alongside its meta-grammar, XML, symbolic-expression, and HL7 modes), selected explicitly or simply by the `.x12/.edi` file extension. Its contract:

- segments are **~~delimited, not line-delimited**: a segment identifier such as GS is a keyword only at the start of the interchange or immediately after a consumed ~, and plain data anywhere else — so an element whose value happens to be GS cannot derail the parse;
- line endings between segments are insignificant: the gate proves that the one-segment-per-line form and the no-newlines stream form of the same interchange produce **byte-identical** SCBs;
- element payload is a dedicated data token: runs of bytes that stop **only** at the separators the grammar itself references — never at characters that merely happen to be special in other language modes (2.3.1, 70-105, net/gross survive as single runs);
- no comment syntax, no whitespace normalization inside elements.

Demo scope, stated plainly: this tokenizer bakes in the conventional separators * : ~. Real X12 declares its separators positionally in the ISA segment (the element separator by position, ISA16 carrying the component separator). The ISA-declared settable surface is designed — it is the same mechanism HL7's MSH needs, one surface serving both frontends — and is on the roadmap, not in the demo (§6.2).

4.2 The grammar

The entire format definition that drives everything in this chapter — parser generation, the five keyword tables, the SCB layout — is this one page. Envelope structure with typed payload segments; elements stay a flat, verbatim token stream:

```
(x12env
  (interchange ::= isaSeg gsSeg stSeg body seSeg geSeg ieaSeg )

  (body      ::= payload { payload } )
  (payload   ::= zzaSeg | zzbSeg )

  (isaSeg    ::= 'ISA' { part } )
  (gsSeg     ::= 'GS'  { part } )
  (stSeg     ::= 'ST'  { part } )
```

```

(zzaSeg ::= 'ZZA' { part } )
(zzbSeg ::= 'ZZB' { part } )
(seSeg  ::= 'SE'  { part } )
(geSeg  ::= 'GE'  { part } )
(ieaSeg ::= 'IEA' { part } )

(part ::= sep | x12Data )
(sep  ::= ( '*' | ':' | '~' ) )
)

```

(The production grammar file carries two bracketing action hooks on the axiom rule; they are elided here for readability. ZZA and ZZB are invented payload segment IDs — see §3 for why the demo stays at the envelope.)

Because the structure is in the grammar, the **parser enforces it**: the gate's red witnesses show a payload segment before ISA refused, and an interchange missing its IEA trailer refused. Envelope validation is not a library you remember to call — it is what parsing means. And the same property scales up: when a licensed engagement puts a transaction set's loop structure into a grammar variant, wrong segment order in a claim becomes a parse error, not a downstream surprise.

From this grammar the toolchain generates the parser and the keyword table in five languages. The Python table, abridged (the SGDL-inherited punctuation-token list is elided here; the .java, .mjs, .rs, and .cc/.h siblings carry the same lists in their native idiom):

```

# Generated by the b3u.dev toolchain from x12env.sgr -- do not edit.
GRAMMAR = "x12env"

PREDEFINED = [
    "Wrong_Key_Word", "identifier", "stringToken", "integerToken",
    "floatToken", "textToken", "termToken", "terminalTokenOfRule",
    "mettaSymbol", "mettaVariable", "mettaSpaceRef", "mettaComment",
    "hl7Data", "x12Data",
]

DECLARED_TERMINALS = [
    "*", "GE", "GS", "IEA", "ISA", "SE", "ST", "ZZA", "ZZB", "~",
]

NON_TERMINALS = [
    "interchange", "body", "payload", "isaSeg", "gsSeg", "stSeg",
]

```

```
"zzaSeg", "zzbSeg", "seSeg", "geSeg", "ieaSeg", "part", "sep",  
]
```

Every reader in this report resolves the grammar's symbols **by name** from this table — no magic numbers, no per-language drift. Note `hl7Data` and `x12Data` side by side in the predefined kinds: the HL7 and X12 frontends are siblings in one compiler, which is the "one platform, two formats" claim made concrete.

4.3 The sample interchange

One synthetic envelope (no real data of any kind; every payload value is deliberately meaningless):

```
ISA*AA*BB CC**DD:EE*20260826*2.3.1~  
GS*GRP*SND*RCV*20260826*1~  
ST*ZZ*0001~  
ZZA*ONE*TWO THREE*A:B:C~  
ZZB*10*net/gross*70-105~  
ZZA*GS*NOTE - -DASHES~  
SE*X*0001~  
GE*X*1~  
IEA*X*000000001~
```

The sample is deliberately adversarial: an empty element (**), a component split (A:B:C — and DD:EE inside ISA, the shape ISA16 takes when the component separator is declared), spaces inside elements (BB CC, TWO THREE), a date and a dotted version that must not split, - - that must not read as a comment — and the third payload segment's first element is the value GS, which must parse as *data*, not as a segment start. Every reader asserts all of these.

4.4 The pipeline at a glance

```
env1.x12 (X12 text – with newlines, or as one stream: same SCB)  
| in-process compile: Java → FFM → libccsx12env.so (C ABI)  
▼  
SCB image (env1.bfgr, 3,504 bytes for this sample)  
|  
├─ Java    ccs.x12  → canonical render = INPUT BYTES  
├─ Python  reader   → render = Java render (byte-identical)  
├─ JS      reader   → render = Java render (byte-identical)  
├─ Rust    reader   → render = Java render (byte-identical)
```

```
└─ C++      reader  →  render == Java render (byte-identical)
└─ obfuscate / deobfuscate (algo 1 XTEA, algo 2/3 ECIES,
    cross-decode both ways, wrong-key REFUSED) – proven from
    Java, Python, and JavaScript
```

The generated frontend is delivered two ways from the same build: a CLI executable, and `libccsx12env.so` — a shared library whose entire export surface is the small `ccs_*` C ABI (the gate verifies with `nm` that nothing else is exported). The Java pipeline uses the library: interchange text goes in as bytes, the SCB image comes back as bytes, and nothing touches disk in between.

4.5 The Java pipeline

The `ccs.x12` package is the facade — compile, load, render, obfuscate — over the same three Java components the HL7 report documents in full (`ccs.scb`, the FFM shell binding, `ccs.obf`). Its battery runs eighteen checks; the transcript:

```
PASS: compileText -> SCB (3504 bytes)
PASS: ISA loaded
PASS: GS + ST envelope heads loaded
PASS: SE + GE + IEA envelope tails loaded
PASS: 3 payload segments
PASS: payload order ZZA ZZB ZZA
PASS: mid-segment 'GS' element value is a DATA part of a ZZA
PASS: spaces preserved inside an element (TWO THREE)
PASS: ISA carries separator parts (8)
PASS: canonical render == input bytes
PASS: SCB fixpoint: compile(render) == compile(input)
PASS: algo 1 wire differs
PASS: algo 1 (XTEA) round-trip recovers SCB
PASS: algo 2 (ECIES) round-trip recovers SCB
PASS: algo 2 -> algo 3 cross-decode (wire-compat)
PASS: algo 3 -> algo 2 cross-decode (wire-compat)
PASS: wrong-key deobfuscate REFUSED (GCM)
PASS: model -> obfuscate -> deobfuscate -> model is total
EnvTest: ALL GREEN
```

Three of those lines carry most of the weight. **Canonical render == input bytes** means fidelity is a diff, not an argument — the node can re-emit exactly what it ingested, which is what reconciliation and audit actually require. **SCB fixpoint** means the compile-render loop is stable:

parsing the canonical form yields the identical binary. And **wrong-key REFUSED** is the authenticated-encryption red: a tampered or misdirected financial payload does not decrypt into garbage, it refuses.

4.6 The other four runtimes — and what the port measured

The Python, JavaScript, Rust, and C++ readers each load the Java-produced SCB through their own runtime's SCB API and render it. Each is a small typed model (entities + loader + renderer, resolving grammar symbols by name from its generated keyword table), and each asserts byte-identity against the Java render plus the structural witnesses of §4.3.

The measurement worth reporting is not that they pass — it is what they cost. All four were transposed from their HL7 counterparts, the walk logic retargeted from the ORU message shape to the interchange envelope, **and all four ran green on the first attempt**. The entire X12 demonstration — the compiler's tokenizer mode, the grammar, the shared library, the Java pipeline, and the four readers — was built and gated in one working day, precisely because the substrate (SCB encodings, keyword-table discipline, oracle harness) was already in place from the HL7 work. That is the maintenance argument of §1 made empirical: the second format was cheap because the architecture made it cheap.

4.7 The oracle — and the reds that earn their place

One command (`tests/run.sh`) runs the full gate: generation, the linked frontend and its tokenizer witnesses, the shared library's export surface, the Java battery, the four parity readers, and the red witnesses — 24 passes end to end.

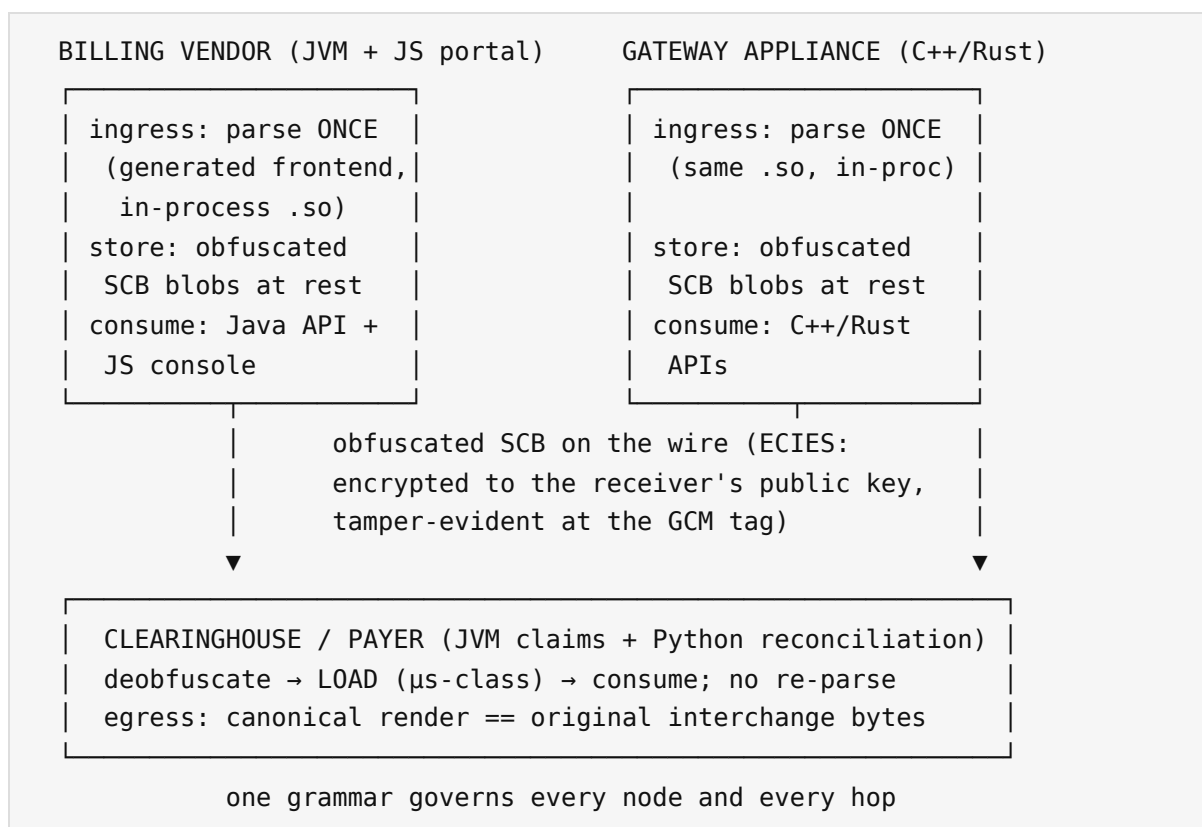
Two classes of red matter beyond the structural refusals. The tokenizer red: an interchange whose first segment ID is undeclared is refused — nothing is silently keyworded. And the comparator red: the gate corrupts one byte of the SCB *on a path the readers actually consume* and asserts the pipeline does **not** silently produce an identical render. A five-way identity oracle is only evidence if it can fail; the gate proves it can.

5. A distributed X12 network on CCS

A real X12 estate is a network: providers, clearinghouses, payers, and trading partners, each with its own stack, exchanging the same transactions — claims out, remittances back, eligibility checks

in real time. Today every node re-parses at ingress, stores text or a proprietary object dump, and re-serializes at egress.

The CCS deployment pattern places the same two components at every node, regardless of the node's language:



The pattern's properties are the ones §4 measured, applied to the money side. **At rest:** claims and remittance data persist as obfuscated SCB — the key-columns-plus-encrypted-blob pattern; a leaked dump of financial/health payloads is unreadable without the private key, and a tampered blob refuses to decrypt. **On the wire:** trading partners exchange obfuscated SCB; the receiver deobfuscates and *loads* — it cannot parse *differently* from the sender, because they share the grammar rather than hoping two hand-written parsers agree. **At the boundary:** canonical render equals the original bytes, which is what remittance reconciliation and audit trails actually require.

What this pattern is not. It is not a clearinghouse and does not replace one — enrollment, routing, payer connectivity, and the regulatory relationship remain the provider's product; CCS components slot underneath as the parse/persist/exchange substrate. It is not a transport-security replacement: TLS, authentication, and access control remain in place. And the obfuscation layer

secures the data layer — it does not make anything HIPAA-compliant by itself; compliance is a property of your whole system.

6. The good, the bad, and the ugly

The title chapter. Everything above is evidence; this is the assessment we would want to read if we were the buyer.

6.1 The good

One substrate, two formats — measured, not promised. The HL7 report proved the architecture on clinical messages; this report proved it transposes: a second tokenizer mode, a second grammar, and five runtimes reading the second format byte-identically, delivered in one working day. For a vendor whose products straddle both sides of the healthcare boundary — and the HL7/X12 vendor lists overlap almost completely — that is the actual pitch: one platform discipline, every format in the estate.

The licensing posture is a feature. §3 is not fine print. In a period when X12's IP policy explicitly prohibits AI-tool consumption of its standards, a toolchain that is deterministic by design — no model in the grammar-production path, no licensed content in any prompt — is a compliance answer most AI-era tooling cannot give. The demonstration itself is the existence proof: everything in this report was built without touching licensed X12 material.

Security for the money side. X12 payloads are exactly the data an attacker wants — patient-linked financial records in bulk. The obfuscation layer gives the data layer a defense-in-depth guarantee: ECIES public-key encryption per receiver, GCM authentication that refuses tampered or misdirected blobs, proven from three runtimes in the gate, with dual-key separation so a node that can encrypt to you cannot read your store.

Structural enforcement, from the envelope up. Even at demo scope, wrong envelope order is a parse refusal. In a licensed engagement the same mechanism holds transaction-set structure: the loop discipline of a claim lives in a reviewable grammar variant, and violations are refused at ingress instead of discovered in reconciliation.

6.2 The bad (current limits — real, and fixable)

1. **The demonstration is envelope-only.** No transaction-set grammar exists yet — not 837, not 835, not 270/271 — because transaction-set structure is licensed material and enters the pipeline only inside a licensed engagement (§3). The envelope demo proves the architecture; it does not prove coverage of any transaction set, and we won't pretend otherwise.
2. **Demo-scope separators.** The tokenizer bakes in * : ~. Real X12 declares separators positionally in ISA. The ISA-declared surface is designed (one mechanism shared with HL7's MSH) and on the roadmap, not in the demo. Until it is, nonstandard-separator feeds are out of scope — and the repetition separator is likewise not yet handled.
3. **ISA's fixed-width semantics are not enforced.** The demo parses ISA as an ordinary delimited segment. Real ISA is fixed at 106 characters with positional semantics; enforcing that is part of the settable-separator work.
4. **The entity-model layer is hand-cloned per runtime.** The keyword tables are generated in five languages; the typed loaders/renderers are disciplined manual transpositions. This report's one-day port shows the cloning is mechanical and cheap — but it is cloning, not generation, and generating it is on the roadmap.
5. **Byte fidelity is proven; semantic validation is not in scope.** Canonical render == input bytes is measured. Balancing rules, control-number arithmetic, code-set validation — the 999/TA1 layer of the world — are application concerns above the parse substrate, and nothing here claims them.
6. **.bfgr is native-byte-order by design.** Ship the portable text form, populate the binary on the target with the one-command tool. Operational step; know about it.

6.3 The ugly (the hard truths — for us and for you)

1. **Transaction-set work requires licensed material — yours.** We deliberately built this demonstration without X12 spec content, and the same discipline governs engagements: the licensed specification comes from the client relationship, processed deterministically. A buyer who wants a prebuilt open-source-style 837 parser off the shelf is asking for something X12's licensing does not permit anyone to sell them that way — and vendors who appear to do so are carrying risk we chose not to carry.
2. **One open licensing question is genuinely open.** Whether a generated parser derived from licensed Table Data counts as "embedded in an offering" or as "distribution" (requiring the end customer's own licence) is not answerable from X12's public pages. For our target buyer — providers who already hold licences — the question is likely moot, but it goes to X12's licensing desk in writing before any production delivery, not after.

3. **X12 in the wild is companion guides, not the base spec.** Every payer's guide constrains and bends the transactions. No parser technology makes that disappear; what CCS changes is where the variance lives — in reviewable grammar variants per partner, instead of conditional code scattered across N codebases.
 4. **The demo proves architecture, not a product.** Five runtimes, byte identity, obfuscation, envelope enforcement — proven. Acknowledgments, batching, control-number management, partner onboarding — a provider's product, not this substrate, and a buyer should ask for exactly that scoping conversation.
 5. **Pilots run on synthetic data only.** No PHI and no real financial data reach b3u.dev systems, ever. Your conformance corpus, de-identified or synthetic, is the oracle. Non-negotiable, even when it slows a pilot down.
 6. **CCS is proprietary and patented.** One vendor, commercial terms, not an OSS parser you can fork. We think this report and its HL7 sibling are the honest case for why that trade is worth it — a maintained single source of truth with a cross-runtime oracle — but it is a trade, and you should weigh it as one.
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7. Working with b3u.dev

The engagement template is deliberately small:

1. **Scope one interchange flow** — one transaction family from your estate, under your X12 licence, with your companion-guide constraints — and we produce the grammar variant and generated components through the deterministic toolchain (§3).
2. **You provide the oracle:** your existing conformance/regression corpus (synthetic or de-identified). Acceptance is your suite passing, plus the byte-identity oracle across every runtime you care about.
3. **You get the component set:** the generated frontend (CLI + C-ABI shared library), the five SCB APIs' keyword tables for your grammar, and reference readers in your stack's languages — the same deliverables §4 printed, at your transaction sets instead of the demo envelope.

Licensing is subscription-based through b3u.dev, with production and OEM/embedding terms under a separate written agreement. The demo in this report, including the five-way oracle harness, runs end to end in one command on delivered artifacts — ask for a walkthrough. If your stack is on the HL7 side too, read the sibling report: the two frontends share one platform, and that is the point.

Contact: support@b3u.dev

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