

RESEARCH ARTICLE

From Tradition to Innovation? A Diachronic Corpus Analysis of Simplified Technical English in Aviation

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Abstract: Reading comprehension and fluency are fundamental for successful text processing, particularly in high-stakes environments like aviation maintenance where unclear technical documentation can have fatal consequences. This risk is amplified by the significant proportion of English as a second language (L2) speakers in the global aviation maintenance workforce. While Simplified Technical English (STE) was introduced in the mid-1980s as an international specification to address these challenges and has evolved through continuous user feedback, its effectiveness in reducing text complexity and improving comprehension remains underexplored. This research examines language changes in aviation maintenance documentation from pre-1990 to 2024, analyzing linguistic variations across two generations of technical manuals for a widely used narrow-body commercial aircraft from an 8.2-million-word corpus. Employing Biber's Multi-Dimensional Analysis (1988) alongside Coh-Metrix (Graesser et al., 2004), the study uncovers significant linguistic variations: later-generation texts demonstrate higher levels of interactive and accessible plain language style (Dimension 1), while higher Dimension 6 scores indicate enhanced real-time informational elaboration oriented towards immediate contextual demands. Follow-up experiments isolating eight distinctive linguistic features reveal that linguistic simplification can be a double-edged sword; while enhancing accessibility, it may inadvertently diminish essential textual attributes that facilitate comprehension. This research offers valuable insights for future STE development, emphasizing the need to balance immediate comprehensibility and operational safety with the preservation of textual cohesion and appropriate linguistic complexity.

Keywords: text complexity, reading comprehension, Simplified Technical English (STE), technical writing, corpus linguistics

Introduction

In the high-stakes field of aviation maintenance, where misinterpreting instructions can lead to serious consequences, clear and precise language is essential. Aircraft maintenance manuals (AMMs), as critical regulatory instruments, govern maintenance operations and constrain technicians' discretionary actions. The precision of their technical language directly impacts maintenance safety, as linguistic ambiguity can propagate through the maintenance chain, potentially

compromising aircraft airworthiness. Empirical evidence from maintenance incident analyses has established unclear maintenance instructions as a recurring causal factor in accidents and incidents (e.g., Baron, 2009; Chang & Wang, 2010; Habib & Turkoglu, 2020; Hackworth et al., 2007; Jiang et al., 2022; Langer & Braithwaite, 2016; Nathanael et al., 2016; Zafiharimalala et al., 2014). This form of linguistic imprecision manifests in both confusion among maintenance personnel and a list of documented maintenance errors (Tretten & Normark, 2019).

The aviation industry implemented Simplified Technical English (STE) as specified in ASD-STE100, establishing a standardized approach through controlled vocabulary and streamlined syntax. Research in cognitive linguistics supports this approach, showing that basic-level and subordinate-level terms reduce processing time and cognitive load, as evidenced by shorter eye fixation times and reduced working memory demands (Crossley & McNamara, 2011; Gorsuch & Taguchi, 2008). Simplified text forms an artificial genre distinct from authentic texts (Allen, 2009), becoming more accepted in international engineering discourse, as the engineering community accepts simplified language when technical content is strong (Rozycki & Johnson, 2013). As the aviation industry experiences rapid globalization, with a growing number of English-as-a-foreign-language (EFL) maintenance technicians, particularly from the Asia-Pacific, the Middle East, and Latin America, the development of effective STE in maintenance documentation requires systematic and extensive investigation.

This study examines the evolution of controlled language principles in aviation technical documentation through analysis of a diachronic corpus (8.2 million tokens) of AMMs. By comparing linguistic features across early- and later-generation variants of a widely used commercial aircraft from pre-1990 to 2024, we track changes in technical writing practices over time. Through systematic analysis using Biber's (1988) Multi-Dimensional Analysis (MDA) alongside the computational tool Coh-Metrix (Graesser et al., 2004), we examine how STE's controlled language rules have shaped technical documentation—a critical reflection that reveals both its achievements and limitations. Understanding these linguistic patterns in high-stakes technical environments has significant implications for advancing documentation standards and refining controlled language approaches across industries.

Literature Review

Text Readability and Comprehension

Text production and comprehension share a fundamental relationship in writing research, with linguistic features serving as predictors of both compositional quality and comprehensibility (Crossley & McNamara, 2011, 2012; McNamara, Louwerse, et al., 2010). Early research considered readability

primarily through formulas (e.g., Flesch Reading Ease, Flesch–Kincaid Grade Level) that relied on surface-level features such as word frequency and sentence length. However, applied linguists have criticized these formulas as weaker indicators of comprehensibility (Graesser et al., 2004), noting how their mechanical application can produce artificially simplified texts that fragment coherence. In response to these limitations, contemporary approaches to text analysis have evolved to examine complexity through a multilevel process: lexical sophistication (word-level features), syntactic complexity (grammatical structures), and discourse organization (textual coherence and cohesion).

Analysis at the lexical level reveals that less readable texts demonstrate complexity through multisyllabic words, greater vocabulary diversity, and less frequent words, which are typically less familiar for readers (Crossley & McNamara, 2011, 2012; McNamara, Louwerse, et al., 2010). This lexical complexity directly impacts reading processes, as reading requires dual processing: word recognition and meaning construction. When word recognition becomes automatic, more cognitive resources become available for comprehension (Gorsuch & Taguchi, 2008).

Similarly, at the syntactic level, more readable texts facilitate comprehension through simplified structures, characterized by decreased subordination, fewer passive voice constructions, fewer nominalizations, lower frequencies of prepositions and pronouns, shorter preverb phrases, and simpler noun phrase modifications, with increased usage of present tense verbs (Crossley & McNamara, 2011; Crossley, Salisbury, & McNamara, 2012; Määttä, 2020). These syntactic simplifications, including occasional subject or modal deletion (Murray, 2000), serve to reduce cognitive processing load and enhance text comprehensibility.

Moving beyond sentence-level analysis, the discursive level examines how cohesive devices (including lexical repetition, discourse connectives, and coordinating/subordinating conjunctions) play a crucial role in text comprehension, although their impact varies by reader characteristics (Crossley & McNamara, 2011, 2012; Kintsch et al., 2007). According to Kintsch and van Dijk's (1978) model, stronger cohesive links in texts facilitate the retention of local relations that form the text's micro- and macrostructures. Beyond these three linguistic

dimensions, text comprehension is also influenced by reader-specific variables, including English proficiency (Galloway et al., 2017), prior domain knowledge (McNamara, Louwerse, et al., 2010), cognitive abilities such as nonverbal intelligence and working memory (Javourey-Drevet et al., 2022), and motivation as reflected in topic interest (Rets & Rogaten, 2021).

Simplification Methodology

While research on text simplification in aviation maintenance documentation remains limited, valuable insights can be drawn from EFL pedagogy, where text simplification has proven to be an effective instructional strategy (Deignan et al., 2019; Glass & Oliveira, 2014; Murphy Odo, 2023; Walsh Marr et al., 2021). This pedagogical strategy involves systematically modifying authentic texts (those originally written for native English speakers) to increase accessibility for learners at different proficiency levels (Crossley, Louwerse, et al., 2007). The approach has gained particular prominence in educational materials development, with simplified texts showing greater pedagogical utility than authentic materials in controlled learning environments (Allen, 2009).

Text simplification methodology in EFL encompasses two complementary approaches: structural and intuitive (Allen, 2009). While distinct in their implementation, both approaches maintain the fundamental balance between accessibility and content integrity. The structural approach, predominantly utilized by established publishers, implements controlled parameters of lexical complexity and syntactic sophistication aligned with specific proficiency levels. Allen's (2009) analysis reveals three distinct levels of grammatical progression:

- Pre-intermediate level: incorporation of defining relative clauses with restricted pronominal usage (*who, which, that*)
- Intermediate level: introduction of nondefining relative clauses and expanded pronominal elements (*whose*)
- Upper intermediate level: integration of embedded relative clauses within complex syntactic structures

Empirical evidence substantiates the effectiveness of this structured progression through systematic variations across proficiency levels: lower level texts demonstrate higher densities of verb phrases and simplified syntactic structures, while advanced-level texts more closely approximate authentic discourse patterns (Allen, 2009). This graduated approach corresponds with established patterns of second language acquisition (SLA), facilitating appropriate linguistic challenges at each developmental stage.

The intuitive approach complements these structural parameters by incorporating authors' professional judgment in assessing text accessibility and pedagogical appropriateness. This approach, widely implemented in practical teaching contexts, operates across three primary linguistic dimensions (Rets et al., 2022):

- Lexical modifications: strategic employment of superordinate terms and circumlocution
- Syntactic restructuring: systematic reduction of clausal complexity and voice alternation
- Discourse-level adaptations: enhancement of cohesive devices and resolution of referential ambiguity

Benefits and Drawbacks of Text Simplification

Despite ongoing controversy over simplified texts in second- and foreign-language classrooms, empirical evidence strongly supports their benefits for learners. Comparative studies have shown that, compared to authentic texts, simplified texts lead to better comprehension (Crossley, Yang, & McNamara, 2014; Walsh Marr et al., 2021) and shorter reinspection time (Rets et al., 2022; Rets & Rogaten, 2021). These findings align with cognitive linguistics research, particularly the automatic information processing theory (LaBerge & Samuels, 1974), which explains how familiar words reduce cognitive load and processing time, enabling readers to dedicate more attention to comprehension, as evidenced by shorter eye fixation times and reduced working memory demands (Crossley & McNamara, 2011).

In terms of their structural design and pedagogical application, simplified texts incorporate specific linguistic features to support second-language learners. At the structural level, they contain increased redundancy and amplified explanation, with emphasis on clarification and elaboration

through strategic reduction, supply, or expansion of information (Crossley, Louwerse, et al., 2007). Higher coreferentiality is achieved through careful attention to word types, clarification, and pronominal reference, along with clear definitions of key terms (Rets et al., 2022). These adaptations specifically address the challenges faced by learners who encounter both language-level difficulties (lexical and syntactic) and meaning-level barriers (conceptual and cultural) in authentic materials (Crossley, Louwerse, et al., 2007). Based on these considerations, researchers recommend that teachers adapt content according to learners' English proficiency levels (Galloway et al., 2017).

Most significantly, the impact of simplified texts extends beyond immediate comprehension to create a positive cycle of learning outcomes. These texts enhance students' affective response to learning materials (Min & Bishop, 2024) and build reader confidence, which increases motivation for reading (Gorsuch & Taguchi, 2008). Enhanced motivation leads learners to engage in multiple rereadings, developing reading fluency and further improving comprehension. This virtuous cycle of improved confidence, motivation, fluency, and comprehension ultimately enables learners to transfer their reading skills to new passages, fostering greater independence in reading. However, researchers have also raised significant concerns about the effectiveness of text simplification in second-/foreign-language contexts, questioning whether it genuinely supports comprehension and language acquisition or potentially impedes learners' linguistic development. These concerns can be examined from several interconnected perspectives: semantic ambiguity, discourse coherence, and SLA theory.

From a semantic perspective, text simplification can paradoxically create ambiguity and misunderstanding. When complex linguistic terms are replaced with more accessible language (Caplan, 2019), the resulting simplified text may become more challenging to comprehend, as simpler and more common English words typically have multiple meanings or high polysemy (Crossley, Louwerse, et al., 2007). Javourey-Drevet et al. (2022) further note that this simplification process can reduce authenticity and result in the loss of semantic nuances, particularly when elaboration modifications introduce grammar that is more complex than the original text. This semantic loss is especially problematic when simplified texts omit important qualifying clauses and details that aid understanding,

potentially making them more difficult for beginner second-language learners to comprehend than authentic texts.

These issues extend beyond semantic concerns to affect discourse coherence and natural language patterns. When texts are simplified, they tend to show a higher concentration of lexical bundles while eliminating common but opaque phrases (Allen, 2009). Several studies (Crossley, Louwerse, et al., 2007; Long, 2020; Oh, 2001) have demonstrated that sentence splitting and information reduction significantly impact text cohesion, resulting in what Long (2020, p. 172) describes as an "irritating, breathless, staccato effect." These choppy, disconnected sentences remove natural language patterns and helpful redundancy that support comprehension (Allen, 2009; Crossley, Louwerse, et al., 2007; Oh, 2001). While proponents like Rets et al. (2022) suggest that adding logical connectives can maintain cohesion when shortening sentences, McNamara, Louwerse, et al. (2010) found that low-cohesion texts only benefit high-knowledge readers who can actively process and generate inferences.

From an SLA perspective, these concerns align with Krashen's (1982) influential theory emphasizing the importance of comprehensible input in the target language. Critics argue that simplified texts may limit second-language learners' exposure to natural language patterns, potentially causing their interlanguage to become fossilized. This limited exposure creates a significant challenge: learners who primarily engage with simplified texts may struggle to transition to authentic materials containing more sophisticated linguistic features and deeply embedded contextual cues.

While existing research has extensively documented both the benefits and limitations of text simplification, less attention has been paid to its application and effectiveness in high-stakes technical contexts, particularly in aviation maintenance where aviation maintenance technicians (AMTs) must accurately comprehend complex technical documentation. Notably, there has been no comparative study examining how STE guidelines have evolved and their progressive impact on reading comprehension from early versions to present-day applications. To address these gaps, this exploratory study aims to investigate the following research questions:

1. What linguistic and functional variations, as well as distinctive linguistic features, differentiate early- and later-generation AMMs?
2. How do these features correlate with readability metrics, and what are their implications for user comprehension and technical documentation?

Methodology

Corpora

Step 1: Data Collection and Corpus Design

The present study analyzed AMMs from two primary variants of a widely used narrow-body commercial aircraft: early-generation (encompassing three subvariants) and later-generation (encompassing four subvariants). AMMs serve as the principal reference source for frontline aviation technicians, providing variant-specific maintenance procedures and troubleshooting protocols. These technical documents follow the Air Transport Association's standardized chapter classification system (ATA 100), which hierarchically organizes maintenance information into four technical domains: General Aircraft (Chapters 00–12), Aircraft Systems (Chapters 20–49), Aircraft Structures (Chapters 51–57), and Propulsion (Chapters 71–80). The corpus, organized according to this ATA 100 classification, contains comprehensive documentation from 45 early-generation and 48 later-generation AMM chapters, representing the complete available maintenance literature for both aircraft variants (Table 1). All textual data and maintenance documentation were obtained from an aircraft maintenance company in the Asia-Pacific region for research purposes.

Step 2: Calculation of Temporal Distribution in Documentation

Our temporal analysis examined the chronological distribution of maintenance documentation updates. Aircraft manufacturers continuously revise their documentation to incorporate (1) technical updates and modifications, (2) new regulatory requirements from aviation authorities, and (3) operational feedback comprising corrections, enhancements, and clarifications. Each document contains an initial issue date and subsequent revision history, tracked through page-level dating systems.

The analysis process involved two stages. First, we converted the PDF documentation to plain text format. Second, we developed Python scripts utilizing regular expressions to identify standardized date formats (e.g., “Jan 01/24”) and datetime functions to analyze the chronological distribution of page-level updates.¹ This analysis revealed distinct temporal patterns in both variants. The early-generation content spans three periods: pre-1990 (3.86%), 1990–1998 (36.52%), and 1999–2007 (59.62%). The later-generation content is distributed across four periods: 2005–2009 (1.70%), 2010–2014 (28.62%), 2015–2019 (33.86%), and 2020–2024 (36.05%; Table 1).

Step 3: Corpus Cleaning

To optimize accuracy, we implemented a systematic text preprocessing pipeline using Python scripts with custom regular expressions. The cleaning protocol was designed to preserve essential maintenance narrative content while systematically removing extraneous

¹ Example regular expression pattern for date extraction: `r'(?i(?:JA|N|FEB|MAR|APR|MAY|JUN|JUL|AUG|SEP|OCT|NOV|DEC)\s+\d{1,2}/\d{2})'`

Table 1. Descriptive Statistics of the AMMs Corpus

Aircraft Models	No. of Texts/ Chapters	First Issue Date (Last Revised)	Distribution of Current Content by Period (%)	No. of Tokens*
Early-generation variants	45	OCT 1983 (JUL 2007)	Pre-1990: 3.86 1990–1998: 36.52 1999–2007: 59.62	3,580,383
Later-generation variants	48	SEP 2005 (JUN 2024)	2005–2009: 1.70 2010–2014: 28.62 2015–2019: 33.86 2020–2024: 36.05	4,679,607

Note. AMMs = aircraft maintenance manuals.

*After cleaning.

elements, including publisher information, document identifiers, formatting artifacts, and PDF conversion residuals. Following this preprocessing procedure, the resulting corpora comprised 3,580,383 tokens for the early-generation AMMs and 4,679,607 tokens for the later-generation AMMs (Table 1).

Methods and Tools: MDA Tagging

To address the first research question, we employed a modified MDA approach following Biber's (1988) dimensions. MDA is a corpus-based framework for analyzing linguistic variation across spoken and written registers, which has become a robust methodological approach in register analysis. Following this framework, we applied Nini's (2019) Multi-Dimensional Analysis Tagger (MAT) to compare linguistic characteristics across early-generation and later-generation AMMs. Unlike Biber's original methodology, which employed exploratory factor analysis, MAT applies a tag-based approach to identify and quantify 67 linguistic features across Biber's preestablished six dimensions, enabling direct comparisons with his baseline corpus data.

The quantitative analysis involves a standardized two-step procedure. First, the frequency counts of linguistic features are normalized per 1,000 words and transformed into *z*-scores using the means and standard deviations from Biber's (1988) reference corpus. These standardized scores are then weighted according to their dimensional loading coefficients (positive or negative) and combined to compute dimensional scores that characterize texts along six functional dimensions: involved versus informational production (D1), narrative versus nonnarrative concerns (D2), explicit versus situation-dependent reference (D3), overt expression of persuasion (D4), abstract versus nonabstract information (D5), and online information elaboration (D6). To verify the reliability of our automated tagging process, we conducted a manual inspection of approximately 1% of the tagged texts (35,800 tokens from the early-generation corpus and 46,800 tokens from the later-generation corpus). This quality control process involved identifying systematic tagging errors, implementing necessary corrections, and recalculating dimension scores. Following this validation step, we performed additional statistical analyses to ensure the robustness of our findings, with detailed results presented in the Dimensional Differences Between AMMs of Two Generations section.

Readability Test

To address the second research question, we used Coh-Metrix 3.0 (Graesser et al., 2004), a computational tool that generates linguistic indices through the integration of lexicons, pattern recognizers, syntactic parsing, and other computational linguistics components (McNamara, Louwerse, et al., 2010). Coh-Metrix analyzes both surface and deep-level textual features using eight primary easability components (McNamara, Graesser, et al., 2014) that operate at three distinct linguistic levels: word level (Word Concreteness), sentence level (Syntactic Simplicity, Connectivity, and Temporality), and text level (Narrativity, Referential Cohesion, Deep Cohesion, and Verb Cohesion), as detailed in Table 2.

Coh-Metrix 3.0 quantifies these eight components using both standardized *z*-scores and percentile rankings. For this analysis, we employed percentile scores (ranging from 0 to 100), where higher scores indicate greater text readability relative to the reference corpus. Specifically, a percentile score of 80 signifies that the analyzed text demonstrates higher readability than 80% of the texts in the reference corpus. Changes between AMM versions are expressed as percentile point differences (Δ). In conjunction with the aforementioned MDA approach, these analytical measures enable a systematic examination of linguistic variations in technical documentation and their potential impact on readability.

Language Experimental Design

Our investigation examines the influence of linguistic features on text comprehensibility through parallel text analysis. The experimental design features controlled comparisons to isolate and measure specific linguistic effects. We designed 10 paired sentences to investigate how changes in linguistic markers impact word-level, sentence-internal, and discourse-level linguistic phenomena. Version A consists of original sentences systematically extracted from commercial AMMs (later generation or early generation), selected based on their high frequency of target linguistic features. For instance, sentences containing relative clauses were sourced from the later-generation manual, while sentences with *that*-adjective complements were drawn from the early-generation manual (see Table 3 for detailed frequency distributions).

Table 2. Coh-Metrix Text Easability Principal Component Scores and Their Descriptions

Level	Component	Description
Word-level metrics	<i>Word Concreteness (WC)</i>	Words that evoke mental images versus abstract concepts that are harder to visualize
Sentence-level metrics	<i>Syntactic Simplicity (SYN)</i>	Measures sentence complexity with fewer words and familiar structures versus longer sentences with complex structures
	<i>Connectivity (CON)</i>	Explicit adversative, additive, and comparative connectives expressing logical relations
	<i>Temporality (TMP)</i>	Temporal cues and consistent tense/aspect usage facilitating event understanding
Discourse-level metrics	<i>Narrativity (NAR)</i>	Storytelling with familiar characters/events, strongly linked to word familiarity and oral language; contrasts with unfamiliar, nonnarrative texts
	<i>Verb Cohesion (VC)</i>	Overlapping verbs creating a coherent event structure, especially important for young readers and narratives
	<i>Referential Cohesion (RC)</i>	Words/ideas overlapping across sentences to form explicit connecting threads; less cohesion means fewer connections
	<i>Deep Cohesion (DC)</i>	Presence of causal/intentional connectives for logical relationships; absence requires readers to infer relationships

Note. Adapted from *Automated Evaluation of Text and Discourse With Coh-Metrix*, by D. S. McNamara, A. C. Graesser, P. McCarthy, and Z. Cai, 2014, Cambridge University Press, pp. 85–86. Copyright (2014) by Cambridge University Press.

For Version B, we employed two strategies to create controlled counterparts. Where possible, we directly removed target linguistic features while preserving semantic content. However, for certain linguistic markers that serve essential grammatical functions, such as *that* in adjective complements, direct omission was not feasible. In these cases, we developed alternative constructions guided by attested patterns in the later-generation corpus. For example, when modifying *that*-adjective complement structures, we transformed them into infinitive constructions, following structural preferences documented in the later-generation manual. The controlled parallel design enables precise isolation of linguistic feature effects, allowing for direct attribution of observed differences to specific feature manipulations.

Results

Dimensional Differences Between AMMs of Two Generations

To examine the linguistic progression from early-generation to later-generation maintenance documentation, we conducted analyses at both macro and micro levels. At the macro level, independent-samples *t*-tests were performed to compare the early-generation and later-generation corpora across six functional dimensions. The analysis revealed significant differences in Dimension 1 (involved vs. informational production) and Dimension 6 (structural elaboration) scores ($p < .05$) as shown in Table 3.

Table 3. Independent-Samples *t*-Tests Comparing Dimensions Between Later Generation and Early Generation

	Early Generation		Later Generation		<i>t</i> -Statistic	<i>p</i> -Value
	Mean	SD	Mean	SD		
D1	−16.55	3.59	−18.11	2.21	2.535	.013*
D2	−6.54	0.58	−6.50	0.42	−0.359	.72
D3	5.95	2.07	5.27	1.16	1.957	.054
D4	−3.43	1.97	−3.91	1.60	1.288	.201
D5	−2.17	0.80	−2.26	0.58	0.638	.525
D6	−0.53	0.73	−2.29	0.40	14.59	.000*

Note. *Significant at $p < .05$.

Subsequent micro-level analysis using independent-samples *t*-tests identified significant differences in eight linguistic features between the corpora ($p < .05$; see Table 4). These differences manifested in two main categories: lexical characteristics (word length [AWL] and type–token ratio [TTR]) and syntactic-cohesive features (sentence relatives [SERE], stranded prepositions [STPR], independent clause coordination [ANDC], demonstratives [DEMO], *that*-adjective complements [THAC], and *that*-verb complements [THVC]). These features primarily clustered within Dimensions 1 and 6, suggesting systematic changes in the linguistic characteristics of maintenance documentation across manual versions.

Table 4. Features in Dimensions 1 and 6

Variable	Linguistic Features	<i>t</i> -Statistic	<i>p</i> -Value	Early-Generation Mean	Later-Generation Mean	Dimension
SERE	Sentence relatives	5.575	.000*	0.78	0.14	1
STPR	Stranded preposition	3.520	.001*	0.04	−0.33	1
ANDC	Independent clause coordination	5.652	.000*	−0.11	−0.52	1
AWL	Word length	3.263	.002*	0.67	0.38	1
TTR	Type–token ratio	−2.128	.037*	−2.46	−1.82	1
DEMO	Demonstratives	14.690	.000*	0.53	−1.24	6
THAC	That-adjective complements	−3.606	.001*	0.00	1.19	6
THVC	That-verb complements	7.152	.000*	0.00	−1.05	6

Note. *Significant at $p < .05$.

Note. Gray areas indicate the larger values between early-generation and later-generation means, representing higher usage of the respective linguistic features.

Lexically, the later-generation manual demonstrated higher AWL (0.67 compared to early generation: 0.38) and lower TTR (2.46 compared to early generation: 1.82). These findings reveal two significant developments in Aviation Maintenance English over the past two decades: the shift toward more technical vocabulary and increased standardization in lexical usage. The higher AWL suggests increased lexical content elaboration and specificity (Biber, 1988, p. 118). This pattern aligns with Crossley, Louwerse, et al.'s (2007) finding that simplified texts contain more complex word structures than authentic texts. While conventional texts with advanced vocabulary typically show higher TTR and greater word variation (McNamara, Louwerse, et al., 2010),

technical documentation follows a distinct pattern of controlled language principles. Specifically, the lower TTR in the later-generation manual reflects a deliberate standardization strategy, where consistent terminology and planned repetition strengthen text cohesion through clear reference chains (Crossley, Louwerse, et al., 2007; Gorsuch & Taguchi, 2008; Oh, 2001). Syntactically, the later-generation manual exhibited higher frequencies of SERE (0.78 vs. 0.14), STPR (0.04 vs. -0.33), and ANDC (-0.11 vs. -0.52). Notably, Dimension 6 showed increased use of DEMO (0.53 vs. -1.24) and THVC (0.00 vs. -1.05), while showing decreased use of THAC (0.00 vs. 1.19). The impact of these linguistic changes on readability will be evaluated through eight components in the Coh-Metrix analysis in the following section.

Readability Differences in AMMs of Two Generations

To systematically evaluate how these linguistic changes affect text comprehension, we conducted a detailed Coh-Metrix analysis of our target or identified features. As shown in Figure 1, our analysis focused on six key linguistic features across both corpora: THAC, which showed higher frequency in early-generation texts, and five features more prevalent in later-generation texts (ANDC, SERE, STPR, DEMO, and THVC). Each feature was analyzed using an if-controlled condition (presence vs. absence). Using a threshold of substantial change ($\Delta \geq |20|$ percentile points) as our analytical criterion, we identified several significant modifications in textual properties.

THVC, when compared to controlled conditions, demonstrated the most dramatic variations in textual properties. These variations were characterized by a substantial increase in referential cohesion ($\Delta = +72$), improved verb cohesion ($\Delta = +46$), and moderately decreased temporality ($\Delta = -22$). ANDC, relative to its controlled conditions, revealed three substantial variations: a marked decrease in syntactic simplicity ($\Delta = -68$), accompanied by significant increases in both verb cohesion ($\Delta = +54$) and word concreteness ($\Delta = +43$). THAC, when compared to controlled conditions, showed two notable changes: decreased narrativity ($\Delta = -30$) and decreased connectivity ($\Delta = -20$). The remaining features, SERE, STPR, and DEMO, exhibited minimal variations below our established threshold ($\Delta \geq |20|$), suggesting their limited

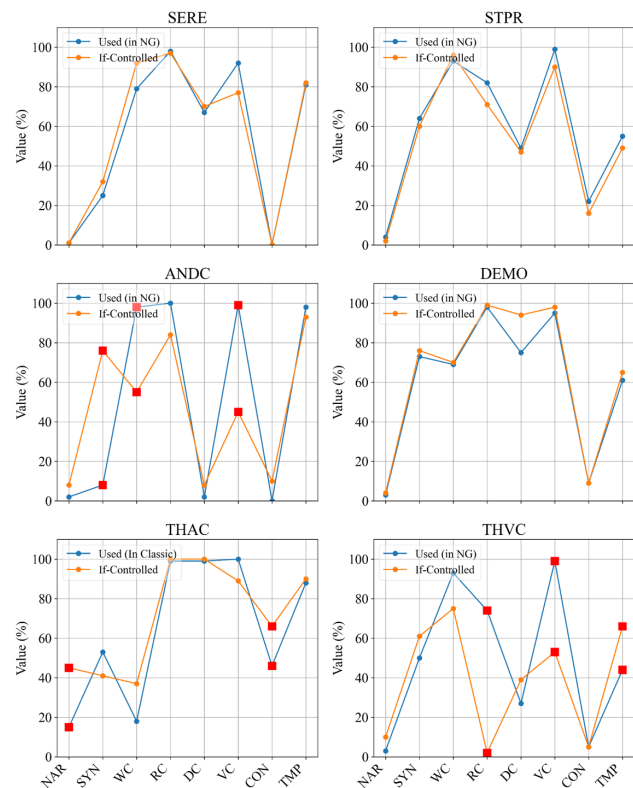


Figure 1. Comparison of six linguistic components.

impact on overall textual properties. In the following sections, we examine each of these linguistic features in detail through authentic examples, analyzing their effects on textual properties and potential processing demands for readers.

Discussion

THVC

Our analysis revealed a higher frequency of THVC in the later-generation corpus compared to the early-generation corpus (see Table 3). THVC, which involves the use of *that* as a complementizer following verbs, showed the most substantial effects between use and controlled versions among the six linguistic features examined. To evaluate its impact, we extracted sentences from the later-generation corpus and created their controlled variants without THVC, as shown in Example (1):

Example (1)

Use (a): Before the airplane hydraulic systems are pressurized, do the steps that follow: 1) Check *that* the main and nose landing gear

ground locks are installed, if necessary do this task: Landing Gear Downlock Pins Installation. 2) Put your hand on the fan case to feel *that* it operates. [Later-generation]

Controlled (b): Before the airplane hydraulic systems are pressurized, do the steps that follow: 1) Check the main and nose landing gear ground locks are installed, if necessary do this task: Landing Gear Downlock Pins Installation. 2) Put your hand on the fan case to feel it operates. [Simulated version]

We observed significantly higher values in referential and verb cohesion ($\Delta = +72$ and $\Delta = +46$, respectively) in the use condition, indicating that THVC serves as an important mechanism for maintaining text cohesion in technical instruction. Texts with reduced cohesion require readers to mentally reorder content and generate inferences to bridge conceptual gaps between ideas, relationships, or events (McNamara, Louwerse, et al., 2010). This cognitive demand creates differential effects based on reader expertise: novice AMTs, as low-knowledge readers, typically experience disrupted comprehension due to insufficient technical knowledge to generate these inferences. In contrast, experienced AMTs, as high-knowledge readers, can compensate for cohesion gaps through active processing and inference generation, despite not having prior exposure to the specific textual information (McNamara, Louwerse, et al., 2010). While simplified features typically reduce reading time (Javourey-Drevet et al., 2022), the decreased temporality score ($\Delta = -22$) may create processing difficulties for higher proficiency readers due to longer sentences with additional THVC markers. The interaction between this potential drawback and the enhanced cohesion benefits on reading speed requires empirical investigation.

ANDC

Our results illustrated a marked disparity in ANDC, characterized by the coordination of independent clauses using conjunctions such as *and*, with higher frequencies in the later-generation corpus than the early-generation corpus (see Table 3). Comparison of ANDC sentences and their controlled variants revealed substantial differences in syntactic simplicity, verb cohesion, and word concreteness, as shown in Example (2):

Example (2)

Use (a): If you think there will be a hard freeze *and* the tires will freeze to the ground, do the step that follows. [Later-generation]

Controlled (b): If you think there will be a hard freeze, do the step that follows. If you think the tires will freeze to the ground, do the step that follows. [Simulated version]

Example (2a) shows lower syntactic simplicity ($\Delta = -68$), which aligns with Crossley, Louwerse, et al.'s (2007) observation that shorter, simplified structures like Example (2b) produce more straightforward syntactic patterns. The coordinated structure in Example (2a) results in higher verb cohesion ($\Delta = +54$) and word concreteness ($\Delta = +43$). The logical operators measured in Coh-Metrix (including variants of *and*, *or*, *not*, and *if-then* combinations) relate directly to text density and correlate with higher demands on working memory (Costermans & Fayol, 1997). This finding illustrates a key consideration: while oversimplified texts may achieve better readability scores through shorter sentences and fewer connectives, they may result in lower cohesion compared to naturally occurring texts (Crossley, Louwerse, et al., 2007).

THAC

We found significant differences in the distribution of THAC structures between corpora, with markedly higher frequencies in the early-generation corpus compared to the later-generation corpus (see Table 3). For this distributional pattern, we examined THAC structures, constructions where *that* functions as a relative pronoun in adjective complements and conventionally cannot be omitted. Using an authentic “*It is important*” construction from the early-generation corpus as source material, we systematically created variant forms to explore structural possibilities. These variants, including one with infinitive structure, reflect the syntactic patterns commonly found in the later-generation corpus, as illustrated in Example (3):

Example (3)

Use (a): It is *important that* all blue stains are removed from the area. [Early-generation]

Controlled (b): It is *important to remove* all surface compound residue so that subsequently applied grease does not readily run/wash off. (Later-generation)

Controlled (c): It is *important to remove_all*
blue stains from the area. [Simulated version]

Analysis of the controlled version (3c) reveals two significant improvements in readability compared to (3a). First, the narrativity score increased ($\Delta = +30$) through the transformation of the passive construction (*that all blue stains are removed*) into an active infinitive (*to remove all blue stains*). This shift creates a more direct, action-oriented sentence structure that better resembles natural storytelling patterns. Second, the connectivity measure improved ($\Delta = +20$) by replacing the complex subordinate *that* clause with a simpler infinitive structure. This streamlined construction strengthens the logical connection between the main clause (*it is important*) and the action (*remove all blue stains*).

These findings have several important implications for current ASD-STE specifications, which mandate that “the conjunction *that* (cannot be omitted) to connect additional information (in a subordinate clause) to a main clause” (ASD, 2024). Our corpus analysis demonstrates a systematic evolution in technical documentation practices, with newer texts favoring infinitive structures over THAC constructions. This documented shift, along with the quantifiable improvements in readability metrics and evidence from authentic later-generation documentation, indicates that ASD-STE specifications should distinguish between different types of *that* constructions (such as THVC and THAC) and provide specific guidance for each structural pattern.

Conclusion

This study addresses a critical gap in research concerning STE’s effectiveness in reducing text complexity and improving comprehension, despite its nearly 40-year implementation as an international requirement in the aviation industry. Originally developed to achieve precise communication, universal understanding, and error-free execution in aviation maintenance, STE has evolved significantly over time. Our MDA revealed notable changes in language patterns, particularly in Dimensions 1 and 6: later-generation texts demonstrated higher levels of interactive and plain language features (Dimension 1) compared to early-generation texts, while higher Dimension 6 scores indicated enhanced real-time

informational elaboration oriented towards immediate contextual demands and time-critical tasks.

Building on these dimensional findings, follow-up experiments isolating eight distinctive linguistic features revealed both the benefits and challenges of linguistic simplification. While aiming to enhance accessibility, advances in one domain may inadvertently diminish essential textual attributes. Analysis of readability metrics showed that newer AMMs exhibit enhanced textual cohesion and connectivity, albeit with corresponding decreases in syntactic simplicity and temporal organization. The increased cohesion supports maintenance technicians in generating bridging inferences necessary for comprehending procedural dependencies and causal relationships. The balance between maintaining cohesion while adjusting simplicity levels represents an approach that optimizes comprehension as supported by psycholinguistic research (Rets et al., 2022). Rather than maximizing simplicity at all costs, this approach recognizes that explicit cohesive markers reduce the need for readers to generate their own connections between ideas, which mitigates the risk of oversimplification. Oversimplification would otherwise require readers to generate additional elaborative inferences—particularly challenging for novice technicians and English-as-a-second-language learners.

Our examination of STE’s practical implementation further reveals that while some linguistic control strategies were effectively implemented in AMMs, others remain underexplored or uncontrolled, suggesting that current STE guidelines need further development to address these gaps in linguistic control and standardization. Drawing on Wittgenstein’s (1953) argument that “Like everything metaphysical, the harmony between thought and reality is to be found in the grammar of the language” (p. 245), we draw upon a philosophical perspective indicating that language structure itself shapes our understanding of reality. Therefore, while controlled simplification of technical English may enhance accessibility, it may inadvertently narrow the pathways through which technical concepts can be fully articulated and understood. Based on this understanding of language’s role in shaping technical comprehension, we argue the relationship between cohesion, syntactic simplicity, and temporality involves inherent trade-offs, necessitating careful optimization while avoiding redundancy that could increase processing complexity.

Our focus on lexical dimensions further revealed that Aviation Maintenance English has developed more specialized technical vocabulary while becoming increasingly standardized in its lexical usage over the past two decades, as evidenced by higher word length and lower type–token ratio. While simplified text generally enhances comprehension, studies by Oh (2001) and Murphy Odo (2023) demonstrated that it fails to improve performance among low-proficiency learners unless matched to their proficiency threshold. This finding underscores that text simplification alone is insufficient, and we cannot afford to take second language (L2) AMTs' English language training lightly.

While these findings provide valuable insights into the evolution and challenges of STE implementation, several limitations warrant consideration. Computational linguistics tools like Coh-Metrix cannot fully capture cognitive processing demands, despite their ability to analyze text complexity. This is evident in McNamara, Crossley, et al.'s (2015) study, which revealed that Natural Language Processing (NLP)-based models (e.g., Coh-Metrix) achieved 55% exact accuracy and 92% adjacent accuracy when compared to human ratings. More recent research by Choi and Crossley (2022) found that Coh-Metrix's second language readability index (CML2RI) model performed marginally better than traditional readability formulas (e.g., Flesch Reading Ease) but slightly lower than more advanced formulas (e.g., Sentence Bidirectional Encoder Representations from Transformers (BERT), Ensemble Transformer Model). Additionally, while some syntactic features (e.g., STPR and DEMO) indicate movement toward plain language style, their changes below the established threshold ($\Delta \geq |20|$) and minimal impact on text comprehension metrics suggest limitations in either our measurement tools or our understanding of how these linguistic features contribute to comprehension. These limitations point to opportunities for future research to explore ways of integrating advanced automated text analysis tools with human judgment to enhance text readability assessment.

References

- Allen, D. (2009). A study of the role of relative clauses in the simplification of news texts for learners of English. *System*, 37(4), 585–599.
- ASD. (2024). *ASD-STE100 Simplified Technical English: International standard for technical documentation* (Prerelease version, Issue 9). ASD.
- Baron, R. I. (2009). An exploration of deviations in aircraft maintenance procedures. *International Journal of Applied Aviation Studies*, 9(1), 197.
- Biber, D. (1988). *Variation across speech and writing*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511621024>
- Caplan, N. A. (2019). Asking the right questions: Demystifying writing assignments across the disciplines. *Journal of English for Academic Purposes*, 41, 100776.
- Chang, Y. H., & Wang, Y. C. (2010). Significant human risk factors in aircraft maintenance technicians. *Safety Science*, 48(1), 54–62.
- Choi, J. S., & Crossley, S. A. (2022, July). Advances in readability research: A new readability Web app for English. In *2022 International Conference on Advanced Learning Technologies (ICALT)* (pp. 1–5). IEEE.
- Costermans, J., & Fayol, M. (Eds.). (1997). *Processing interclausal relationships: Studies in the production and comprehension of text*. Psychology Press.
- Crossley, S. A., & McNamara, D. S. (2011). Understanding expert ratings of essay quality: Coh-Metrix analyses of first and second language writing. *International Journal of Continuing Engineering Education and Life-Long Learning*, 21(2–3), 170–191.
- Crossley, S. A., & McNamara, D. S. (2012). Predicting second language writing proficiency: The role of cohesion, readability, and lexical difficulty. *Journal of Research in Reading*, 35(2), 115–135.
- Crossley, S. A., Louwerse, M. M., McCarthy, P. M., & McNamara, D. S. (2007). A linguistic analysis of simplified and authentic texts. *The Modern Language Journal*, 91(1), 15–30.
- Crossley, S. A., Salsbury, T., & McNamara, D. S. (2012). Predicting the proficiency level of language learners using lexical indices. *Language Testing*, 29(2), 243–263.
- Crossley, S. A., Yang, H. S., & McNamara, D. S. (2014). What's so simple about simplified texts? A computational and psycholinguistic investigation of text comprehension and text processing. *Reading in a Foreign Language*, 26(1), 92–113.
- Deignan, A., Semino, E., & Paul, S. A. (2019). Metaphors of climate science in three genres: Research articles, educational texts, and secondary school student talk. *Applied Linguistics*, 40(2), 379–403.
- Galloway, N., Kriukow, J., & Numajiri, T. (2017). *Internationalisation, higher education and the growing*

- demand for English: An investigation into the English medium of instruction (EMI) movement in China and Japan*. British Council.
- Glass, R., & Oliveira, A. W. (2014). Science language accommodation in elementary school read-alouds. *International Journal of Science Education*, 36(4), 577–609.
- Gorsuch, G., & Taguchi, E. (2008). Repeated reading for developing reading fluency and reading comprehension: The case of EFL learners in Vietnam. *System*, 36(2), 253–278.
- Graesser, A. C., McNamara, D. S., Louwerse, M. M., & Cai, Z. (2004). Coh-Metrix: Analysis of text on cohesion and language. *Behavior Research Methods, Instruments, and Computers*, 36, 193–202.
- Habib, K. A., & Turkoglu, C. (2020). Analysis of aircraft maintenance related accidents and serious incidents in Nigeria. *Aerospace*, 7(12), 178.
- Hackworth, C., Holcomb, K., Banks, J., Schroeder, D., & Johnson, W. B. (2007). A survey of maintenance human factors programs across the world. *International Journal of Applied Aviation Studies*, 7(2), 212–231.
- Javourey-Drevet, L., Dufau, S., François, T., Gala, N., Ginestie, J., & Ziegler, J. C. (2022). Simplification of literary and scientific texts to improve reading fluency and comprehension in beginning readers of French. *Applied Psycholinguistics*, 43(2), 485–512.
- Jiang, T. W., Lu, C. T., Fu, H., Palmer, N., & Peng, J. (2022). An inductive approach to identify aviation maintenance human errors and risk controls. *The Collegiate Aviation Review International*, 40(1), 113–142.
- Kintsch, W., McNamara, D. S., Dennis, S., & Landauer, T. K. (2007). LSA and meaning: In theory and application. In *Handbook of latent semantic analysis* (pp. 479–492). Psychology Press.
- Kintsch, W., & van Dijk, T. A. (1978). Towards a model of text comprehension and production. *Psychological Review*, 85, 363–394.
- Krashen, S. (1982). *Principles and practice in second language acquisition*. Pergamon Press.
- LaBerge, D., & Samuels, S. J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology*, 6(2), 293–323.
- Langer, M., & Braithwaite, G. R. (2016). The development and deployment of a maintenance operations safety survey. *Human Factors*, 58(7), 986–1006.
- Long, M. H. (2020). Optimal input for language learning: Genuine, simplified, elaborated, or modified elaborated? *Language Teaching*, 53(2), 169–182.
- Määttä, S. K. (2020). Translating child protection assessments for ELF users: Accommodation, accessibility, and accuracy. *Journal of English as a Lingua Franca*, 9(2), 287–307.
- McNamara, D. S., Crossley, S. A., Roscoe, R. D., Allen, L. K., & Dai, J. (2015). Hierarchical classification approach to automated essay scoring. *Assessing Writing*, 23, 35–59.
- McNamara, D. S., Graesser, A. C., McCarthy, P., & Cai, Z. (2014). Automated evaluation of text and discourse with Coh-Metrix. Cambridge University Press.
- McNamara, D. S., Louwerse, M. M., McCarthy, P. M., & Graesser, A. C. (2010). Coh-Metrix: Capturing linguistic features of cohesion. *Discourse Processes*, 47(4), 292–330.
- Min, S., & Bishop, K. (2024). A shortened test is feasible: Evaluating a large-scale multistage adaptive English language assessment. *Language Testing*, 41(3), 627–648.
- Murphy Odo, D. (2023). The effect of automatic text simplification on L2 readers' text comprehension. *Applied Linguistics*, 44(6), 1030–1046.
- Murray, D. E. (2000). Protean 1 communication: The language of computer-mediated communication. *TESOL Quarterly*, 34(3), 397–421.
- Nathanael, D., Tsagkas, V., & Marmaras, N. (2016). Trade-offs among factors shaping operators decision-making: The case of aircraft maintenance technicians. *Cognition, Technology & Work*, 18, 807–820.
- Nini, A. (2019). The Multi-Dimensional Analysis Tagger. In T. B. Sardinha & M. V. Pinto (Eds.), *Multi-dimensional analysis: Research methods and current issues* (pp. 67–96). Bloomsbury. <https://doi.org/10.5040/9781350023857.0012>
- Oh, S. Y. (2001). Two types of input modification and EFL reading comprehension: Simplification versus elaboration. *TESOL Quarterly*, 35(1), 69–96.
- Rets, I., Astruc, L., Coughlan, T., & Stickler, U. (2022). Approaches to simplifying academic texts in English: English teachers' views and practices. *English for Specific Purposes*, 68, 31–46.
- Rets, I., & Rogaten, J. (2021). To simplify or not? Facilitating English L2 users' comprehension and processing of open educational resources in English using text simplification. *Journal of Computer Assisted Learning*, 37(3), 705–717.
- Rozycki, W., & Johnson, N. H. (2013). Non-canonical grammar in Best Paper award winners in engineering. *English for Specific Purposes*, 32(3), 157–169.
- Tretten, P., & Normark, J. (2019). Guidelines for a mobile tool to address human factors issues in aircraft maintenance. *International Journal of Human Factors and Ergonomics*, 6(3), 208–226.
- Walsh Marr, J., Lynch, S., & Tervit, T. (2021). Defining with purpose: Connecting lexicogrammatical features to textual purpose in authentic undergraduate texts. *TESOL Quarterly*, 55(4), 1092–1101.
- Wittgenstein, L. (1953). *Philosophical investigations* (G. E. M. Anscombe, Trans.). Basil Blackwell.

Zafiharimalala, H., Robin, D., & Tricot, A. (2014). Why aircraft maintenance technicians sometimes do not use their maintenance documents: Towards a new qualitative perspective. *The International Journal of Aviation Psychology*, 24(3), 190–209.

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Declaration of Authors' Contributions

Conceptualization, A.W.W.; methodology, A.W.W. and E.F.; data analysis, A.W.W.; writing--original draft preparation, A.W.W.; writing--review and editing, E.F.; supervision, E.F. All authors have read and agreed to the published version of the manuscript.

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