FRAMING AERODYNAMIC TERMINOLOGY: A LINGUISTIC APPROACH /PRELIMINARY STUDY/

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Abstract: *The aerodynamic terminological field is characterized by highly complex and specific terms which are used to describe various scientific phenomena that occur during flights. The aim of the paper is to analyze aerodynamic terminology using a frame semantics approach to study terms categorized into frames and subframes. The study reveals the linguistic behavior of aerodynamic terms within the frames. Using the corpus linguistic software Sketch Engine, we identified recurring patterns, collocations, and term frequency in a compiled corpus of books on aerodynamics. The findings reveal that aerodynamic terminology can be systematically structured into frames, which can overlap, thus demonstrating the conceptual construction of complex, technical meanings of the aerodynamic terms. The research contributes to a better understanding of aerodynamic terms as part of the aviation terminological field and is of great help to people interested in learning, teaching, and working in the field of aerodynamics.*

Keywords: *frame semantics, aerodynamics, cognitive linguistics, corpus linguistics, terminology*

1. INTRODUCTION

The dream of flying and conquering the skies has always been one of the main goals people have had. Referring to the history of aerodynamics, we can point out the names of Aristotle, who proposed that air has weight, and Archimedes, who discovered the law of floating bodies. One of the most prominent people related to the development of aerodynamics is the Italian painter, sculptor, and engineer Leonardo da Vinci, who described and designed ornithopters (machines that copied the actions of a bird's wing), the first helicopter and the first parachute. He also concluded that *'it was the movement of the wing relative to the air and the resulting reaction that produced lift necessary to fly'* [1]. The term *aerodynamics,* meaning *'science of the motion of air or other gases'* [2] dates back to 1837, and was formed from *aero- (air)* and dynamics. It was in the 20th century that the term aerodynamics was used in relation to aircraft and aviation. The beginning of the 20th century marked the first successful flight with heavier-than-air powered aircraft. Since then (1903), aviation and aerodynamics have been developing rapidly and today with the constant advancements in technology and science, we witness the emergence of new highly developed technologies. Inventions in technology have undoubtedly influenced specialized languages, including aviation language. A lot of new concepts have appeared, thus enriching and expanding the terminological field. Aerodynamics, as part of the aviation domain, is no exception. With the development of theories, and the acquisition of new knowledge about various phenomena related to flying, the terminological system of aerodynamics is constantly evolving, making it worth researching from a linguistic perspective.

Terminology used in aerodynamics can be described as highly specialized, precise, and multidisciplinary, as there are terms borrowed from Physics, Mathematics, Engineering. There are various studies on aviation language and its characteristics- Breul (2013) [3], Aziz and Rosa (2018) [4], Estival et al. (2016) [5], Kovtun (2012) [6], Katsarska (2021) [7]. Anić and Brač (2022) [8] present the process of developing the Airframe database in an article. The list of researchers who have dedicated their work to aviation language is a long one. Moreover, each of these scholars has contributed to the study of aviation language. When we began our research on aviation language, we noticed that most of the research described radiotelephony (the phraseology used between pilots and air traffic controllers) or analysed the linguistic aspects of the terminology used by aviation professionals, e.g. Fomina (2022) [9], Osadchaya (2020) [10], Katsarska (2024) [11]. What attracted our attention was that we could not find linguistic research on aerodynamic terminology. Therefore, we consider our research on aerodynamic terms innovative and unique; research that can reveal facts about a niche that has not been studied enough.

As mentioned, aerodynamics is characterized by a highly specialized scientific terminology. The concepts in this specific terminological field describe complex scientific phenomena and principles. Therefore, we asked ourselves how these concepts are structured and organized in mental representations, i.e. particularly within frames. And if they are organized in such frames, what is the common feature that links them with one another? In other words, if within a frame, there are subframes, how are these terms in the subframes related to each other? Can they exist in more than one frame? If they exist in more than one frame, does this affect their meaning?

We also thought about how these concepts behave linguistically-whether there are any recurring patterns, whether they collocate, and how often they are used in the context of aerodynamics. To find the answers to these questions, we refer to Frame Semantics and the corpus linguistic software Sketch Engine.

2. **. FRAME SEMANTICS**

Croft and Cruse [3] note that words denote concepts, which are units of meaning. Based on their meanings, concepts, represented by words can be compared and contrasted with each other. Words and their corresponding concepts are connected to one another. However, there are concepts that are connected to one another by a person's encyclopedic knowledge. i.e. by experience. For example, *AIRPLANE* is not merely a means of transportation. Concepts not directly related to it by hyponymy or other lexical relations, emerge from a person's knowledge: *pilot, passengers, landing, turbulence, aerodynamics.* The reason why these concepts are in a relationship lies in the fact that they are *'motivated by, founded on, and co-structured with, specific unified frameworks of knowledge, or coherent schematizations of experience, for which the general word **frame** can be used'* [12]. Fillmore also notes that a variety of terms have been proposed for these kinds of structures, e.g. frame, schema, script, cognitive model, experiential gestalt, base, and scene. However, he points out that these terms are used in various ways and some scholars distinguish among them depending on whether they are static or dynamic, '*according to the kinds of inference making they support'* [12].

Frame Semantics is a research programme in empirical semantics. It studies word meanings, describing the principles for creating new words and adding new meanings to words. Fillmore [13] refers to the notion of '*frame'*as '*the appeal, in perceiving, thinking, and communicating, to structured ways of interpreting experiences.*

Fillmore believes that to describe a language system, one has to include a description of the cognitive and interactive 'frames' that people use to interpret the world around them, create messages, thus creating cognitive models from their experiences. The concept of 'frames', also known as 'schemata' and 'scenario' is related to the idea that people have a cognitive inventory of schemata, which they use to structure and interpret their experiences. Although frames are not dependent on language, they play an essential role in language processing. According to Fillmore [13], when particular words or grammatical structures are associated with particular frames in a person's mind, these words and structures activate the frame which, in turn, allows access to the linguistic elements related to it. The term *frame* refers to a system of concepts that are related to one another in such a way that for a person to be able to understand one of these concepts, they have to know the whole structure this concept belongs to. According to Fillmore [14], words represent categories of experiences, based on a particular situation which has evoked a person's encyclopedic knowledge. He also adds that there are words that help people during the communication process by providing access to knowledge of frames and performing categorization. It means that words are more than mere meanings but they are also related to some background information. Thus, for an aviation professional, aerodynamic terms such as *lift, weight, drag* and *thrust* mean more than the basic meanings they have but are associated with principles and phenomena related to flight. It is evident that background context is of utmost importance in understanding a category. Fillmore [14] notes that a lot of framing words appear in highly specialized contexts. He also points out that '*the process of understanding a text involves retrieving or perceiving the frames evoked by the text's lexical content and assembling this kind of schematic knowledge (in some way which cannot be easily formalized) into some sort of 'envisionment' of the 'world' of the text'* [14]. In other words, to understand a text, a person uses frames evoked by the context and the schematic knowledge (the mental structure of the existing knowledge) they interpret the meaning of the text.

A word and its meaning can be related to one another in an associational way. Hearing the term *aerodynamics*, a person's mind evokes mental pictures of aircraft, airflow, or speed. Moreover, the term aerodynamics is not only related to aircraft but it may also be associated with cars, or why not with bikers or skiers who use aerodynamic principles to gain speed. Fillmore [13] notes that Frame Semantics strives for the same representation of 'word meanings, sentence meanings, text interpretation and world models'. A word can link different frames and understanding the meaning of the word requires knowledge of the scenario; the sentence that contains the word requires knowledge of the scenario, the lexical items, grammar. Fillmore [13] also argues that one aspect of a linguistic system is a person's cognitive and interactional frames are connected with language. To analyse a language, then, one has to access the frames that exist in language, pay attention to the number of frames, and study how frames are structured.

3. DATA AND SKETCH ENGINE SOFTWARE

This research is a preliminary stage of a broader linguistic study on aerodynamic terminology. Therefore, the number of terms we have extracted,109, is relatively small, however, we believe that the results will help us to lay the foundations of our study and will, undoubtedly. shed light on the research questions we have asked.

The present research mainly focuses on the terms that have the highest number of occurrences in the corpus we have compiled. We have manually extracted aerodynamic terms using the e-book *Pilot's Handbook of Aeronautical Knowledge*, published by FAA (Federal Aviation Administration), namely: Chapter 4 *Principles of Flight* and Chapter 5 *Aerodynamics of Flight* [15].

When we compiled the list, we looked up the definitions and categorized each term into its corresponding group. We used the *Dictionary of Aviation* [16], *The Encyclopedia of Aerodynamics* [17], and various websites for the definitions of the terms. Then, we studied the terms in each frame and where it was possible, we created subframes. That way, we created the following frames and subframes:

1. Aircraft Components, and subframes: Wing-Related Components, Stabilizer Components, Rotorcraft Components, Structural Components;
2. Flight Dynamics, and the following subframes: Aerodynamic Forces, Aircraft Motion and Stability, Aerodynamic Effects and Rotational Forces, Angles, Performance and Flight Limits;
3. Fluid Dynamics and the subframes Aerodynamic Flow and Aerodynamic Principles
4. Flight Performance Parameters and the subframes: Altitude-Related Parameter, Speed;
5. Flight Control and Navigation System and the subframes: Flight Control Surfaces, Pilot Control and Flight Instruments
6. Aircraft Flight Phases and Maneuvers, and the subframes: Takeoff and Landing, Aircraft Attitude and Maneuvers
7. Powerplant and the subframes: Types of Engines, Engine Components

In this paper, we will present only the first three frames and their corresponding subframes because our research is ongoing. Due to the extensive nature of the research, we discuss only the terms with the highest frequency distribution in the corpus. The other frames and subframes are being examined and the results of the study need more detailed examination and analysis. The conclusions that we have come to, are based on this particular research. We consider them preliminary findings, however, we firmly believe that they have established the foundations of our research on aerodynamic terminology.

Most of the terms belong to the Flight Dynamics and Fluid Dynamics frames, which can be explained by the fact that aerodynamics is part of physics and this includes fluid dynamics, and fluid mechanics. The Flight Dynamics frame comprises terms related to physical phenomena and principles; therefore, the prevailing number of aerodynamic terms is not surprising.

To study the terms in each frame and subframe, we decided to use the corpus linguistic software *Sketch Engine (*https://www.sketchengine.eu/*)*. Sketch Engine is web-based corpus linguistic software, which allows users to create their own corpus (corpora) by uploading text(s). A researcher can analyse the data in terms of Word Sketch (it shows a word's collocates), concordance (examples of use in context), collocation and N-grams or frequency analysis. For the purpose of this research, we uploaded the two chapters we extracted the terms from (Chapter 4 *Principles of Flight* and Chapter 5 *Aerodynamics of Flight)* and the books on aerodynamics *Introduction to the aerodynamics of flight* [1] and *Fundamentals of Aerodynamics* [18]. Creating a corpus and using the corpus linguistic software will help us analyze the terms linguistically not as extracted lexemes from texts but in a specific, specialized context.

4. PRELIMINARY FINDINGS AND DISCUSSION

Using the definitions of aerodynamic terms, we established seven frames and their corresponding subframes.

The terms in each frame, and their respective subframes, are closely related to one another as they contribute to the construction of the frame. They are dependent on each other but are also tied to a particular context.

This leads to the fact that we can observe that some terms can belong to more than one frame. The definitions given in the dictionary (i.e. their lexical meanings) do not change, however, the context they are used in, influences their meaning construction and how people perceive and understand these terms, in other words people's cognitive ability to comprehend complex, scientific concepts.

4.1. Aircraft components frame

The first frame is Aircraft Components. As the name suggests, this frame consists of terms that denote different parts of an aircraft, e.g. *aileron* (*a horizontal control surface hinged to the mainplane, which enables an aeroplane to bank or roll), fuselage* (*the central body of a plane, to which the wings and tail assembly are attached and which accommodates the crew, passengers, and cargo), rudder* (*a control surface on the fin which rotates the aircraft about its vertical axis to produce yaw)*, *wing* (*the main horizontal aerofoil or mainplane).*

Some terms that belong to the Aircraft Components frame belong to other frames as they have both structural and functional roles. For example, the term *flap* has the following definition: *a movable* ***control surface on the trailing edge of an aircraft wing****, used primarily to* ***increase lift and drag during final approach and landing***. From the definition, it is evident that the term *flap* belongs to the frames of *Aircraft Components* (as part of the wing) and *Flight Dynamics* (flaps divert the airflow). Another example of a term that can belong to different frames is *propeller (****a rotating shaft with blades*** *which,* ***together with the engine****, moves an aircraft through the air).* In this case, the term *propeller* refers to a structural component, but it is also part of the Powerplant frame, as it is connected to the engine.

If we look closely at all the terms that belong to Aircraft Components*,* we can observe that most of them belong to more than one frame. The reason for this behaviour is that as they are structural components, they are applied during flight and their meanings are influenced by the particular context, and that way they are understood as part of another frame. This, actually, confirms Fillmore's idea that concepts within frames are context-dependent. Aerodynamic terms are no exception.

To gain a better understanding of the terms in the Aircraft components frame, we established the following subframes:

i) Wing-Related Components (wing, wingtip, leading edge, wing tank, trailing edge, slat);

ii) Stabilizer Components (tail, elevator, fin);

iii) Rotorcraft Components (rotor, rotor blades, propeller)

iv) Structural Components (fuselage, landing gear, nose).

The terms that belong to this subframe are related to the aircraft's wing. These terms cannot exist independently as they enable a person to describe the structural components of the wing or the control surfaces that are part of the wing. When describing a wing, a person uses all of these terms which makes each term dependent on the others, i.e. its meaning leading to the meaning of the other concept in the subframe. Therefore, it is not surprising that *wing* has the highest frequency among these terms in our corpus- it is used 1,406 times, compared to *flap* which has 106 occurrences.

The term *wing* has an essential role in the aerodynamic terminological field. Together with the modifiers such as *delta, rectangular, straight*, it indicates different types of wings. The term w*ing* is also part of other structural concepts, which belong to the *Aircraft components frame,* such as *wing root (the part of the wing where it meets with the fuselage), wing tip (the outermost part of the wing)* or *wingspan (a measurement from the tip of one wing to the tip of the other wing).* Using N-gram analysis, we studied how the lemma *wing* is used in the aerodynamic context.

Our research shows that *wing* appears in definite noun phrases *the wing* 467 occurrences , followed by possessive constructions *of the wing* (134), and *finite wing (a wing of fixed span with wingtips)* (117). Figure 1 shows a visualization of nouns that are commonly modified by *wing* and the modifiers of *wing* in the corpus.

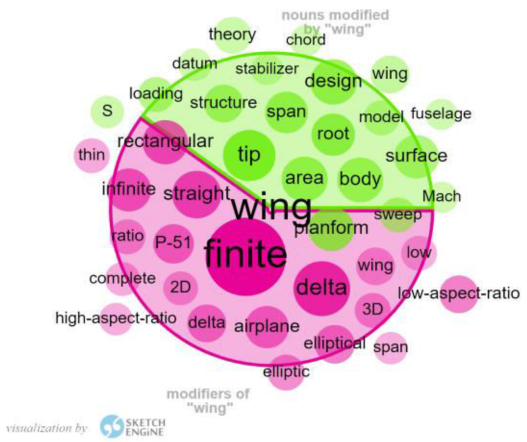

FIG. 1. Modifiers and nouns used with 'wing'

It is evident that when modified in the corpus, *wing* refers to different wing shapes and types: *delta, elliptical, finite. Finite and delta* appear to be the most frequent modifiers in the corpus while *span, structure,* and *tip* are the nouns that are modified by *wing* most frequently. The high frequency result in the corpus reveals that the term *wing* is central (core) to aerodynamic discourse and is part of compound nouns that are used in technical and aerodynamic contexts.

The second subframe of Aircraft Components is the Stabilizer Components. The terms that belong to this subframe describe structural elements that are responsible for the stability of the aircraft. The terms that belong to this subframe are: *tail (the rear part of the aircraft), fin (a fixed vertical aerofoil at the rear of a plane,* ***the vertical stabiliser****), elevator (****a movable control surface,*** *usually attached to the horizontal stabiliser of an aircraft,* ***used to produce the nose up/down motion of an aircraft*** *in level flight known as pitch), empennage (the tail assembly of an aircraft),* and *rudder (****a control surface*** *on the fin which* ***rotates the aircraft about its vertical axis to produce yaw****).* Analysing the definitions of the terms, we can observe that there are terms that can belong to more than one frame, namely: *elevator* and *rudder* are control surfaces; consequently, they can belong to the Flight Dynamics and Flight Control And Navigation frames. The term f*in* belongs to the Flight Dynamics frame because the vertical stabilizer plays a role in providing directional stability.

The term that is most frequently used in our corpus is *tail* (120 occurrences), followed by *elevator* (54 occurrences). The term *tail* denotes a structural element; therefore, it is modified by adjectives, providing information about the tail, e.g. *horizontal, vertical, wedge-shaped tail, butterfly.*

Using 2-3-grams, we observe that *tail surfaces* and *tail surface* have the highest frequency occurrences which can be explained that the term *tail* is referred to as a structural component related to aircraft stability in aerodynamic discourse. It is also used in possessive-of-constructions because of the occurrence of *tail of* (11 occurrences) and *tail of the* (7 occurrences). The analysis of the Stabilizer component frame shows that terms in this subframe can belong to multiple frames, without a change in the lexical meaning but depending on their function.

The third subframe of the Aircraft Components frame is the Rotorcraft Components. We have identified the following terms: *rotor (a device which turns about an axis or centre), rotor blades (a long thin aerofoil on a helicopter rotor),* and *propeller (a rotating shaft with blades which, together with the engine, moves an aircraft through the air).* As the name of the subframe suggests, these terms are united by a common conceptual base, the rotational motion that generates lift (rotorcraft) or thrust (propeller aircraft). We can also note that *rotor blades* is a hyponym of *rotor* as it is more specific in meaning. We have already mentioned that the term *propeller* belongs to the Powerplant frame.

Both terms *rotor and rotor blades* are not used often in the corpus we have compiled- *rotor* is used 29 times while *rotor blades* has only 5 occurrences. However, this fact does not lead to the conclusion that these terms are not important in aerodynamics. It should be noted that the corpus that we have compiled, consists of texts that are focused on basic, general aerodynamics and the texts mostly discuss airplanes. These two terms are fundamental and of utmost importance in rotorcraft aerodynamics.

The term *propeller* has 170 occurrences in the corpus. The term modifies nouns such as: *efficiency, tip, blade, forces.* The most frequently used 2-3-grams are *propeller blade* (16 occurrences), followed by *propeller and* (7 occurrences) and *propeller is* (6 occurrences). With regard to prepositional phrases, *propeller* is used in possessive structures *of propeller, propeller of* when describing components or characteristics of the propeller (*the pitch of a propeller; the length of the propeller).*

The last subframe that we have identified is that of Structural Components. This subframe consists of a few terms, however, they are worth researching as they are essential in the context of aircraft construction. These terms are: *fairing (a device to* ***improve the flow of air*** *over a surface), fuselage (the central body of a plane, to which the wings and tail assembly are attached and which accommodates the crew, passengers, and cargo), landing gear/ undercarriage (the landing gear of an aircraft), and nose (the extreme forward end of the aircraft).*In our opinion, the term *fairing* belongs to a second frame, the Flight Dynamic frame, as it also denotes a structure that reduces drag.

4.2. Flight dynamics frame

It is no surprise that the Flight Dynamic frame and the Fluid Dynamics frame include the majority of aerodynamic terms in our corpus. These two frames contain concepts closely tied to aerodynamics, its principles and various physical phenomena. Therefore, we propose that most core terminology related to aerodynamics can be found within these frames.

The Flight Dynamic frame comprises terms such as: the four fundamental aerodynamic forces: *lift (component of the total aerodynamic force acting on an aerofoil which causes an aeroplane), weight (the force with which a body is drawn towards the centre of the Earth), drag (the resistance of the air created by moving the aircraft through the air),* and *thrust (a force produced by a propeller, jet or rocket); angle of attack (the angle formed between the relative airflow and the chord line of the aerofoil), Dutch roll (a combination of rolling and yawing oscillations that occurs when the dihedral effects of an aircraft are more powerful than the directional stability).*

There are terms that belong to other frames, which again proves that there is frame overlapping in the aerodynamic terminological field and aerodynamic terms are dependent on context.

Some of the terms belonging to the Flight Dynamic frame are polysemous since they have distinct meanings in frames belonging to the domain of Aerodynamics. For example, the term *'pitch'* has the following meanings: *1. a nose up/down movement of the aircraft about its lateral;* and *2. the distance a propeller would advance in one rotation if there was no slip.*

The first meaning is related to aircraft stability while the second one refers to the Powerplant frame, i.e. these meanings describe different phenomena in aerodynamics. The term *pitch* is also used in domains that have nothing in common with aerodynamics, e.g. the music domain *(the property of a sound and especially a musical tone that is determined by the frequency of the waves producing it : highness or lowness of sound)* or in the sports domain (*an area painted with lines for playing particular sports, especially football)*.

In our opinion, the aerodynamic term *stall* is also polysemous because it can belong to two different frames. *Stall* has two meanings: *1. a loss of lift caused by the breakdown of airflow over the wing when the angle of attack passes a critical point. 2. a situation in which an engine or machine stops suddenly because an opposing force overcomes its driving power.* We can categorise the term in the frames of Flight Dynamics and Powerplant (the Engine Performance subframe). These two meanings cannot be used interchangeably, the first meaning describes the loss of lift during flight while the second one refers to engines and their performance.

These two examples demonstrate that even though the terminology in aerodynamics is highly specialized, there are cases of polysemy. It is worth noting that despite the polysemous nature of some terms, it does not create ambiguity and the terms cannot cause misunderstanding.

We have identified the following subframes:

i) Primary Aerodynamic Forces;
ii) Aircraft Motion and Stability;
iii) Aerodynamic Effects and Rotational Forces;
iv) Angles, and Performance and Flight Limits.

The first subframe Primary Aerodynamic Forces comprises the concepts that denote the four fundamental forces, namely: *lift, weight, drag,* and *thrust.* The frequency distribution results are quite interesting because the results show the dominance of two forces, namely: *lift* (1,154 occurrences) and *drag* (1,412 occurrences). The other two forces *weight* and *thrust* are used 232 and 191 times respectively. In our opinion, these figures are a result of the dynamic nature of the concepts of drag and *lift* which describe various physical phenomena while *thrust* is related to propulsion, and *weight* does not have a dynamic nature.

The highest frequency distribution of *drag* is no surprise because the term is part of collocations such as: *friction drag (drag caused by the friction of a fluid against the surface of an object that is moving through it); wave drag (it is caused by the formation of shock waves around the aircraft in supersonic flight or around some surfaces of the aircraft whilst in transonic flight); parasite (profile) drag (a type of aerodynamic drag that acts on any object when the object is moving through a fluid); interference drag (drag that is generated by the mixing of airflow streamlines between airframe components such as the wing and the fuselage, the engine pylon and the wing); total drag.* Nouns that are modified by *drag* are: *coefficient, force, friction.*

Figure 2 shows the modifiers of *'drag'* and the nouns modified by *'drag'*. The representation can serve as an example of the concept of *'drag'* as a core concept in the aerodynamic terminological field, a term that comprises a number of collocations which denote different types of drag, as well as it describes various dynamic physical phenomena. From Fig. 2, it is evident that *coefficient* is frequently used with *drag*. The 2-3-grams results show that *drag coefficient* has 208 occurrences in our corpus. We believe that it is due to the fact that *drag coefficient* is often used in formulae and calculations. Interestingly, the term *lift coefficient* is used only 149 times.

We are not experts in aerodynamics to explain if there is a clear reason for this difference, however, we are inclined to propose that this difference in frequency distribution is based on the technical contexts of the books that compile our corpus.

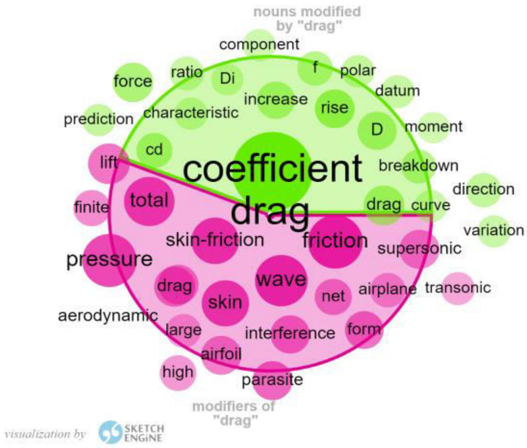

FIG. 2. Modifiers and nouns used with drag

The second subframe is *Aircraft motion and stability.* This subframe contains concepts such as: *pitch, roll (1. a rotation about the longitudinal axis of the aircraft, created by movement of the ailerons; 2. a flight maneuver with 360° rotation about the longitudinal axis of the aircraft), yaw (rotation of the aircraft around its vertical axis),* or *bank (to rotate or roll around its longitudinal axis to a particular angle).*

The term *bank* has the highest result of frequency distribution in the corpus: 87 occurrences, followed by *pitch* (79) and *yaw* (68). In the Aerodynamics corpus, *bank* is part of the collocation *bank angle*, meaning *'angle at which an aircraft is tilted sideways during a turn'*. *Angle of bank* is also used in the corpus- it has 21 occurrences. The degree symbol ° has an MI (Mutual Information) of 9.56, and LogDice of 8.99, which means that it has a strong connection with *bank.* However, it has only 3 occurrences; therefore, we can conclude that *bank* is not often used with a degree value, but is used in descriptions of aircraft motion.

The term *bank* also appears in the corpus as a verb (21 occurrences). The concordance analysis shows that the verb *'to bank'* is sometimes used in passive structures (*The aircraft **is banked** too much.; the aircraft **must be banked** approximately..),* and the KWIC (Keyword in Context) results show that '*it'* is a pronominal subject of *to bank*: *If **it** is not banked, there is no force available to cause;* and *'... the aircraft attempts to turn whenever **it** is banked.* This result supports our conclusion that the term *'bank'* is used to describe motion.

The verb t*o bank* is defined as: *(of an aircraft) to rotate or roll around its longitudinal axis to a particular angl*e. It is evident from the definition that the verb represents a characteristic motion related to the aircraft. Therefore, we decided to compare this meaning with the meanings the verb *to bank* has in other domains.

Do these meanings share some commonalities or are they completely distinct? To find the answer to this question, we used the online dictionary Merriam-Webster (https://www.merriam-webster.com/). Some of the examples given on the website are: i) *bank a fishpond (to build a raised border);ii) they banked the campfire (to restrict the flow of air to (a fire)); iii) torpedo planes… darting in to attack, then banking off (to incline laterally), and iv) skiers banking around the turn (to follow a curve or incline).*

Using these examples, we can propose that the following meanings of the verb *to bank* tend to be close to one another rather than completely distinct: they are related by control and motion (two terms closely tied to aviation).

The fact that the verb *to bank* has meanings which, on the one hand, have something in common but, on the other hand, they are distinct leads to the proposition that this verb is an example of polysemy.

The third subframe of the Flight Dynamic frame is Aerodynamic effects and Rotational forces. In our opinion, this subframe contains the following concepts: *P-factor (asymmetric blade effect and asymmetric disc effect), keel effect (pendulum stability), torque (a moment of forces causing rotation),* and *moment (the tendency to cause rotation about a point or an axis).* The term that has the highest frequency distribution across the corpus is *moment* with 330 occurrences, compared to *torque* with 20, and *keel effect*-only 3. The term *P-factor* appears too infrequently in the corpus and cannot be computed.

The highest frequency distribution of *moment* leads to the proposition that we can consider it as a key term in aerodynamics. Modifiers of *moment* are: *roll(ing), pitching, negative, positive, aerodynamic. Pitching* has the highest MI (12.25) and LogDice (10.93), followed by *rolling* with MI (11.71) and LogDice (10.21). These results strongly suggest that *pitching moment* and *rolling moment* are collocations related to the highly specific domain of aerodynamics. The 2-3-gram results show that *'and moment'* is the most frequently used (47 times) which suggests that *moment* is used in descriptions: (*where the lift, drag, and moment.., and moment coefficient data, and moment coefficients are defined as..).* The term *moment* has 37 occurrences which can mean that the term is used in specific aerodynamic context, related to forces and motion.

The next subframe is Angles. This frame comprises concepts such as: *bank angle (angle at which an aircraft is tilted sideways during a turn), climb angle (the angle between a horizontal plane representing the Earth's surface, and the actual flight path followed by the aircraft during its ascent.), pitch angle (the angle between the chord of the propeller and the plane of rotation of the propeller),* or *angle of attack (the angle formed between the relative airflow and the chord line of the aerofoil).* There are two structural patterns in this subframe: the majority of terms in our list follow the pattern *X angle,* and two terms (*angle of incidence* and *angle of attack)* follow the pattern *angle of X,* where X stands for the concept in question. Considering that *angle* forms patterns, we decided to check how frequently this concept is used in aerodynamics. The frequency distribution of *angle* in the corpus is quite impressive- it has 985 occurrences. Therefore, we can propose that *angle* is a fundamental concept in the aerodynamic context, and it has a central role in the aerodynamic terminological field. We can find modifiers such as *deflection, small, geometric, effective, stall, sideslip, bank, conical shock wave,* the list is long. The 2-3-grams results show that *angle of* has 489 occurrences while *the angle* and *an angle* have 159 and 60 occurrences, respectively. Consequently, we can suggest that the pattern *angle of X* is predominant in the corpus compared to *X angle.* This statement can seem contradictory to our statement that in our data we have terms that follow the pattern *X angle* while only two terms have the pattern of *angle of X.* However, when we studied the frequency distribution of terms with the pattern *X angle*, we found that it is less frequent compared to the pattern *angle of X: bank angle*- 21 occurrences, *blade angle*- 20 occurrences and *angle of attack*- 413 occurrences.

Based on the results discussed above, we propose that *angle* is a core concept in the aerodynamic terminological field, and with the high number of collocations, it holds a central place in the domain of aviation terminology.

The last subframe of the Flight Dynamics frame is Performance and flight limits. Concepts that belong to this subframe are: *airspeed (the speed of the aircraft relative to the air around it), (flight) envelope (the set of limitations within which a technological system, especially an aircraft, can perform safely and effectively), endurance (the length of time an aircraft can stay in the air without refuelling), Mach number (a number that expresses the ratio of the speed of an object to the speed of sound).* The term that has the highest frequency distribution in the corpus is *Mach number* (544 occurrences), followed by *airspeed* with 158 occurrences. Given the high frequency of these two terms, we can suggest that they can be referred to as key terms in aerodynamics. Examples of the modifiers of *Mach number* are *critical, high, low, subsonic, supersonic, hypersonic*; we can note that they describe the properties of the *Mach number.* The verbs that are used with *Mach number* show that it can be *calculated, measured, increased* or *reduced.*

According to the 2-3-gram results *critical* is the most commonly associated modifier of *Mach number* with a LogDice of 11.39, which means that we can accept *critical Mach number* as a specific and key aerodynamic term. The MI of *critical Mach number* is also the highest- 8.86, which confirms that it is a common and fixed collocation in this specific discourse.

4.3. Fluid dynamics frame

The frame Fluid Dynamics comprises a group of concepts such as *airflow (1. the movement of air over the aircraft as it travels through the atmosphere 2. a current of air flowing through or past an object or body), airstream (the flow of air caused by the movement of the aircraft through the air), Kutta condition (the relationship between the*

smooth airflow circulation around the wing and the resulting lift it produces) , or *eddy (a current of air moving in the opposite direction to the main current, especially in a circular motion).* The terms that belong to this frame are related to the movement of the airflow around the aircraft and the Aerodynamic flow subframe includes concepts such as *airflow, airstream, downstream (in the direction of flow, or further along the line of flow), streamline (a path traced out by a massless particle as it moves with the flow), eddy (a current of air moving in the opposite direction to the main current, especially in a circular motion).*

The highest frequency distribution in our corpus has *streamline* (476 occurrences), followed by *downstream* (138) and *airflow* (104). *Streamline* can be modified by *parallel, horizontal,* or *circular.* The collocation *streamline pattern* has the highest MI (10.68) and LogDice (11.74), indicating that it is a key collocation in aerodynamic discourse. The 2-3-gram results show that most frequently *streamline* is used with determiners (indefinite and definite articles) and we can suggest that it is typically used in descriptions as it is used in *along the streamline* (38 times). Also, it can be used in possessive-of-constructions (*a streamline of the flow)* and is part of the prepositional phrase pattern *X of a streamline, (the concept of a streamline)*, where X stands for a noun (in our case *concept, definition, equation).* The verb *to be* most frequently follows *streamline,* when used as a subject, *'are'* is used more frequently than *'is'*, 41 and 31 occurrences, respectively.

The second subframe consists of concepts that refer to principles in aerodynamics; therefore, the subframe is labelled Aerodynamic Principles, related to airflow and forces.

Concepts that belong to this subframe are: *Kutta condition (the relationship between the smooth airflow circulation around the wing and the resulting lift it produces), Bernoulli's principle (an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy)* and *Reynolds number (the dimensionless coefficient related to the ratio of inertia force to the kinematic viscosity force).*

The term *Reynolds number* has the highest frequency distribution of all- with 168 occurrences in the corpus, which indicates that it is an important concept within the corpus. It is commonly used in prepositional phrases (*of a low Reynolds number, the value of the Reynolds number, associated with the very low Reynolds number)*. Modifiers of *Reynolds number* are*: critical, high, low*. It is also used as *Re* (175 occurrences), which shows that the abbreviation is also commonly used in aerodynamic discourse, especially in formulas and equations; therefore, we can conclude that *Re* is mostly used in mathematical contexts, Verbs used with *Reynolds number* are: *associate, achieve, determine, define, calculate (define a critical Reynolds number; calculate the Reynolds number)*. The most commonly used collocation in the corpus is *critical Reynolds number* with an MI of 9.10 and LogDice of 11.08. It is followed by *low Reynolds number* (MI-5.97, LogDice- 8.18) and *high Reynolds number* (MI-5.13, LogDice-7,68). *Critical Reynolds number* is *used to define the transition from laminar to turbulent flow for a particular system as the fluid flow rate increases,* which suggests that this collocation is mostly used in the corpus to describe the transition between laminar and turbulent flow.

CONCLUSIONS

Our study is likely the first attempt to systematically structure aerodynamic terminology, using Frame Semantics and Corpus Linguistics software. It is a necessity that connects linguistics and the aviation scientific terminological field. We do not claim that the presented preliminary findings are definitive as the research is still ongoing. To achieve more accurate and insightful results, further analysis will be carried out using an expanded corpus and data.

Analysing the presented data, we can infer that aerodynamic terminology can be systematically structured in conceptual frames. Most of the terms are not polysemous, however, they are strongly dependent on a particular context. These terms can belong to more than one frame, which does not affect their primary meanings. It is a well-known fact that polysemy is avoided in aviation language as it can lead to confusion and misunderstanding. While researching aerodynamic terminology, however, we have found that even though language of aerodynamics is highly scientific and technically specialised, there are terms that can be polysemous. It should be noted that these cases are not numerous and if there is a polysemous term, it does not lead to confusion and aviation professionals will easily recognise the correct meaning.

We believe that our preliminary findings contribute to the development of the linguistic study on aviation language and they will be of help to educators, translators, aviation professionals and linguists.

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