Determinants of Pilots' Performance: Investigating Technology Trust and Situation Awareness

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Determinants of Pilots Performance: Investigating Technology Trust and Situation Awareness

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Abstract

Simulation devices have been used in aviation training for decades, probably more than in other industries. Embarking on this study, we aim to understand the relationship between the information quality provided by the information system (simulator) to pilots with the effect on situational awareness and trust in technology. Also, we aim to understand how experienced pilots with total flight and simulator hours affect their situational awareness. Furthermore, the study introduces a novel theoretical model to explore how situational awareness and trust in technology jointly impact individual pilot performance. We used structured equation modelling within the data retrieved from a survey do 233 pilots. Our results show a large effect on individual pilot performance in a simulator between situation awareness, and information quality. Also, the impact on trust in technology is supported with a large effect by information quality. There is a medium effect between Information quality and situational awareness, with the experience shown by pilots having a small effect on situational awareness.

Keywords: Pilot Training, Simulation, Human Machine-Interface, Individual Performance, Trust in Technology

1. Introduction

With the advancement of technology, simulator flight training is a substitute for partial flight time requirements in an aircraft [1]. Pilots must have a minimum number of flight hours in a real plane, and simulation training is already considered a viable tool for supporting flight training [2]. It is assumed from the literature that from both cost and efficiency, preflight learning using ground-based simulators produces good results in pilot training [3]. Simulator training also evaluates pilot cognitive abilities, human factors, and performance [4]. Nevertheless, according to Malakis et al. [5], today's pilot simulator training cannot deal with various systems disturbances in real life by only demonstrating

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skills in scenarios. So, it is essential to study other determinants in simulator pilot training further. Information quality is vital to Human-machine interaction by providing pilots with a cognitive fit in the relationship between software comprehension and modification [6, 7]. If the mental cue provided by the information system creates an ambiguous mental cue for the pilot, then technostress can arise in the cockpit [8], undermining flight safety. So trust in technology becomes a major issue when it must correspond to the pilot's beliefs that a specific technology has the requirements to perform as expected in a situation where negative consequences are possible [9]. According to Endsley [10], situational awareness is a crucial determinant of pilot performance, with the loss of situational awareness being a significant cause of aviation accidents in the last years [11]. Also, experienced pilots with a reasonable amount of simulator and flight hours should be able to perform better in their work [12].

This paper's main and global objective is to understand the determinants of pilots' individual performance in a simulator context, allowing the exploration of Situational Awareness (SA), Information Quality (IQ) and digital tools, Trust in Technology (TT), and Information Quality (IQ). A survey was available online, and the retrieved data was analyzed with structural equation modelling – partial least squares (SEM-PLS). The main findings of this study are fourfold. First, pilots performance (IP) depends on situational awareness (SA) and Trust in Technology (TT); second, information quality (IQ) has a significant impact on Trust in Technology (TT). Third, Information Quality has a moderate effect on situational awareness (SA). IQ has a positive impact on situation awareness, and also has a positive impact on TT, comparing both impacts IQ has a higher impact on TT. Fourth, Flight Hours and Simulator Flight hours, thus signifying a pilot's experience in flight training, are not significantly affecting Situational Awareness (SA), contrary to the positive impact of IQ. This study contributes to understanding the main determinants of situation awareness, trust in technology, also impacting positivelly on pilots' performance.

In the next section, we present the literature background. In section II, we present the research model and hypothesis. In sections III we present the methodological approach. Sections IV and V present

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the results. Section VI present the discussion. Section VII presents conclusions, implications, and future work.

2. Theoretical background

A brief history of simulator devices

The simulation industry appeared by creating and using flight training devices [13]. Today is a multi-million-dollar industry with applications spread to all fields of industry and research. A *“simulator is a platform for predicting the behaviour or verifying the functionality of coupled subsystems using corresponding models originating in different engineering domains.”* [14]. The use of flight simulators became an integral part of commercial airline pilot training in the 1960’s. Situational awareness in simulation environments, especially those used for training and research, is crucial for achieving realistic and effective outcomes. The limitations of past simulators in providing situational awareness can be attributed to several factors, including technological constraints [15], design choices [16], and the inherent challenges of replicating complex real-world scenarios [17]. For both safety and training effectiveness, it became no longer practical to train in the actual aircraft [13]. Figure 1 shows the main milestones in building and conceptualizing simulator flight training devices.

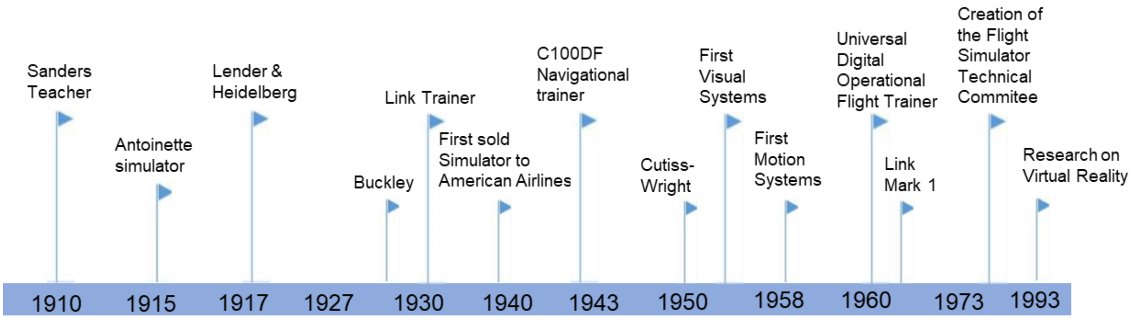

Figure 1: Main milestones on manufacturing and conceptualising training devices [13].

Figure 1 shows the main milestones in simulator development in the aviation industry. At the beginning of pilot training, progress was slow, with student pilots would learn through a grade sequence of practice on actual aircraft. After some practice as a passenger with another pilot, in real flight, they would attempt to control the plane on the ground given small control inputs and eventually achieve flight. This method was also used during World War I, known as the “penguin system, " with the French

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Ecole de Combat with a cut-down Bleriot monoplane. The Sanders Teacher is considered the first simulator device for truly ground-based trainers; Figure 2 shows a photo of this device.

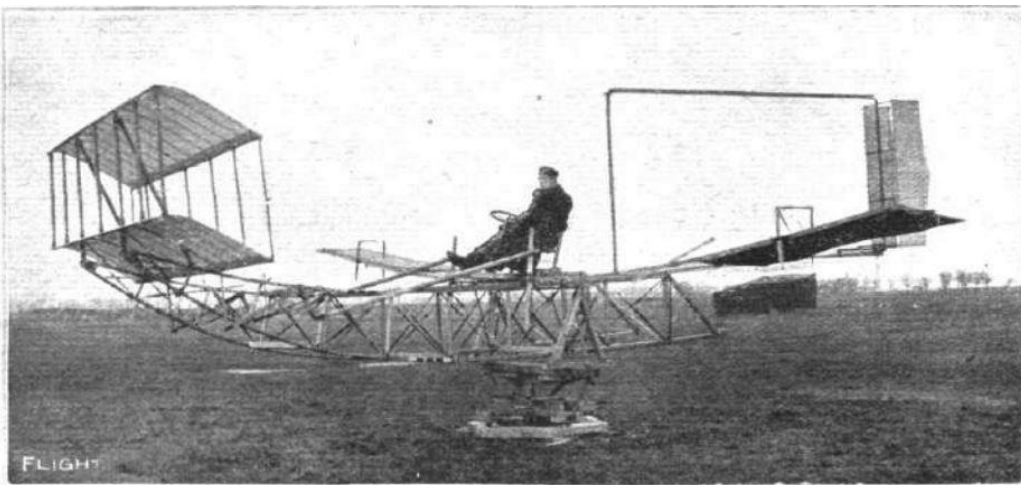

Figure 2: The Sanders Teacher simulator [18]

The need for aviation pilots during World War I encouraged the development of other simulator devices, such as the Antoinette simulator. It was the first time such a device was used to pilot selection with the development of a new discipline of aviation psychology and tests. Figure 3 shows the Antoinette simulator.

Figure 3: Antoinette simulator, 1910 Antoinette catalog, [13]

For the first time, lender and Heildelberg used the Antoinette simulator with mechanical and electric actuators that allowed pitch, roll and yaw motions produced by compressed air motors. Buckley patented an electric version of this trainer in the EUA in 1929. The most well-known and successful of this type of trainer was the Link Trainer, introduced in 1930. With an electrically driven suction

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pump, the Link Trainer allowed the movement of the various control surfaces, while another motor-driven device produced attitude disturbances; Figure 4 shows the Link Trainer simulator device.

Figure 4: Link Trainer simulator device [13, 19]

This was the start of the recognition of simulation for pilot training and the sale of Link Trainers, where American Airlines 1940 first acquired the first training simulator [20]. From the late 1930s, the evolution of these devices was based on the application of electrical and electronic methods [13]. The next significant advancement of these devices was the C100DF simulator model, which allowed the training of aircrews in navigation skills using ground beacons.

After the war, the competition between Curtiss-wright and Link led to the development of electronic simulators, a far more demanding technology capable of greater precision. This led to the purchase by Pan American and Qantas, the first airlines to put into service simulators for Boeing 707 aircraft, which at the time were the world's most advanced simulator devices ever produced [20]. The need for more precise and extensive data was required by the hardware in use. It became evident that the analogue computer could not overcome the increased fidelity and reliability demands necessary to achieve the objectives. The first research about digital simulators was produced at the University of Pennsylvania, named UDOFT (Universal Digital Operational Flight Trainer). In the early 60s, Link developed the Mark 1, which was the most successful innovative digital simulator. These devices were purchased by most of the airlines and the military.

In 1958 the first ever produced pitch motion simulator was built by Redifon as part of the Comet IV aircraft used at the time by BOAC (British Overseas Airways Corporation) aircraft transport airline.

The innovative designs demanded massive hydraulic structures, which became a nightmare for maintenance and often provided incorrect cues for the pilots.

The first visual systems allowed a panoramic display of the outside environment with the illusion of flying high. These optical systems allowed a 180º view of the outside environment, thereby enabling training for a circling approach.

Due to the importance of simulator pilot training, the IATA (International Air Transport Association) invited the airlines in October 1973 to form the first meeting of the Flight Simulator Technical Sub-Committee (FSTSC) to redefine the future standards of pilot simulator training. Nowadays, simulator training is still costly and often hard to access, with high maintenance costs [21]. New alternatives are being researched with the inclusion of virtual-reality systems, far more cost-effective and portable, to bridge the gap between instruction and high-fidelity methods of simulation [21].

Drivers for this research

With this study, we aim to research the correlation between information quality, trust in technology, and situational awareness, with pilots' performance in a simulator context. Modelling human performance and human behaviour to improve overall system performance has received more attention from researchers [22]. From a general perspective, automation positively affects pilot workload, thus, flight safety and performance. However, there is a risk of automation bias where the crew may perceive that it is not their responsibility to start a turn, for instance, or to monitor the conditions that drive autopilot’s behaviour [23]. Information processing, system monitoring, diagnosing potential risks and controlling the aircraft demonstrate the pilot’s ability and performance by executing complex tasks simultaneously [24]. Pilots became dependent on the information systems and the quality of the information they provided, sometimes leading to misinterpretation and tragic accidents [25]. Not only must pilots interpret what they see in the instruments, but they also have to trust the information provided by the technology. For instance, when pilots fly a CAT III (precision instrument approach and landing) approach to a runway where the meteorological conditions don’t allow visual references to the ground, having to rely solely on autopilot and aircraft instruments to make a successful landing [26]. Monitoring aircraft instruments allows pilots to maintain situational awareness, thus allowing good decisions in a complex and dynamic environment such as flying an aircraft [27]. Situational awareness is considered a crucial driver of pilot performance, with its loss being attributed to many aircraft accidents [28]. Nevertheless, perhaps due to the extension methods to measure situational awareness [29], with pros and cons, some authors consider that further investigation is needed to collect more evidence methodically [30].

Situational awareness

The concept of Situation Awareness (SA) was first conceptualized and delineated by Endsley [31] in 1988, defined as the ability to perceive environmental elements within a specific temporal and spatial context, comprehend their significance, and anticipate their future states. In contemporary research, Situation Awareness has emerged as a critical cognitive construct within the field of human factors, posited as a fundamental determinant of human performance in various high-risk sectors including military operations, healthcare, and other safety-critical environments [32] [33]. Further, Situation Awareness is recognized as an instrumental construct in understanding and forecasting performance in human-system interactions, particularly in environments characterized by complexity and dynamism. This application of Situation Awareness is supported by research from Endsley et al. [34], Parasuraman et al.[35], and Wickens [36]. Enhanced training in Situation Awareness is hypothesized to positively influence performance, as noted in studies by Carretta et al. [37], Endsley et al. [38], Jones et al. [39], and Salas et al.[40].

However, the relationship between Situation Awareness and performance is not without contention. Authors like Bakdash et al. [32], Sarter et al. [41], and Webber et al. [42] challenge the validity of Situation Awareness in relation to performance. Dekker et al. [43] argue against the causal psychological mechanisms of Situation Awareness pertinent to performance. Flach [44] raises issues of circularity in the literature concerning the loss and measurement of Situation Awareness. Conversely, Endsley [45] addresses these concerns by asserting that Situation Awareness research lays the groundwork for system design enhancements. Situation Awareness is undeniably a multidisciplinary field, extending beyond psychology to include engineering, medicine, and aeronautical safety culture, as discussed in recent works by Fan et al. [46], Moesl et al. [47], Olin et al. [48], and Kale et al. [49].

In the aviation industry, key research areas within the Situation Awareness domain focus on human-machine interaction, safety, and human error. This includes designing automated systems to reduce pilot workload and enhance crew awareness, as seen in studies by Bolstad et al. [50], Endsley [51], and Potts et al. [52]. These systems encompass monitoring of nearby traffic, meteorological assessment, flight conditions, and air traffic control, detailed in research by Kožović et al. [53], Kumar et al. [54], Blundell et al. [55], Papanikou et al. [56], Bongo et al. [57], Langford et al. [58], Lopes et al. [59], and Reyes-Munoz et al. [60]. From a safety perspective, research focuses on aircraft maintenance, risk management, psychological factors affecting behavior, and Crew Resource Management (CRM), analyzing crew competencies in the context of flight deck performance [61].

Despite technological advances, human error remains a critical concern in aviation safety. This is evident in the persistent occurrence of accidents attributable to human error, with a significant percentage linked to limited Situation Awareness in pilots, as reported by Ayala et al. [62] and Yu et al. [63]. The Situation Awareness literature encompasses a broad spectrum of narrative reviews and theoretical discourses. However, there is a noted deficiency in quantitative analyses, meta-analyses, and statistical evaluations of Situation Awareness, a gap highlighted in the work of Bakdash et al. [32].

3.Research Model and Hypothesis

We suggest a new model that combines constructs from information systems theory [64] with the situational awareness model in dynamic systems [28], the experience of pilots with flight hours and simulator flight hours, and technostress to evaluate the impact on pilots individual performance in a simulator. Table 1 shows the model constructs with the definition and bibliographic reference.

Table 1: Model Constructs

Construct	Code	Construct definition	Author
Information Quality	IQ	The quality of the content of information systems shows Information Quality. Information quality is measured by completeness, accuracy, relevance and steadiness of information output.	[65-67]
Trust in Technology	TT	Trust in technology corresponds to a student pilot's belief that a specific technology has the necessary attributes to perform as expected in a situation where negative consequences are possible.	[68, 69]

Construct	Code	Construct definition	Author
Individual Performance	IP	Corresponds to the performance a student pilot has in solving a task as resulting from the interaction between the external representation and a problem-solving task	[70]
Situation Awareness	SA	Corresponds to:"The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."	[71]
Simulator Flight Hours	-	Corresponds to the number of simulator flight hours each pilot reported in the survey.	(Proposed by authors)
Flight Hours	-	Corresponds to the number of flight hours each pilot reported in the survey.	(Proposed by authors)

According to Endsley [28], abilities, training, and experience impact the three levels of situation awareness by influencing the cognitive skills of the operator. Level one is the perception of elements in the current situation, and level two is the comprehension of the current situation and level three is the projection of future status. Figure 5 depicts part of the situation awareness model in dynamic decision-making by Endsley [28].

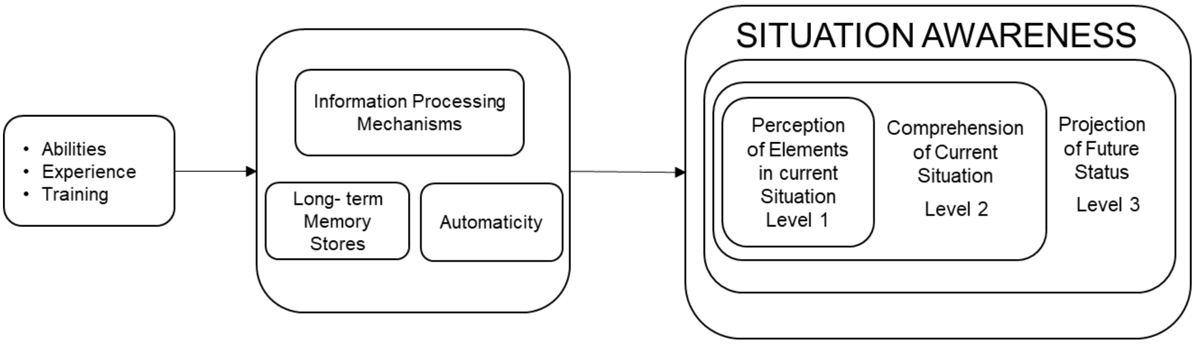

Figure 5: Situation awareness model in dynamic decision-making. Adapted from Endsley [28].

A pilot's situational awareness, according to [72], is the outcome of several cognitive processes. So people's ability to build situational awareness depends on individual capabilities, training, and experience. Flight hours correspond to a pilot's total number of hours, thus showing proficiency in flying an aircraft. Therefore, we hypothesize:

H1: *Flight hours positively affect Situational Awareness (SA).*

Flight simulators are essential for pilot training and human factors research [73]. So as stated above by Endsley [72], training in a simulator can directly impact situational awareness. Simulator hours correspond to a pilot's experience with such a device. Therefore, we hypothesize:

H2: *Simulator hours positively affect Situational Awareness (SA).*

To support the cognitive processes, information systems and technology provide the needed information to pilots to maintain awareness of system status [74]. If the info provides the mental representation of the task, then it is expected the increasing software comprehension by the pilot [75]. According to Endsley [72], situational awareness is significantly impacted by several technological attributes. Information systems support working environments with increasing data amounts and complexity [76]. Pilots must monitor several systems in the simulator environment to maintain flight parameters and, consequently, the aircraft's and passengers' safety [77]. In cases of low trust in technology, information systems provide low value for users and organizations [76, 78]. A previous study [10] reported that "What's it doing now.", "Well, I never seen that before.", and "I wonder why it is doing that" are widely heard comments in advance cockpits. If trust in technology exists, then it has been shown to function as a precognition of the beneficial effects that the system can provide [76, 79]. Therefore, we hypothesize:

H3a: *Information Quality (IQ) positively affects Situational Awareness (SA).*

H3b: *Information Quality (IQ) positively affects Trust in Technology (TT).*

Trust in technology is a construct that literature shows positively related to behavioural intentions to use the technology [76]. Also, trust in technology is positively correlated with individual performance [80]. A study [79] showed that participants could save cognitive capabilities with higher well-being than others. These positive effects only occurred for participants who trusted the system [76]. Therefore, we hypothesize:

H4: *Trust in Technology (TT) positively affects Individual Performance (IP).*

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Situation awareness is often theorized in the literature as a critical factor for performance [45]. Nevertheless, some authors raised some concerns about this relationship. Dekker et al., [81] argues that [71] the situation awareness model does not have meaningful probabilistic associations with performance. Situation awareness theory involves three hierarchical levels (perception, comprehension, and projection) [71]. Depending on the awareness of the pilot, within a decision episode, individual performance can be affected [82]. A meta-analysis of 77 papers [32] shows that situation awareness validity for performance tends to be on the average week with significant variations among effects. Due to the differences shown above, we hypothesize that:

H5: *Situational Awareness (SA) positively affects Individual Performance (IP).*

Figure 6 represents the model to be tested. The measurement items are presented in Appendix A.

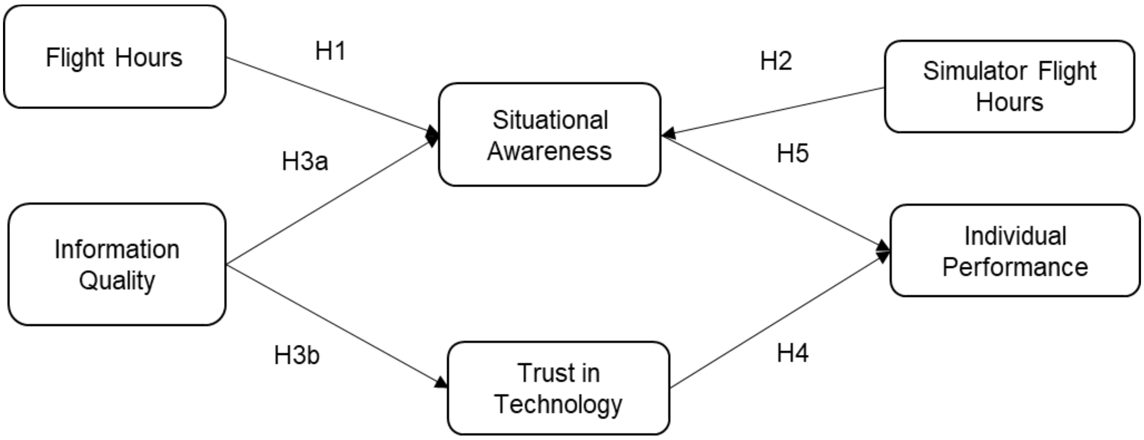

Figure 6: Proposed Research Model

4. Methodological approach

An online survey was created and supported by validated scales, previously tested in the literature, and proven to operationalize each construct to increase the validity. The survey was provided on an online platform (Qualtrics XM). The first part of the survey asked questions about the sample's characterization. The second part measured the latent variables chosen using a seven-point numerical scale (1–completely disagree, (...) 7–I agree completely). The following scales were used to measure all constructs: Information Quality [65], Trust in Technology [68, 69], Individual Performance [70], and Situation Awareness [83]. Regarding Simulator Flight Hours and Flight hours we used a ordinal scale, which corresponds to the reported number of hours by each respondent. These scales are detailed in Appendix A. Survey was shared within pilots' community groups and with several aviation schools. Social network pilot groups were also used. Data was cleaned in a Spreadsheet software with a total of 294 pilots answering the questionnaire, with 232 complete answers. We considered the 232 complete answers for this study. Sample characterization revealed an average age of 33.1 and 2415.9 flight hours and 254.3 simulator hours. Table 2 shows the sample attributes.

Table 2: Sample Attributes

	Type	**Frequency**	**Percentage**	**Minimum**	**Maximum**
Gender	Male	207	89.2%	-	-
	Female	25	10.7%		
Age	18-29	63	27.1%	18	29
	30-39	45	19.3%	30	39
	40-49	42	18.1%	40	49
	50-59	35	15%	50	59
	60-69	33	14.2%	60	69
	70-79	11	4,7%	70	78
	≥80	3	1.2%	84	90
Total Hours	1-2000	89	38.3%	10	1900
	2001-4000	76	32.7%	2100	3800
	4001-6000	47	20.2%	4200	5200
	6001-8000	11	4.7%	6300	7800
	8000-10.000	5	2.1%	8300	9400
	≥10.000	4	1.7%	11.000	19.000
Simulator Hours	1-100	144	62%	24	100
	101-200	72	31%	120	200
	201-300	14	6%	204	290
	≥301	2	0.8%	340	460

To analyze the theoretical relationships in the proposed model, we follow structural equation modelling (SEM) by combining statistical data and theoretical causal assumptions. The literature indicates that the structural equation modelling (SEM) method is widely used [84, 85]. Because covariance-based techniques (CBSEM) may generate inaccurate results or concerns regarding lesser samples due to non-normal distribution, we also used Partial Least Squares (PLS) to understand the causal assumptions better. The PLS method was used with a two-step approach, first testing the validity and reliability of the measurement model and second testing the structural model. We analyze

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the construct reliability, indicator reliability, convergence validity and discriminant validity, as suggested by [86]. Smart/PLS 4.0 was used to analyze the two-step approach described above.

5. Measurement Model Assessment

In our assessment of the measurement model, first, we tested indicator reliability. To do so, we used the PLS-SEM algorithm. This implies that we will examine how much of each indicator's variance is explained by the construct. Outer loading indicates contruct's weight, which should be above 0.70 [87]. The algorithm computes the square of the indicator loading for each construct, which is the bivariate correlation between an indicator and the respective construct. Indicator loadings are construct representative if the value is above 0.70 since it indicates that the construct explains more than 50 per cent of indicators variance, thus showing reliability in an indicator [87]. Composite reliability is higher than 0.70 which indicates the internal consistency of the variables [88]. Cronbach's Alpha indicates a good internal consistency higher than 0.70 [89]. AVE shows the construct convergent validity showing more than 0.50 [90]. These results are shown in Table 3. Table 3, shows all item loadings are above 0.70, thus indicating that all the variables are reliable.

Table 3: Measurement Model Results

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Individual Performance(IP)	0.937	0.938	0.969	0.940
Information Quality(IQ)	0.940	0.946	0.957	0.848
Situational Awareness(SA)	0.899	0.933	0.925	0.713
Trust in Technology(TT)	0.928	0.946	0.943	0.733

Table 4: Measurement Outer Loadings

Construct	Items	Flight Hours	IP	IQ	SA	Simulator Hours	TT
Flight Hours	Flight Hours	1.000					
Individual Performance	IP_1		0.968				
	IP_2		0.971				
Information Quality	IQ_1			0.949			
	IQ_2			0.879			
	IQ_3			0.942			
	IQ_4			0.913			
	SA_3				0.778		

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Situation Awareness	SA_4	0.910		
	SA_5	0.885		
	SA_6	0.865		
	SA_7	0.773		
Simulator Hours	Simulator Hours		1.000	
Trust in Technology	TT_1			0.891
	TT_2			0.901
	TT_3			0.819
	TT_4			0.860
	TT_5			0.837
	TT_6			0.826

The model indicates Composite Reliability above .80 (please see Table 3) indicating this criteria is met [91]. Henseler et al., [92] propose another approach, the Heterotrait-Monotrait ratio (HTMT) ratio of correlations. If the HTMT ratio value in Table 6 is below .90, discriminant validity has been established between two reflective constructs, indicating discriminant validity. As shown in Table 5, all constructs have values below .90, so a third criterion is also completed. We can conclude that the measurement model presents discriminant validity.

Table 5: Fornell-Larcker criterion, inter-construct correlations.

Fornel Larker

	Flight Hours	IP	IQ	SA	Simulator Hours	TT
Flight Hours	**1.000**					
IP	0.028	**0.970**				
IQ	0.083	0.474	**0.921**			
SA	0.148	0.449	0.266	**0.844**		
Simulator Hours	0.206	0.157	0.101	0.087	**1.000**	
TT	0.158	0.529	0.633	0.318	0.119	**0.856**

Table 6: Heterotrait-Monotrait ratio (HTMT).

	Flight Hours	IP	IQ	SA	Simulator Hours	TT
Flight Hours						
IP	0.036					
IQ	0.087	0.504				
SA	0.151	0.474	0.275			
Simulator Hours	0.206	0.163	0.104	0.089		
TT	0.164	0.553	0.658	0.330	0.125	

In Appendix B, we show the latent variables descriptive statistics. The data provided offers a comprehensive statistical overview of each variable, indicating a diverse and non-normal distribution across the variables. This understanding is crucial in structuring and interpretating the SEM-PLS model, ensuring that the assumptions, methodological choices, and interpretations align with the data characteristics.

6. Structural Model Assessment

To analyse the structural model, we ran the PLS software and bootstrapping algorithm with 5000 subsamples [93]. Figure 7 shows the structural model results. Table 6 shows the hypothesis test results, indicating that four of the six hypotheses are supported in our model. In Figure 3, we report the R^2, p-values, and β^. We identify that four hypotheses are endowed with significant effects, where trust in technology is explained by information quality in 40% ($\beta = 0.633$ and $p < 0.001$) and individual performance is explained by both situational awareness ($\beta = 0.313$ and $p < 0.001$), and trust in technology ($\beta = 0.430$ and $p < 0.001$). H3a has a medium impact on situation awareness ($\beta = 0.253$ and $p < 0.01$), explaining the importance of information quality on pilots' situation awareness. Hypothesis H1 ($\beta = 0.119$ and $p < 0.001$) and H2 ($\beta = 0.037$ and $p < 0.001$) are somehow unexpected, both non supported in our model, showing that experience does not have impact on situation awareness.

Also, we report F^2 indicator to determine if some construct has a substantive significance or not. According to Costa et al., [94], for F^2 greater than .350, the construct has a large effect; if F^2 is between .150 and .350 then the construct has a medium effect, and for $.020 < F^2 < .150$, the construct has a small impact in the model. The results are shown in table 3 where only H1 and H2 are not meaningful. Hypothesis H3a and H5 have small effects, H4 has a medium effect, and H3b has a large effect.

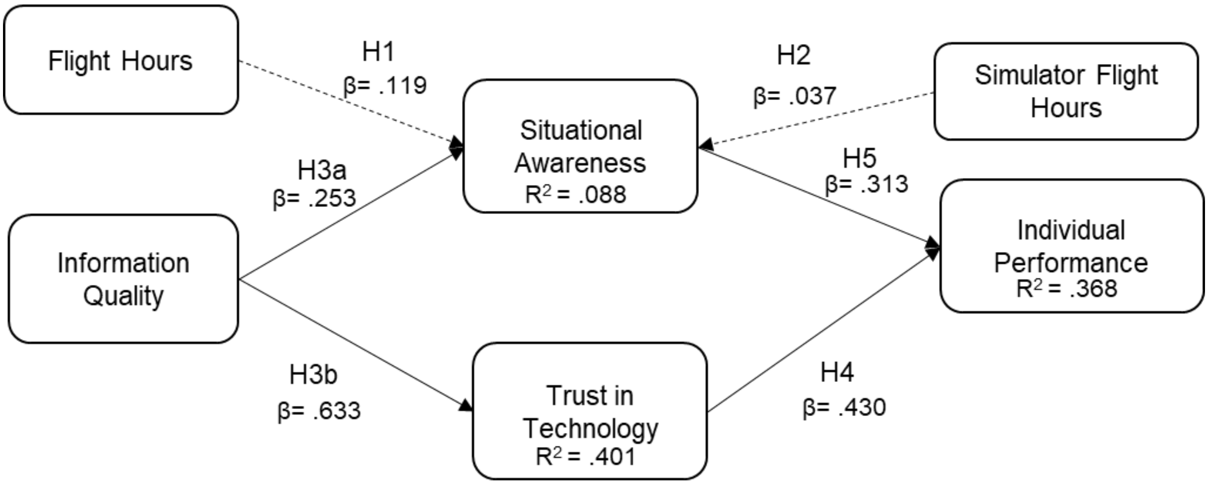

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Figure 7: Structural model results.

Note: *Significant at $p < 0.05$; ** significant at $p < 0.01$; and ***significant at $p < 0.001$.

Table 6: Hypothesis Test Results

Hypothesis	Independent Variable	Dependent Variable	F^2	Effect Size	P values	Findings	Conclusion
H1	Flight Hours	Situation Awareness	0.015	Small	0.172	non-significant	non-supported
H2	Simulator Flight Hours	Situation Awareness	0.001	Small	0.465	non-significant	non-supported
H3a	Information Quality	Situation Awareness	0.069	Medium	0.005	Positively and statistical significant ** (β= .253 and $p < 0.01$)	Supported with medium effect
H3b	Information Quality	Trust in Technology	0.670	Large	0.000	Positively and statistical significant *** (β= .633 and $p < 0.001$)	Supported with large effect
H4	Trust in Technology	Individual Performance	0.263	Large	0.000	Positively and statistical significant *** (β= .430 and $p < 0.001$)	Supported with large effect
H5	Situation Awareness	Individual Performance	0.139	Large	0.001	Positively and statistical significant *** (β= .313 and $p < 0.001$)	Supported with large effect

7. Discussion

This study uses SEM-PLS [84], information systems success theory [64], and situational awareness model [28] to propose a new theoretical model for individual pilot performance in the simulator training context. In this model, we measured individual performance by the effects of trust in technology, situational awareness and information quality. Moreover, we used pilots' current experience with flight hours and simulator flight hours to analyse the impact of experience on situation awareness. We also used Gender in our survey, with our sample showing fewer women than men, so we removed the Gender construct from the theoretical model. A total of 294 pilots answered the questionnaire, with 233 complete answers. We considered the 232 complete answers for this study. Sample characterization revealed an average age of 33.1 and 2415.9 flight hours and 254.3 simulator hours. We believe that this large sample brings value to this work.

For proposing the model, we selected the constructs and designed the relationships based on previous findings in the literature. Previous work on pilot simulator training shows the importance of using these devices in pilot training in all facets [73]. Also, the human factor in the design of a simulator system can substantially affect the human-machine interaction, thus improving the simulation's performance and reality [95]. We evaluated individual performance dimensions and verified that situational awareness and trust in technology are second-order constructs on performance [72, 96]. Like previous studies, we found that information quality (H3a and H3b), situational awareness (H5), and trust in technology (H6) significantly affect pilots' individual performance [96-98]. In the case of our model four hypothesis are supported with significant effects, where Trust in Technology (TT) is explained by Information Quality (IQ) in 40% ($\beta = 0.633$ and $p < 0.001$) and Individual Performance (IP) is explained by both Situational Awareness ($\beta = 0.313$ and $p < 0.001$), and Trust in Technology ($\beta = 0.430$ and $p < 0.001$). Hypothesis H3a has a medium impact on situation awareness ($\beta = 0.253$ and $p < 0.01$), explaining the importance of information quality on pilots' situation awareness. Hypothesis H1 ($\beta = 0.119$ and $p < 0.001$) and H2 ($\beta = 0.037$ and $p < 0.001$) are somehow unexpected, both non supported in our model, showing that experience does not have impact on situation awareness.

Regarding pilots' experience, our results show that flight and simulator flight hours have a small impact on situation awareness (H1 and H2), thus contradicting Endsley's [72] assumption that people can form situational awareness in complex and complex and dynamic environments is dependent on training and experience. This can be due to the flight time and simulator hours reported in our sample. Although we consider the number of respondents excellent, further work on experience and situational awareness must be deepened regarding these two items.

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8. Conclusions, Implications and Future Work

This study aims to understand the impact on pilot individual performance by technology, situational awareness, and experience in a simulator context. For this reason, we propose a new theoretical model consisting of technological dimensions with information quality and technostress involving situational awareness and experience. The research model explains 37% of individual performance by correlating the abovementioned constructs. Information Quality significantly affects Trust in Technology, showing that pilots depend on the completeness, accuracy, relevance and steadiness of the information output of aircraft instruments. On the other hand, the experience of pilots shown by the number of hours in a cockpit does not reveal effects on situational awareness. We have also demonstrated that trust in technology can significantly drive individual performance.

The theoretical implications of this study contribute to the literature on measuring individual pilot performance when in simulator training. This new perspective, supported by the proposed theoretical model, allows the correlation between information systems theory, technology adoption use and trust, and the situation awareness model in dynamic systems. This article provides new insights into individual pilot performance by statistically quantifying the impact of the variables in the model.

The practical implications of this article show the critical role of used information systems in aircraft cockpits regarding information quality, situational awareness, and trust in technology and their impact on pilots' performance. Pilots are dependent on the information provided by the aircraft instruments.

Also, there are new insights about simulator training regarding the use of technology and training curricula improvement opportunities.

In further studies, it would be essential to understand better the relation between pilots' experience (flight hours and simulator flight hours) and situation awareness regarding hypotheses H1 and H2. Furthermore, new research for analyzing training curricula regarding the mathematical models used and how they deal with real-life situations in a simulator context.

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Appendix A – Model Measurement Scales

Constructs	Code	Indicators	Theoretical support
Information Quality	IQ	IQ1: The information provided by the simulator platform system is useful IQ2:The information provided by the simulator platform system is understandable IQ3: The information provided by the simulator platform system is interesting. IQ4:The information provided by the simulator platform system is reliable.	[65]

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Trust in Technology	TT	TT1: The Simulator platform has the functionalities I need. TT2: The Simulator platform has the features required for my tasks. TT3: The Simulator platform provides whatever help I need. TT4: The Simulator platform is truthful in its dealings with me. TT5: The Simulator platform performs it's role of database/facilitating online tools very well. TT6: The Simulator platform acts in my best interest. TT7: The Simulator platform does it's best to help me if I need help.	[99]
Individual Performance	IP	IP1:The Simulator platform enables me to accomplish tasks more quickly IP2:The Simulator platform makes it easier to accomplish tasks	[70]
Situation Awareness	SA	SA1:I sometimes lose track of safety due to receiving too much information at the same time. SA2:The information I need to assess safety is easily available. SA3:I know which information is relevant for safety and which information is not relevant for safety. SA4:I know how to act to maintain safety. SA5:I feel confident that I know how to deal with the various adverse incidents that may arise. SA6:I plan ahead in order to handle various adverse incident that may arise. SA7:I usually know what's going to happen next with regards to safety.	[83]
Simulator Flight Hours	-	Number of simulator flight hours each pilot reported in the survey.	(Proposed by authors)
Flight Hours	-	Number of flight hours each pilot reported in the survey.	(Proposed by authors)

Appendix B – Latent Variables Descriptives

	Mean	Median	Observed min	Observed max	Standard deviation	Excess kurtosis	Skewness	Number of observations used	Cramér-von Mises test statistic	Cramér-von Mises p value
Flight Hours	-0.000	-0.436	-0.537	4.200	1.000	6.381	2.627	232.000	7.813	0.000
IP	0.000	-0.168	-4.959	2.227	1.000	6.031	-0.792	232.000	6.304	0.000
IQ	-0.000	-0.126	-3.760	1.691	1.000	4.626	-1.495	232.000	2.835	0.000
SA	-0.000	-0.031	-6.866	2.247	1.000	10.893	-1.640	232.000	7.545	0.000
Simulator Hours	0.000	-0.262	-0.430	10.607	1.000	64.740	7.276	232.000	7.869	0.000
TT	-0.000	-0.027	-4.619	2.268	1.000	6.470	-1.529	232.000	4.619	0.000

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