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İnsansız Hava Araçlarına Yönelik Toplumsal Algı Çalışmalarının Bibliyometrik İncelemesi

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Öz

Bu çalışma, insansız hava araçlarına (İHA) yönelik toplumsal algı kavramını ele alan literatürdeki araştırmaları, bibliyometrik analiz yöntemiyle incelemeyi amaçlamaktadır. Araştırma, 2010-2025 yılları arasında yayımlanmış İngilizce yayınları kapsamakta olup, mahremiyet, endişe ve etik gibi konulara odaklanan çalışmaları içermektedir. Çalışma kapsamında, Scopus, Web of Science ve Google Scholar veri tabanlarında, önceden belirlenmiş anahtar kelimeler aracılığıyla sistematik bir literatür taraması yürütülmüştür. Literatür taraması kapsamında kullanılan veri tabanı sorguları için arama dizinleri tanımlanmış, tarama süresince geçerli olacak dışlama kriterleri belirlenmiştir. Bu süreç, PRISMA akış şeması ile görselleştirilmiştir. VOSviewer yazılımı ile gerçekleştirilen veri analizi sonucunda, anahtar kelime analizi, coğrafi dağılım ve atıf durumu gibi bulgular elde edilmiştir. Aynı zamanda elde edilen verilere göre çalışmaların yıllık büyüme hızının %33,99 olması bu alandaki araştırmaların hızla arttığını ve konuya olan ilginin giderek yükseldiğini göstermektedir. Ortalama doküman yaşının 3,78 yıl olması, literatürdeki çalışmaların büyük ölçüde güncel olduğunu ve konunun dinamik bir araştırma alanı olarak geliştiğini göstermektedir. Bu veri, İHA'lara yönelik toplumsal algı araştırmalarının hâlen evrim geçirmekte olduğunu ve bilimsel literatürde önemli bir hareketlilik içerdiğini işaret etmektedir. Bu çalışma, konunun mevcut durumunu analiz ederek literatürdeki boşlukları tespit etmekte ve gelecekteki disiplinler arası araştırmalara yön vermektedir.

Anahtar Kelimeler: Algı, Bibliyometrik Analiz, İnsansız Hava Aracı, Toplum

JEL Sınıflandırma: L93, O33, D83.

Bibliometric Review of Public Perception Studies on Unmanned Aerial Vehicles

Abstract

This study aims to examine the literature on the concept of public perception toward unmanned aerial vehicles (UAVs) through a bibliometric analysis method. The research covers English-language publications published between 2010 and 2025, focusing on topics such as privacy, concern, and ethics. As part of the study, a systematic literature review was conducted using predefined keywords in the Scopus, Web of Science, and Google Scholar databases. Search indices for database queries were defined, and exclusion criteria to be applied during the screening process were established. This process was visually represented using a PRISMA flow diagram. As a result of the data analysis carried out with the VOSviewer software, findings such as keyword analysis, geographical distribution, and citation status were obtained. In addition, the annual growth rate of publications was found to be 33,99%, indicating a rapid increase in research in this field and a growing interest in the topic. The average document age of 3,78 years suggests that the literature is largely up to date and that the topic is developing as a dynamic research area. These findings indicate that research on public perception of UAVs is still evolving and that there is significant academic activity in this area. By analysing the current

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state of the literature, this study identifies existing research gaps and provides direction for future interdisciplinary studies.

Key Words: Perception, Bibliometric Analysis, Unmanned Aerial Vehicle, Society

JEL Classification: L93, O33, D83.

GİRİŞ

İnsan Hava Aracı (İHA) teknolojisi, günümüzde toplumlar için giderek daha önemli hale gelmektedir. Bu teknolojilerin sunduğu yetenekler, farklı uygulamalarda (arama kurtarma, tarım, lojistik gibi) kullanım alanlarını genişletirken, aynı zamanda toplumda bu teknolojilere dair algıların da şekillenmesine yol açmaktadır. Gelişen teknolojilerin toplumsal etkilerinin anlaşılması ve bu süreçte ortaya çıkan endişe, gizlilik, güvenlik ve etik meselelerin sistematik olarak değerlendirilmesi, gelecekte geliştirilecek politika ve düzenlemelerin sağlam temellere dayanması açısından büyük önem taşımaktadır (Teplyo, Straubinger ve Laliberte, 2023).

İHA'ların kullanım alanlarındaki artışın gelecekte çok daha hızlı bir şekilde olacağı öngörülmektedir. Akademik literatürün ve geçmiş uygulamaların değerlendirilmesi, teknolojik ilerlemenin yönlendirilmesi ve toplumsal algının biçimlendirilmesi açısından kritik bir rol oynamaktadır. Dolayısıyla, geçmişte yapılmış çalışmaların sistematik biçimde değerlendirilmesi, hem mevcut bilgi birikiminin ortaya konulması hem de yeni araştırma fırsatlarının belirlenmesi açısından büyük önem taşımaktadır (Sabino vd., 2022).

Bu çalışmada, İHA'lara yönelik toplumsal algı literatürünü bibliyometrik olarak analiz edebilmek için 2010–2025 yılları arasında yayımlanan İngilizce kaynaklar, Google Scholar (Scholar, 2025), Scopus (Scopus, 2025) ve Web of Science (Web of Science, 2025) veri tabanları aracılığıyla taranmıştır. Çalışmada verilerin seçimi, arama stratejisi ile dahil etme ve hariç tutma kriterleri, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses – Sistematik Derlemeler ve Meta-Analizler için Tercih Edilen Raporlama Ögeleri) modeline dayalı olarak oluşturulmuştur. PRISMA, analiz sürecinde şeffaflığı artırmak ve elde edilen bulguların tutarlı bir biçimde raporlanmasını sağlamak amacıyla geliştirilmiş metodolojik bir rehberdir. Bu rehber uygun olarak, araştırmanın temel sorusu ve konusu net bir biçimde tanımlanmakta; daha sonra incelemeler ve yayınların belirlenmesi, seçim kriterleri ile dahil edilme süreçlerini içeren PRISMA akış diyagramı kullanılarak seçilecek yayınlar tespit edilmektedir (Page vd., 2021).

Bu çalışma kapsamında, yöntem bölümünde belirtilen anahtar kelimeler doğrultusunda aşağıdaki araştırma sorularına yanıt aranacaktır.

1. İHA'lara yönelik toplumsal algıyı ele alan yayınların yıllara göre dağılımı nasıldır?
2. İlgili yayınların coğrafi dağılımı (ülkelere göre) nasıl şekillenmektedir?
3. Bu alanda en çok atıf alan çalışmalar ve en çok yayın yapan dergiler hangileridir?
4. En aktif yazarlar ve kurumlar kimlerdir, aralarındaki iş birliği ve atıf ilişkileri nasıldır?
5. Seçilen yayınlar arasında en sık kullanılan anahtar kelimeler nelerdir?

Çalışmada, İHA'ların toplumsal algı bakımından incelendiği çalışmaların kapsamlı bir bibliyometrik analizi gerçekleştirilerek, bu alandaki çalışmalar hakkında nicel veriler

sunulması amaçlanmaktadır. Literatürdeki boşlukların ve potansiyel araştırma alanlarının ortaya konmasıyla, İHA teknolojisinin sosyal boyutlarına ilişkin gelecekteki akademik çalışmalara stratejik bir yön verilmesi hedeflenmektedir.

Bu doğrultuda, literatürdeki mevcut eğilimler, en etkili yazarlar, ülkeler, dergiler ve iş birliği ağları gibi birçok değişken analiz edilerek, İHA'ların toplumsal algı boyutuna yönelik derinlemesine bir bakış sağlanması hedeflenmektedir.

Çalışmanın ikinci bölümünde, İHA teknolojilerine ilişkin mevcut akademik literatür kapsamlı biçimde ele alınmış, özellikle İHA'ların farklı sektörlerdeki kullanım alanları ve toplumda yarattığı algıya dair çalışmalar analiz edilmiştir. Bu bölümde, toplumsal algının mahremiyet, güvenlik ve risk gibi temalarla nasıl şekillendiği değerlendirilmiştir.

Üçüncü bölümde ise bibliyometrik analiz yöntemi detaylı biçimde açıklanmış; anahtar kelime seçimi, arama stratejisi ve hariç tutma kriterleri belirtilmiştir. Ayrıca, veri toplama sürecinde kullanılan veri tabanları (Scopus, Web of Science ve Google Scholar) ile analizde yararlanılan yazılımlar (VOSviewer, Bibliometrix) tanıtılmıştır.

Dördüncü bölümde, seçilen yayınlara ilişkin tanımlayıcı istatistikler, yayınların yıllara ve ülkelere göre dağılımı, anahtar kelime analizi, en çok atıf alan yayınlar, konu alanları ve iş birliği ağları gibi veriler tablo ve şekillerle görselleştirilerek sunulmuştur.

Beşinci ve son bölümde ise bulgular ışığında kapsamlı bir değerlendirme yapılmış, elde edilen sonuçlar tartışılmış ve gelecekteki araştırmalara yönelik önerilerde bulunulmuştur. Bu sayede, İHA'lara yönelik toplumsal algı konusunun daha geniş ve disiplinler arası bir perspektiften ele alınmasına katkı sunulması amaçlanmıştır.

1. LİTERATÜR TARAMASI

İnsansız hava araçları (İHA), mürettebat veya yolcu taşımayan, kamera ve çeşitli teknik ekipmanlar içeren, uzaktan kumanda edilebilen ya da otonom olarak uçuş gerçekleştirebilen hava araçlarıdır (Martinez ve Cardona, 2018). Son yıllarda teknolojik gelişmelerle birlikte İHA'ların hem ticari hem de özel alanlarda kullanımı artmıştır. İHA'lar tarımsal faaliyetlerde, arama-kurtarma, yangın söndürme, havadan görüntü elde etme ve kargo taşımacılığı faaliyetlerinde önemli roller üstlenmektedir. Örneğin, arama-kurtarma operasyonlarında kaybolan bireylerin tespiti ve felaket anında risk altındaki kişilerin sayısının belirlenmesi gibi kritik bilgiler sağlanmaktadır. İHA'ların sunduğu bu çeşitli avantajlar, onların modern toplumda giderek daha fazla entegre edilmesine olanak tanımakta ve bu araçların etkinliğini artırmaktadır. Gelişen teknolojiler sayesinde, İHA'ların potansiyeli daha da genişlemekte ve gelecekte daha fazla alanda kullanılmaları beklenmektedir (Wang, Mutzner ve Blanchet, 2023).

İHA teknolojileri, kullanım amaçlarına ve yaygınlık düzeyine bağlı olarak toplumsal algıyı doğrudan etkileyen bir unsur hâline gelmiştir. İHA'lara yönelik toplumsal algı, çok sayıda faktörün etkisiyle şekillenmektedir. Bu algının sonuçları ise bireylerin ve toplumların teknolojiyi nasıl değerlendirdiği ve benimsediğiyle yakından ilişkilidir. Toplumsal algı, bir toplumun belirli bir konu, grup veya olguya yönelik geliştirdiği düşünceler, duygular ve tutumların toplamıdır. Bu kavram, bireylerin ve grupların sosyal etkileşimleri ve deneyimleri sonucunda şekillenmektedir. Toplumsal algı şu unsurları içermektedir (Rice vd., 2018):

- Bireylerin bir konu hakkında sahip olduđu bilgi ve inançlar,
- Belirli bir konuya karşı hissedilen duygusal tepkiler (örneğin: korku, güven, endişe),
- Bireylerin bir konuya karşı geliřtirdiđi olumlu veya olumsuz tutumlar.

İHA'lara yönelik algı, literatürde çok boyutlu bir şekilde incelenmekte olup bu boyutlar arasında emniyet kaygıları, mahremiyet, erişim kolaylığı, toplumsal kabul ve teknolojik yenilik ön plana çıkmaktadır. Del-Real ve Díaz-Fernández (2021) çalışmalarında sahil kurtarma İHA'larının insan cankurtaranlara göre daha avantajlı olduğunu vurgulamışlardır. İHA'ların daha geniş alanları kontrol edebilme kabiliyeti, hız yeteneđi ve insan kurtarıcılar için çok tehlikeli olabilecek koşullar altında çalışıp daha fazla can kaybının önüne geçebileceđi belirtilmiştir. Çalışmada gerçekleştirilen anket ile katılımcıların %52,3'ünün kurtarma İHA'ları kullanılsa bile plaja gitmeye devam edeceğini, %47,8'inin ise plaja gitmeyeceđini söylediđi belirtilmiştir. Kurtarma İHA'larının toplumda kabul görmesinin orta düzeyde olduđu yorumlanmıştır.

Komasová, Tesař ve Soukup (2020) çalışmalarında, aşinalık hipotezinin, kullanıcı grubunda daha düşük risk algısı ve daha yüksek onay ile ilişkilendirildiđi belirtilmiştir. Ancak İHA teknolojisinin artan kullanılabilirliğinin, algılanan riskleri azaltacađı ya da farklı kullanım biçimlerinin onay oranını artıracađı sonucuna ulaşılmadıđı vurgulanmıştır. Çalışma sonucuna göre İHA kullanımının artması, algılanan risklerin azalmasını sağlamadıđı belirtilmiştir.

Eißfeldt vd. (2020) çalışmalarında, Almanya'da sivil İHA'ların kabulü üzerine yapılan ulusal bir çalışmanın sonuçlarını aktarmıştır. Almanya'da kurtarma çalışmalarında görev alacak İHA'lara karşı olumlu tutum sergilenirken eğlence, reklam ve paket teslimatı gibi amaçlar için kullanımında yarıdan fazla katılımcı tarafından kabul görmediđi vurgulanmıştır. Bu çalışmalar toplumun İHA'lara yönelik tutumlarını ve bu tutumların sebeplerini anlamaya yönelik önemli sonuçları açıklamaktadır.

Durak (2024) çalışmasında hava yolu stratejilerine yönelik literatürü bibliyometrik olarak yöntemle incelemiştir. Web of Science veri tabanında “airline” ve “strategy” anahtar kelimeleriyle yalnızca özetler temelinde yapılan taramada 637 çalışmaya ulaşılmış ve seçilen 471 çalışma üzerinden 1991-2022 yılları arasındaki yayınlar değerlendirilmiştir. Yayın eğilimleri, en çok atıf alan makaleler, etkili yazarlar, dergiler, ortak yazarlık ilişkileri incelenmiş; VOSviewer ile ağ ve yoğunluk haritaları oluşturulmuştur. Hava yolu stratejilerine yönelik akademik ilginin özellikle son yıllarda artıđı vurgulanmıştır.

Uzgör, Savaş ve Kafalı (2024), havacılıkta çevre yönetiminin literatürde yeterince ele alınmadığını tespit etmiştir. Bu eksikliđi gidermek amacıyla çevresel sürdürülebilirlik konulu çalışmalar bibliyometrik yöntemle incelenmiştir. Analizde, R tabanlı Bibliometrix yazılımı kullanılmış, başlık, özet ve anahtar kelimeler üzerinden tarama yapılmıştır. Teknik alanlar dışarıda bırakılmış, yalnızca hava taşımacılığının yönetsel yönüne odaklanan çalışmalar değerlendirilmiştir. Yayın ve atıf sayılarına ilişkin temel istatistikler sunulmuştur.

Kumar ve Dulloo (2024) çalışmalarında, havacılık endüstrisinde sürdürülebilirlik konulu akademik makaleleri bibliyometrik analiz yöntemiyle incelemiştir. Veriler “sürdürülebilirlik” ve “havacılık” anahtar kelimeleriyle Web of Science veri tabanından elde edilmiştir.

Analizde, R programındaki Bibliometrix eklentisi kullanılmış ve yalnızca İngilizce yayınlar dikkate alınmıştır. 2001-2023 yılları arasını kapsayan çalışmada sürdürülebilirlik, çevresel, sosyal ve ekonomik boyutlarıyla ele alınmıştır. Sonuçlarda 2022 ve 2023 yıllarında yayımlanan çalışmaların sayısında belirgin bir artış olduğu tespit edilmiş, bu artışın çevresel farkındalığın yükselmesi ve pandemi sonrası kaynak verimliliği arayışıyla ilişkili olduğu vurgulanmıştır.

Altıntaş, Açikel ve Turhan (2024) tarafından gerçekleştirilen çalışmada, 2003–2022 yılları arasında yayımlanan İHA odaklı akademik yayınlar, emniyet odaklı bir bakış açısıyla bibliyometrik yöntemle incelenmiştir. Dimensions veri tabanındaki yayınlar yıl, yazar, ülke ve kurum gibi kriterlere göre filtrelenebilir; analizde VOSviewer yazılımı kullanılmıştır. Çalışmaların büyük çoğunluğunun 2021 yılında yayımlandığını ortaya koymuştur. Yayınların ağırlıklı olarak ABD (Amerika Birleşik Devletleri) kaynaklı olduğu ve en fazla atıf alan kurumun Florida Üniversitesi olduğu tespit edilmiştir.

Falcao ve arkadaşları (2021), Brezilya’da hava taşımacılığı alanında gerçekleştirilen akademik çalışmaları bibliyometrik yöntemle analiz ederek, literatürün genel eğilimlerini ve araştırma boşluklarını ortaya koymayı hedeflemiştir. Arama filtreleri anahtar kelimelerle sınırlandırılmıştır. Çalışmaların %86’sının hava yolları ve havaalanları konusuna odaklandığını; bunların %47’sinden fazlasının ekonomi temelli olduğunu ortaya koymuştur. Uçaklar ve hava seyrüseferi %14, kargo taşımacılığı ise %3 oranında yer almıştır.

Raza, Ashrafi ve Akgunduz (2020) çalışmasında hava yolu gelir yönetimi literatürünü bibliyometrik analizle inceleyerek sektörün trend belirleyici konularını, en etkili yazarlar ile kurumları tespit etmiştir. 2008-2018 dönemini kapsayan sistematik literatür incelemesi kapsamında, SCOPUS veri tabanından toplanan çalışmalar değerlendirilmiştir. Yayınların çoğunluğu ABD kaynaklı olup Çin, Almanya, Hindistan, İngiltere ve Kanada takip etmiştir. Ayrıca analiz edilen çalışmaların coğrafi dağılımı ve temalarına ilişkin önemli eğilimler tespit edilmiştir.

Li vd. (2023) çalışmasında havacılıkta karbon emisyonlarına ilişkin yayınları bibliyometrik yöntemle haritalayarak analiz etmiştir. Scopus veri tabanında 1992-2021 arasında indekslenen çalışmalar, CiteSpace yazılımı kullanılarak değerlendirilmiştir. Yazarlar arasında güçlü iş birliği bağlantılarının olmadığı tespit edilmiştir. Ayrıca ABD, Birleşik Krallık, Çin, Almanya, Kanada ve Avustralya’nın bu alanda en aktif ülkeler olduğu vurgulanmıştır.

Sorsa ve Bona-Sánchez (2024) çalışmalarında, hava yolu endüstrisinde kurumsal sosyal sorumluluk konusundaki akademik yayınları bibliyometrik yöntemle incelemiş ve alandaki gelişmelerle gelecek eğilimleri vurgulamıştır. Bibliometrix ve VOSviewer yazılımlarıyla yapılan analizlerde, çalışmaların son yıllarda belirgin bir şekilde arttığı tespit edilmiştir. 2008-2023 arasında elde edilen veri seti, yıllık ortalama %20,79 büyümeye ile konunun önem kazandığını göstermiştir.

Burak ve Küsbeci (2024) çalışmasında, 2007-2023 yılları arasında Web of Science veri tabanında yayımlanan nesnelerin interneti ve havacılık konusundaki yayınları bibliyometrik yöntemlerle analiz etmiştir. Eş-yazar, eş-atıf, bibliyografik eşleştirme ve anahtar kelime

geçiş analizleri gerçekleştirilmiş, VOSviewer ve Biblioshiny araçlarıyla görselleştirme sağlanmıştır. Nesnelerin interneti ve havacılık alanındaki yayınların son yıllarda arttığını, henüz bilimsel olgunluğa ulaşmadığını ve yeni çalışmalar için önemli potansiyel taşıdığını ortaya koymuştur.

Okine, Zarei ve Roggow (2024) çalışmalarında, 10191 yayından oluşan veri seti kullanılarak havacılık güvenliği literatürünü sistematik biçimde incelemiştir. VOSviewer ve Bibliometrix R paketi ile yapılan bibliyometrik analizde atıf alan kaynaklar, dergiler, yazarlar ve anahtar kelimeler tespit edilmiştir. En fazla yayın ve atıf alan kaynakların Havacılık, Uzun ve Çevre Tıbbi ile Güvenlik Bilimleri alanlarında olduğu belirlenmiş, ABD, Çin ve İngiltere'nin en çok yayına sahip ülkeler olduğu vurgulanmıştır.

Bakır vd. (2022), çalışmasında 1975–2020 yılları arasında havalimanı hizmet kalitesi alanında yapılan çalışmaları bibliyometrik analizle incelemiş ve literatürdeki eğilimleri ortaya koymuştur. Web of Science Core Collection veri tabanında yapılan taramada 312 çalışmadan kriterlere uygun 100 çalışma analiz edilmiştir. R tabanlı Bibliometrix yazılımıyla gerçekleştirilen analizde, Journal of Air Transport Management dergisinin alanda öncü olduğu belirlenmiş; en yüksek katkının Çinli araştırmacılar tarafından sağlandığı ve çalışmaların büyük ölçüde uluslararası iş birliğine dayandığı vurgulanmıştır.

Dixit ve Jakhar (2021) çalışmasında bibliyometrik analizle havalimanı kapasite yönetimi literatürünü incelemiştir. ABD, Çin ve İngiltere en çok yayına sahip ülkeler olarak belirlenmiş, Journal of Air Transport Management dergisi alanın başlıca kaynağı olarak öne çıkmıştır. Ayrıca sürdürülebilirlik ve havalimanı iş birliği gibi yeni temaların önem kazandığı tespit edilmiştir.

Tanrıverdi ve Durak (2022) çalışmasında, hava yolu iş modeliyle ilgili literatürü analiz etmek amacıyla SCI-Expanded, SSCI, ESCI ve WoS Core Collection veri tabanlarında anahtar kelimelerle tarama yapılmış ve 1078 kayıt elde edilmiştir. Bu araştırmalara ait yazar adı, yayın yılı, atıf sayısı ve DOI bilgileri toplanarak veri seti CiteSpace yazılımına aktarılmıştır. Yinelen kayıtlar otomatik olarak çıkarıldıktan sonra dışlama kriterleri doğrultusunda kitaplar, konferans bildirileri ve İngilizce dışı yayınlar elenmiş böylece 652 çalışma bibliyometrik analiz için seçilmiştir.

See vd. (2023) çalışmalarında havaalanı verimliliği ve üretkenliğine yönelik literatürü daha iyi kavrayabilmek amacıyla bibliyometrik analiz yöntemiyle gerçekleştirilmiştir. Analiz sürecinde ortaya çıkan yazarlar, kurumlar, ülkeler, iş birliği ağları, etkili dergiler ve en çok atıf alan makaleler belirlenmiştir. Anahtar kelime analizleriyle literatürde öne çıkan araştırma temaları ortaya konmuştur. Yayınların yıllık büyüme oranının %10,96 olduğu ve 1999-2019 döneminde artış gösterdiği tespit edilmiştir. Çalışmaların yarısının Avrupa, %21,88'inin ise Asya havalimanlarına odaklandığı görülmüştür.

Dinçer vd. (2024) çalışmalarında 2001-2023 yılları arasında sürdürülebilir havacılık alanındaki eğilimleri belirlemek amacıyla bibliyometrik bir analiz gerçekleştirmiştir. Web of Science'da indekslenen 726 yayın VOSviewer ile incelenmiş, anahtar kelime, atıf ve eş yazarlık analizleri uygulanmıştır. Çalışmaların özellikle 2020-2023 döneminde

yoğunlaştığını ve “sürdürülebilir havacılık yakıtı” temasının öne çıktığını göstermiştir. En çok atıf alan ülkenin ABD olduğu tespit edilmiştir.

Literatür incelendiğinde, İHA teknolojilerinin toplum tarafından nasıl algılandığına ilişkin yapılan çalışmaların sayıca sınırlı olduğu ve özellikle bu konuyu sistematik biçimde ele alan kapsamlı bibliyometrik analizlerin eksik kaldığı görülmektedir. Mevcut çalışmaların büyük bir kısmı belirli temalarla sınırlı kalmakta, bu da İHA'ların toplumsal boyutunu geniş perspektiften ele alan bütüncül bir değerlendirmeyi zorlaştırmaktadır.

Bu bağlamda, söz konusu çalışmanın temel amacı, İHA'lara yönelik toplumsal algıyı, bibliyometrik analiz yöntemi kullanarak disiplinler arası bir yaklaşımla incelemek ve literatürdeki önemli bir boşluğu doldurmaktır. Araştırma kapsamında 2010–2025 yılları arasında yayımlanmış İngilizce akademik yayınlar sistematik olarak taranmış, İHA'lara ilişkin toplumsal algının nasıl şekillendiği, bu konudaki akademik eğilimlerin hangi yönlerde yoğunlaştığı ve zaman içerisinde nasıl bir değişim gösterdiği ortaya konulmuştur.

Yayınlar üzerinde yapılan analizlerde, anahtar kelime kullanımları, atıf ilişkileri, yazar ve kurum iş birlikleri, yayın yapılan ülkeler gibi temel değişkenler dikkate alınarak, alandaki yapısal örüntüler görselleştirilmiştir. Elde edilen veriler doğrultusunda, İHA'lara yönelik toplumsal algı alanındaki çalışmaların coğrafi dağılımı, atıf yoğunluğu, tematik eğilimleri ve bilimsel iş birliği ağları detaylı şekilde analiz edilmiştir.

Bu çalışma, yalnızca mevcut durumu tespit etmekle kalmamış; aynı zamanda ileride yapılacak araştırmalara yön gösterecek potansiyel araştırma boşluklarını da ortaya koyarak, İHA teknolojisinin sosyal boyutlarına ilişkin bilimsel bilgi üretimini destekleyecek nitelikte bir katkı sunmaktadır.

2. YÖNTEM

Çalışmada, mevcut araştırmalar sistematik bir yaklaşımla bibliyometrik analiz yöntemiyle değerlendirilmiştir. Bibliyometrik analiz, bir araştırma alanının güncel durumuna dair biçimsel ve nicel veriler elde etmek için kullanılan, görselleştirme yazılımları aracılığıyla akademik eğilimleri takip etmeyi sağlayan analitik bir metottur. Bibliyometrik analiz, ülkelerin, yazarların, üniversitelerin ve bilimsel belgelerin üretkenliğini değerlendirmeye olanak tanımaktadır. Bu analiz, araştırma alanlarındaki güçlü ve zayıf yönleri belirlerken, literatürdeki boşlukları, iş birliği ağlarını, potansiyel fırsatları ve belirli bir alanda üretilen sonuçların geniş kapsamlı etkilerini nicel veriler aracılığıyla sunar. Bu sayede araştırmacılara konu ile ilgili bilgi kazanma olanağı sağlar (Dirik, Eryılmaz ve Erhan, 2023). Bibliyometrik analiz, bilimsel yayınların başlıkları, anahtar kelimeleri, yazarları ve atıf yapılan referanslar gibi çeşitli bibliyografik verileri inceleyen bir tekniktir. Ayrıca, akademik ve sektörel araştırmalarda, araştırma alanlarındaki eğilimleri, ilişkileri ve gelişmeleri anlamaya yönelik etkili bir araç olarak kullanılır (Arslan, 2022).

3.1. Anahtar Kelime Seçimi, Arama Stratejisi ve Hariç Tutma Kriterleri

Bu çalışma kapsamında kullanılan anahtar kelimeler, araştırma amacına uygun olacak şekilde titizlikle seçilmiş ve literatürde İHA'lara yönelik toplumsal algıyı yansıtan temel kavramları kapsayacak biçimde belirlenmiştir. Anahtar kelimelerin seçiminde, alan yazında yaygın olarak kullanılan terimler ile konuya ilişkin kavramsal bütünlüğü sağlayan ifadelerin

dahil edilmesine özen gösterilmiştir. Böylece, literatür taramasının kapsamı genişletilerek, ilgili çalışmalara sistematik ve bütüncül bir şekilde ulaşılması hedeflenmiştir. Tablo 1.’de, çalışmaların başlık, anahtar kelime ve özet bölümlerinde; “UAV” (Unmanned Aerial Vehicle - İnsansız Hava Aracı), “UAS” (Unmanned Aircraft System - İnsansız Hava Sistemi), “RPAS” (Remotely Piloted Aircraft System - Uzaktan Kumandalı Hava Aracı Sistemi), “DRONE” (Drone - İHA) ve “PERCEPTION” (Algı) arama kavramları, “ve” ile “ya da” şeklindeki mantıksal operatörlerle birlikte kullanılmıştır.

Tablo 1. Araştırmaya Dahil Edilen Arama Dizinleri

Arama Seçeneği	Arama Dizini
Başlık- Anahtar Kelime -Arama Dizini	*UAV ya da *UAS ya da *RPAS ya da *DRONE ve * PERCEPTION

Veri tabanlarında anahtar kelimeler ve mantık operatörlerinin kullanımı ile elde edilecek yayınların, çalışmamıza uygun olmayanları belirlemek amacıyla, dışlanan dizinler belirlenmiştir (Tablo 2).

Tablo 2. Araştırmadan Dışlanan Arama Dizinleri

Arama Seçeneği	Hariç Tutulan Arama Kriteri
Başlık- Anahtar Kelime -Arama Dizini	*Military (Askeri) ve *Technical (Teknik) ve *Design (Tasarım)

Tablo 3’te, literatür taramasında kullanılan hariç tutma kriterleri belirli kavramsal çerçeveler doğrultusunda, A-F harf aralıklarıyla kategorize edilerek sunulmuştur. Bu çerçevede, A-B harfleri İnsansız Hava Araçları, C-D harfleri Algı, E-F harfleri ise Teknik Kriterler başlıklarına karşılık gelmektedir. Söz konusu merkezi kavramlar, araştırma kapsamının netleştirilmesi ve uygun yayınların seçilmesini sağlamak amacıyla yapılandırılmıştır. Her bir kavramsal kategoriye ilişkin hariç tutma ölçütleri aşağıda ayrıntılı olarak açıklanmaktadır.

Tablo 3. Hariç Tutma Kriterleri

Merkezi Kavram	Hariç Tutma Kriterleri
İnsansız Hava Araçları	A. İHA ile ilgili bilgilere yer verilmiştir fakat teknik veya tasarım konularına değinilmiştir. B. Yayında teknolojik algılar yer almaktadır fakat direkt olarak İHA’lara yönelik değildir.
Algı	C. Yayında teknolojik algılar yer almaktadır fakat direkt olarak İHA’lara yönelik değildir. D. Algı kavramı topluma yönelik olarak değil İHA’ların sensör algısı olarak ele alınmıştır.
Teknik Kriterler	E. Yayın dili İngilizce değildir. F. Çalışmanın tam metin hali mevcut değildir.

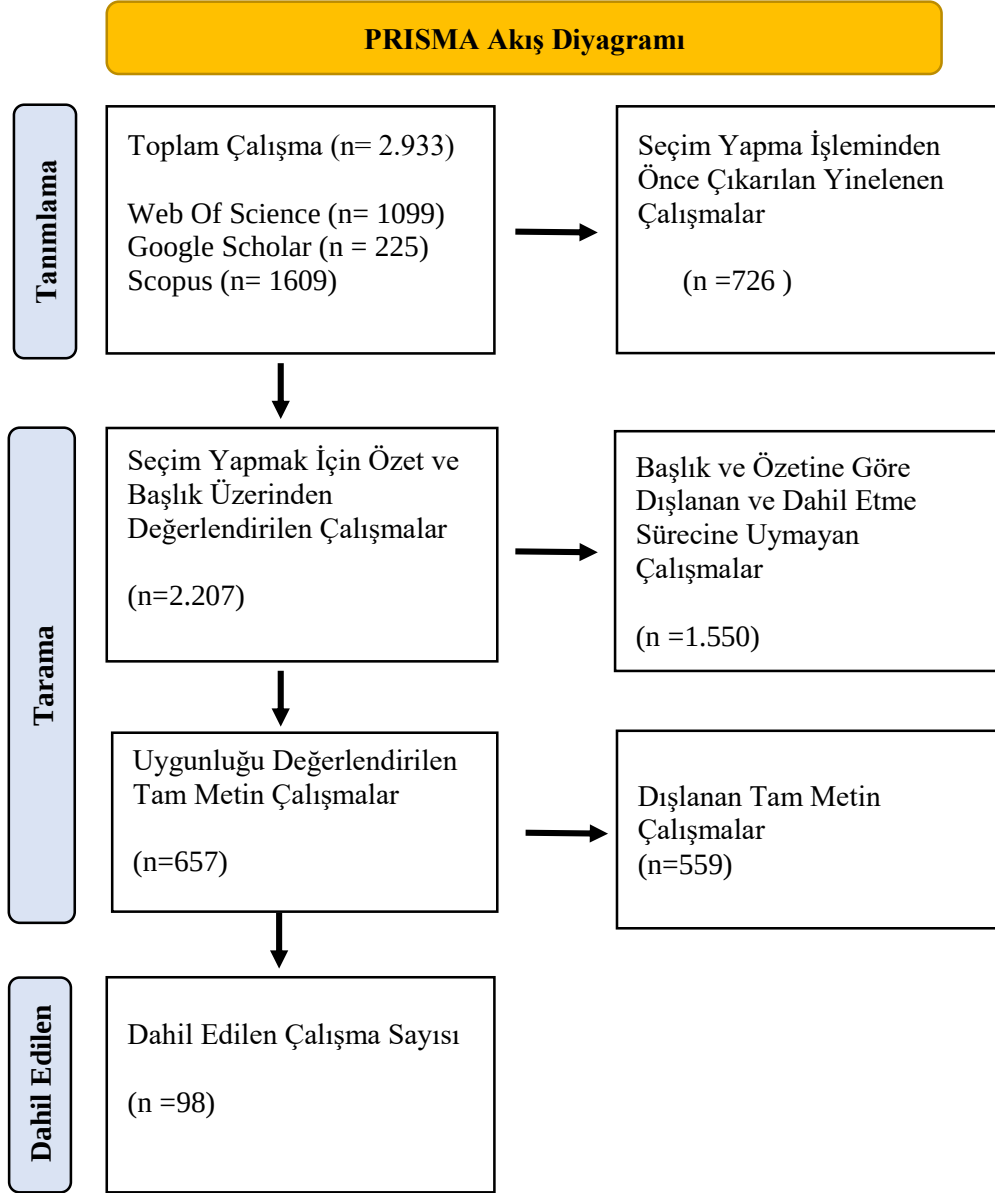
3.2. Araştırma ve Veri Toplama Süreci

Literatür taraması, 2010–2025 yılları arasında yayımlanmış İngilizce yayınları kapsayacak şekilde Google Scholar arama motoru ile Scopus ve Web of Science gibi akademik veri

tabanları kullanılarak gerçekleştirilmiştir. Google Scholar platformu, doğrudan analiz edilebilir bir veri çıktısı sunmadığı için bu kaynaktan veri toplama süreci manuel olarak yürütülmüştür. Belirlenen anahtar kelimeler kullanılarak ilgili yayınlar taranmış, uygun görülen çalışmaların künyeleri manuel olarak kaydedilmiştir. Ardından bu veriler, analiz edilebilir hale getirilmek üzere RIS formatına dönüştürülmüş ve diğer veri tabanlarından elde edilen kayıtlarla birleştirilmiştir.

Daha önce yapılmış bazı bibliyometrik çalışmalarda ise yalnızca tek bir veri kaynağı kullanılmış olması, kapsam açısından belirli sınırlılıklar doğurmuştur. Örneğin, Florido-Benítez (2023) çalışmasında sadece Web of Science veri tabanı kullanılarak havalimanları ve hava yolları konulu yayınları incelemiş, Google Scholar gibi alternatif kaynaklar kullanılmadığı için bu durum çalışmanın sınırlılıkları arasında belirtilmiştir. Benzer şekilde Le (2024) çalışmasında da yalnızca Scopus veri tabanı temel alınarak havacılık sektöründe gönüllü karbon dengelemeleri konusundaki literatürü analiz etmiştir. Bu bağlamda, Web of Science gibi diğer veri tabanlarında yer alan önemli çalışmaların dışarıda kalmasına neden olabileceği vurgulanmıştır. Bu çalışmada ise birden fazla veri tabanı kullanılarak literatür kapsamı genişletilmiş böylece elde edilen sonuçların güvenilirliği ve temsiliyeti artırılmaya çalışılmıştır.

Seçilen anahtar kelimelerle yapılan arama sonucunda toplam 2933 yayına ulaşılmıştır. Çalışmada yinelenen, çalışma konusuna uygun olmayan, İngilizce olmayan, özet halinde olan (tam metni yer almayan) çalışmalar hariç tutulmuştur. Şekil 1’de sunulan PRISMA akış şemasına göre, belirlenen dahil etme ve hariç tutma kriterleri doğrultusunda toplam 98 yayın analiz kapsamına alınmıştır.



Şekil 1. PRISMA Akış Şeması

3.3. Araştırma Verilerinin Analizi

Çalışmada toplanan verilerin analizi ve görselleştirilmesi VOSviewer paket programı kullanılarak gerçekleştirilmiştir. VOSviewer, büyük ölçekli bibliyografik verileri analiz edebilme ve bu verileri görsel temsiller hâline dönüştürebilme yeteneğine sahip bir yazılımdır. Program, bilimsel yayınlar, dergiler, yazarlar ve anahtar kelimeler gibi çeşitli bileşenler arasındaki ilişkileri görselleştirmeye olanak tanımakta; bu sayede ilgili araştırma alanlarındaki eğilimlerin ve iş birliği ağlarının anlaşılmasına katkı sağlamaktadır (Dereli, 2024).

3. BULGULAR

Seçilen çalışmaların tanımlayıcı istatistikleri, yıllara göre dağılımı, anahtar sözcük analizi, ülkelere göre dağılımı, en çok atıf yapılan yayınları, konu dağılımı, kurumların atıf bağları,

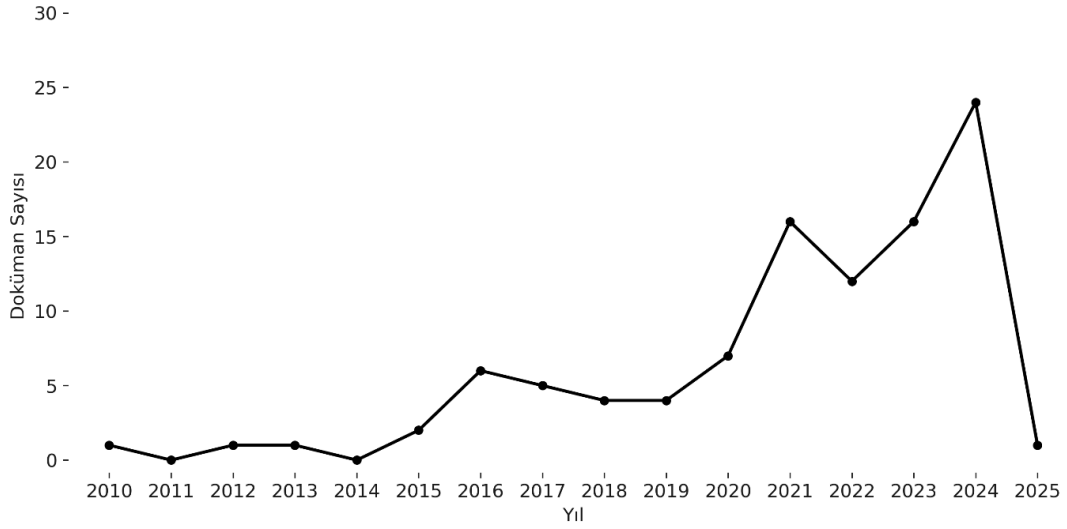
yazarların ortak atıf analizi, yayınlandığı dergilere dair bilgiler analiz edilerek bu bölümde tablo ve şekillerle bu bölümde sunulmuştur.

Tablo 4'te yer alan temel verilere göre seçilen toplam 98 yayın bulunmaktadır. Dokümanların ortalama yaşı 3.78 ve konuya dair çalışmaların büyüme hızı yıllık %33,99'dur. Dokümanların yaşı, incelenen belgelerin yayınlandığı tarihten itibaren hesaplanan ortalama süresidir. Büyüme oranı, bir araştırma alanının ne kadar hızla geliştiğini ve bu alanla ilgili ilginin arttığını gösterir. Yüksek bir büyüme oranı, genellikle o alanda yeni bulguların, teknolojilerin veya kavramların ortaya çıktığını, araştırmacıların bu konulara yatırım yaptığını ve dolayısıyla bilimsel birikimin hızlandığını göstermektedir. Her bir dokümanın ortalama atıf oranı 22.57'dir. Toplam kaynakça referans sayısı 5531'dir. Toplam 361 yazarın temsil edildiği veri setinde yer alan çalışmalardan 5'i tek yazarlıdır. Tek yazarlılık, bir eser veya akademik çalışmanın yalnızca bir yazar tarafından kaleme alınmış olması durumunu ifade etmektedir. Uluslararası iş birliği ile üretilen eser oranı %28,57'dir. Bu oran araştırma alanında iş birliğinin önemini ve farklı ülkelerden araştırmacıların birlikte çalışma eğilimini göstermektedir. Uluslararası iş birlikleri bilgi alışverişini kolaylaştırarak kaynakların etkin kullanımını mümkün kılmakta ve farklı perspektiflerin bir araya gelmesiyle araştırma kalitesini artırmaktadır.

Tablo 4. Tanımlayıcı İstatistikler

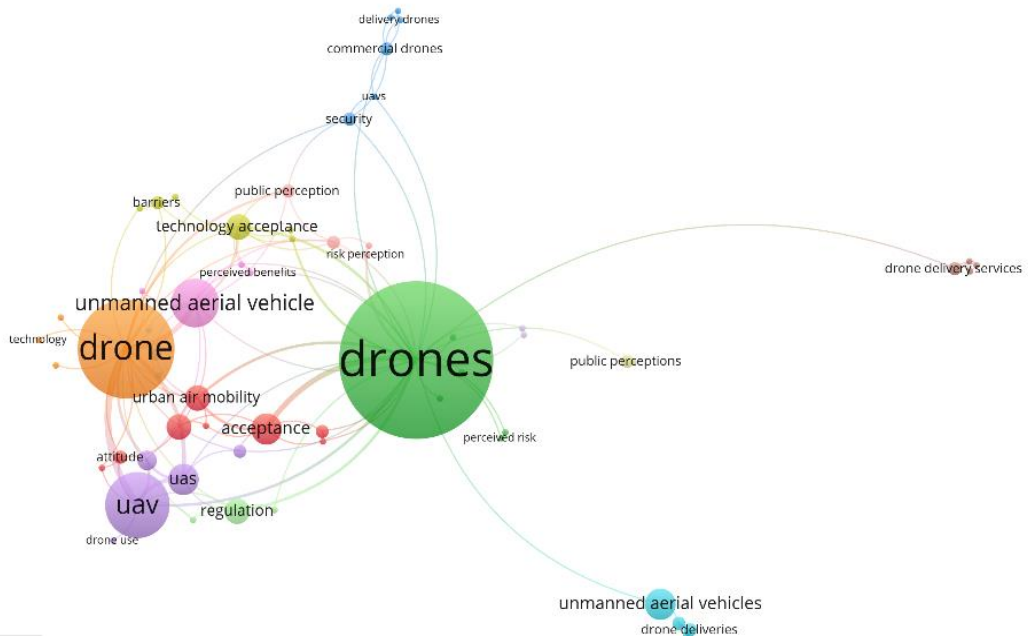
Seçilen Çalışma Sayısı	98
Dokümanların Ortalama Yaşı	3.78
Yıllık Büyüme Hızı	%33,99
Doküman Başına Düşen Atıf Sayısı	22.57
Kaynakçada Atıf Verilen Eserlerin Toplam Sayısı	5531
Yazar Sayısı	361
Tek Yazarlı Çalışma Sayısı	5
Uluslararası İş Birliğiyle Üretilen Eser Oranı	%28,57

Araştırmamıza konu olan yayınların yıllara göre dağılımı incelendiğinde, 2024 yılında en fazla sayıda çalışmanın yapıldığı görülmektedir. Bu yıl içerisinde 25 çalışmaya ulaşılması konuyla ilgili alandaki artan ilgi ve araştırma faaliyetlerinin bir göstergesidir. Şekil 2'de dağılım detaylı olarak sunulmaktadır.



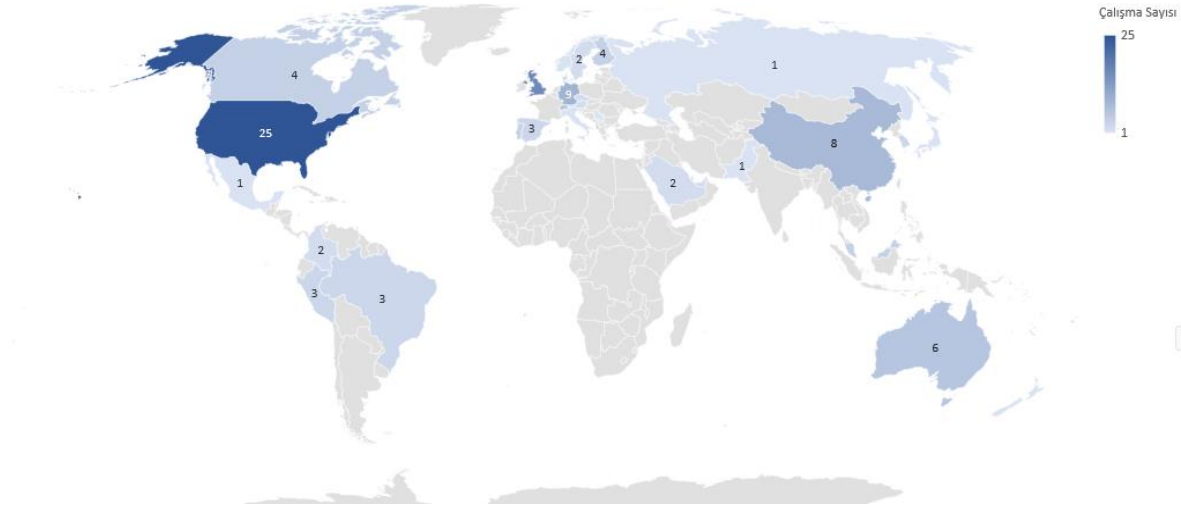
Şekil 2. Seçilen Yayınların Yıllara Göre Dağılımı

Şekil 3’te, yayıncıların anahtar kelimeleriyle oluşturulan analiz sunulmaktadır. Bu analiz ilgili alandaki temel kavramların görsel bir temsiliyi sağlar ve kelimelerin görülme sıklığına dayalı olarak önem derecelerini ortaya koyar. Analiz sonuçlarına göre en sık rastlanan terimler arasında “drones” (İHA), “uav” (İHA), “perception” (algı), “acceptance” (kabul) yer almaktadır. Bunun yanı sıra “public perception” (kamu algısı), “technology acceptance” (teknoloji kabulü) gibi terimleri de önemli bir yere sahip olup, araştırmaların sosyal kabul ve teknolojik benimseme konularına odaklandığını göstermektedir. Son olarak “risk perception” (risk algısı) kavramı, bu alandaki risk algısını ve yönetimini vurgulayan bir diğer önemli terimdir. Bu anahtar sözcük analizi, araştırma alanındaki eğilimleri ve odak noktalarını daha iyi anlamamıza yardımcı olmaktadır.



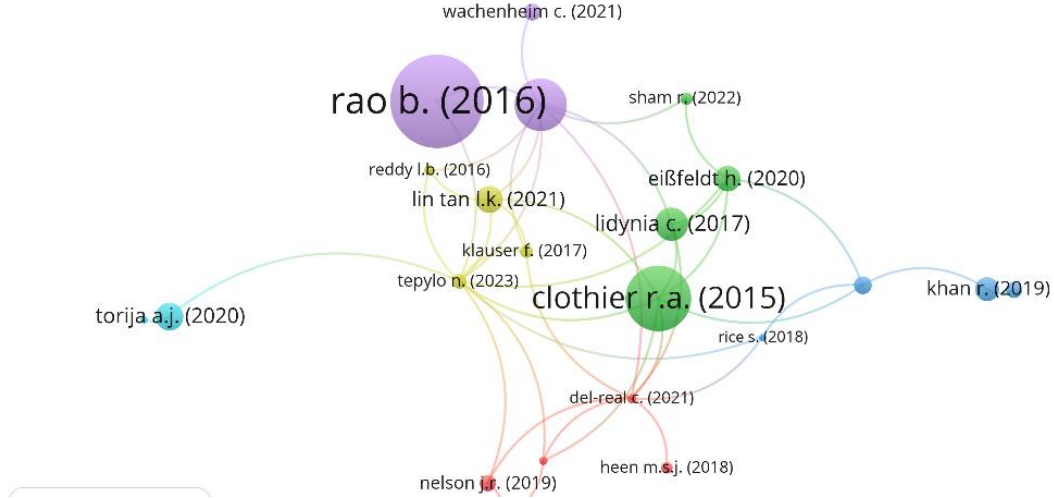
Şekil 3. Anahtar Sözcük Analizi

Çalışmaların coğrafi dağılımı, her ülkeye ait yayın sayılarına göre sınıflandırılarak Şekil 4'te dünya haritası üzerinde görselleştirilmiştir. Şekilde sunulan coğrafi dağılım, yayının gerçekleştirildiği ülkenin bilgilerine göre manuel olarak sınıflandırılmış ve Microsoft Excel aracılığıyla görselleştirilmiştir. Bu veriler, VOSviewer analizinden bağımsız olarak oluşturulmuştur. Araştırma kapsamındaki 98 yayının coğrafi dağılımına bakıldığında, bazı ülkelerin 25 yayına kadar katkı sağladığı, bazılarının ise yalnızca 1 yayımla temsil edildiği görülmektedir. Çalışmaların en yoğun şekilde gerçekleştirildiği ülke 25 yayını ile ABD'dir. ABD'yi sırasıyla Birleşik Krallık (16), Almanya (9) ve Çin (8) takip etmektedir.



Şekil 4. Çalışmaların Ülkelere Göre Dağılımı

İncelenen yayınların atıf alma durumları Şekil 5'te gösterilmektedir. Tabloya göre yayınlar arasında en yüksek atıf alan yayın Rao, Gopi ve Maione (2016) yaptığı ‘‘The societal impact of commercial drones’’ isimli makale olmuştur. Bu makalede ticari İHA'ların toplumsal algılarını inceleyerek İHA teknolojisinin güvenlik, gizlilik, hava sahası düzenlemeleri ve hukuki sorumluluk alanlarında yarattığı fırsatları, riskleri ve endişeleri ele almaktadır. İHA'ların ticari ve sivil uygulamalarda kullanımının artması tarım, teslimat, film yapımı gibi alanlarda devrim yaratırken; çarpışma riskleri ve gizlilik ihlalleri gibi endişelere yol açtığı açıklanmaktadır. Düzenleyici çerçevenin yetersizliği, teknolojinin hızıyla aynı oranda ilerlememesi hem işletmeler hem de bireyler için sorunlar meydana getirdiği belirtilmiştir. Çalışma sonuç olarak İHA'ların etkili ve güvenli kullanımı için düzenlemeler, eğitim ve iş birliğinin önemini vurgulamaktadır.



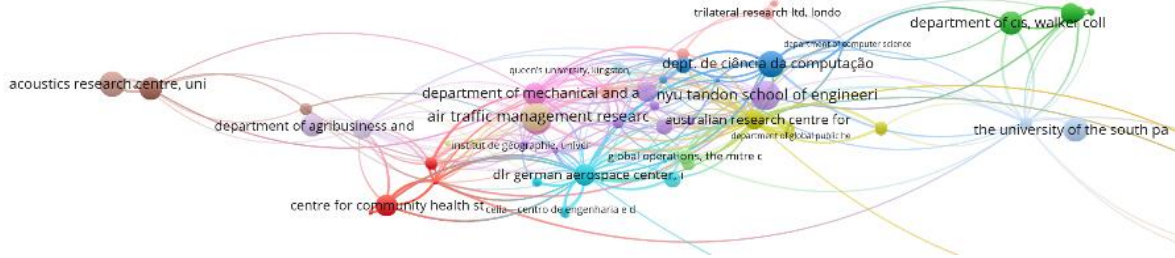
Şekil 5. En çok Atıf Yapılan Yayınlar

Çalışmaların konu alanlarına göre dağılımı Tablo 5’te sunulmuş olup, en fazla yayın Sosyal Bilimler alanında gerçekleştirilmiştir. Bu alanı sırasıyla Mühendislik, Bilgisayar Bilimleri ve İşletme, Yönetim ve Muhasebe izlemektedir. Araştırmamızın odaklandığı yayınlar arasında, en popüler konu alanının Sosyal Bilimler olduğu görülmektedir. Bu bulgular, araştırma topluluğunun hangi disiplinlere daha fazla yayın yapıldığını göstermektedir. Toplumsal dinamikleri ve insan davranışlarını analiz etmede Sosyal Bilimler belirleyici bir role sahiptir. Bununla birlikte, teknolojik gelişmelerle eş zamanlı olarak farklı disiplinler de yönetim ve karar destek sistemlerinin geliştirilmesine katkı sağlamaktadır.

Tablo 5. Seçilen Yayınların Konu Dağılımı

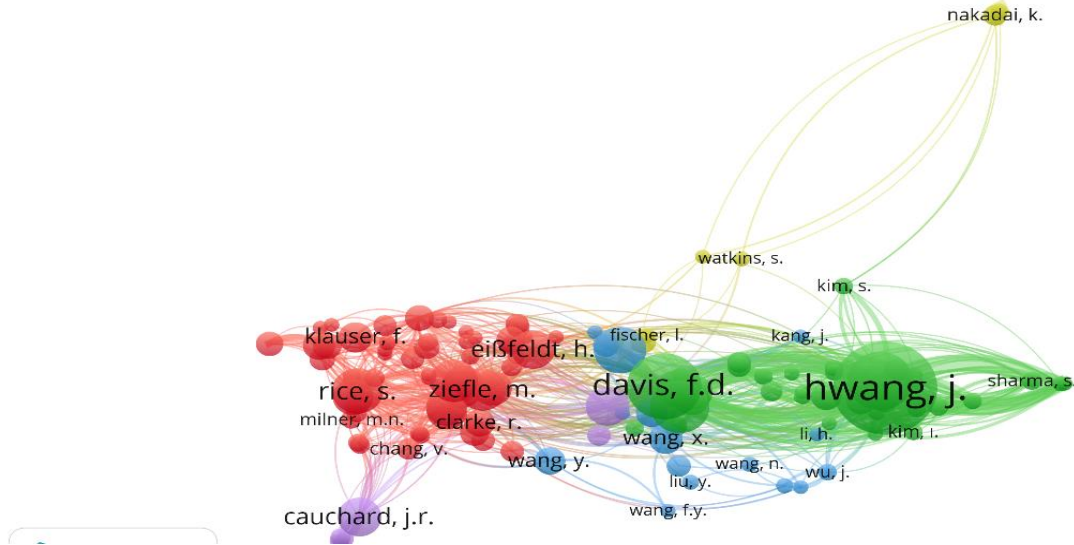
Konu Alanı	Yayın Sayısı
Sosyal Bilimler	41
Mühendislik	34
Bilgisayar Bilimleri	28
İşletme, Yönetim ve Muhasebe	26

Kurumların atıf analizi, bir araştırma alanında hangi kurumların öne çıktığını ve aralarındaki bilimsel etkileşim düzeylerini belirlemeye yardımcı olmaktadır. Bu bağlamda, en fazla atıf alan çalışmaların Salford Üniversitesi, Appalachian State Üniversitesi, Purdue Üniversitesi ve Syracuse Üniversitesi kaynaklı olduğu tespit edilmiştir. Kurumlar arası atıf ağları Şekil 6’da detaylı şekilde gösterilmiştir.



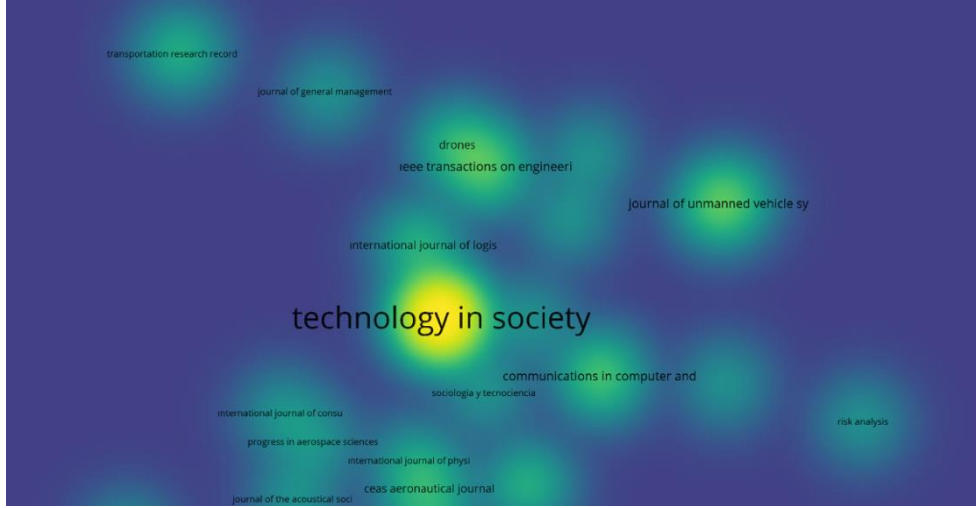
Şekil 6. Kurumların Atıf Bağları

Şekil 7'de sunulan Yazarların Ortak Atıf Analizi (Co-citation of Co-authors), belirli bir araştırma alanında yazarlar arasındaki ilişkileri ve bilimsel etkileşimleri incelemeyi amaçlamaktadır. Aynı yayında birlikte atıf alan farklı kaynaklar, "ortak atıf" (co-citation) olarak tanımlanır. Yapılan analiz sonucunda, en fazla ortak atıf alan yazarlar Hwang, J., Davis, F.D. ve Kim, J.J. olarak belirlenmiştir.



Şekil 7. Yazarların Ortak Atıf Analizi

Şekil 8’de görüldüğü üzere, “**Technology in Society**” dergisi, araştırma alanında en fazla yayına sahip dergi olarak öne çıkmaktadır. Bu dergi, yalnızca teknolojinin toplumsal etkilerini ele alan makalelere değil, aynı zamanda bilim ve teknolojinin entegrasyonu, dijital dönüşüm, sosyal değişim, etik tartışmalar ve yenilikçi düşünce gibi çok disiplinli konulara da ev sahipliği yapmaktadır. Literatürdeki yüksek yayın sayısı ve atıf oranı, derginin alandaki akademik etkisini ve görünürlüğünü ortaya koymaktadır. Bu bağlamda, Technology in Society dergisi, İHA’lara yönelik toplumsal algı gibi teknoloji-toplum etkileşimini konu alan çalışmalarda sıklıkla başvurulacak bir kaynak niteliğindedir.



Şekil 8. Seçilen Çalışmaların Yayınlandığı Dergiler

4. TARTIŞMA VE SONUÇ

Bu çalışma, İHA'lara yönelik toplumsal algı çalışmalarının bibliyometrik incelemesi başlığı altında, İHA ve algı kavramlarına dair literatürün kapsamlı bir nicel analizini sunmayı amaçlamaktadır. Bu sayede İHA'lara yönelik toplumsal algı araştırmalarının genel eğilimleri, yayın sayıları, coğrafi dağılımı, önde gelen yazarlar ve iş birlikleri gibi temel bileşenler ortaya konmuştur. Çalışma ilgili alandaki araştırma dinamiklerini ve gelişim süreçlerini anlamaya yönelik önemli bir kaynak oluşturmayı hedeflemektedir.

Seçilen çalışmaların 2020 itibariyle artış gösterdiği ve 2024 yılına kadar belirli dalgalanmaların yaşandığı gözlemlenmiştir. 2024 yılında çalışmaların zirve yaptığı dönemine ulaşmıştır. 2025 yılında ise bu araştırma ve çalışmaların daha da artması beklenmektedir. Ayrıca, çalışma 2025 yılının ilk aylarını kapsadığı için 2024'ten sonra bir düşüş olduğu yönünde yanılgıya kapılmamak önem taşımaktadır. Dokümanların ortalama yaşı 3,78 ve konuya dair çalışmaların büyüme hızı yıllık %33,99 olması bu fikrin kanıtı niteliğindedir.

Anahtar kelime analizinden elde edilen bulgular, İHA'lara yönelik toplumsal algının özellikle “kabul”, “algı”, “güvenlik”, “risk”, “mahremiyet” ve “teknoloji kabulü” gibi temalar çerçevesinde şekillendiğini ortaya koymaktadır. “Perception (algı)” ve “acceptance (kabul)” gibi kavramların yüksek sıklıkla kullanılması, bireylerin bu teknolojiyi nasıl algıladıklarını ve bu algının benimseme düzeyleri üzerindeki etkilerine işaret etmektedir. Bu durum, bireylerin teknolojiyi benimsemelerinde algılanan fayda, kullanım kolaylığı ve güven unsurlarının belirleyici olduğunu göstermektedir. Özellikle “public perception (toplum algısı)” ve “risk perception (risk algısı)” terimlerinin öne çıkması, İHA'lara yönelik toplumsal kabulün yalnızca bireysel düzeyde değil, kamu güvenliği ve toplumsal değerler perspektifinden de tartışıldığını göstermektedir. Bu çerçevede, İHA teknolojilerinin yalnızca teknik yeterliliğiyle değil, toplumun kültürel kodları, değer sistemi ve güven düzeyiyle de yakından ilişkili olduğu anlaşılmaktadır. Dolayısıyla, İHA'ların yaygın kabul görebilmesi için mühendislik çözümlerinin yanında, toplumsal algı yönetimi ve kamusal iletişim stratejilerinin geliştirilmesi kritik önemdedir.

Gelecekte yapılacak araştırmaların, bu kavramların etkileşimini daha derinlemesine inceleyen disiplinler arası yaklaşımlar içermesi; özellikle karşılaştırmalı, deneysel ve kültürel bağlamı gözeten çalışmalara yönelmesi önerilmektedir.

İHA'lara yönelik toplumsal algı çalışmaları ağırlıklı olarak ABD, Birleşik Krallık, Almanya ve Çin gibi gelişmiş ülkelerde yoğunlaşmaktadır. Bu durum, bu ülkelerin teknoloji ve sosyal etkiler alanında daha fazla kaynak ayırdığını gösterirken, gelişmekte olan ülkelerdeki toplumsal algı dinamiklerinin yeterince incelenmediğini ortaya koymaktadır. Coğrafi çeşitliliğinin sınırlı olması, farklı kültür ve sosyoekonomik yapılarla İHA algısının anlaşılması için karşılaştırmalı çalışmaların ve uluslararası iş birliklerinin artırılması gerekliliğine işaret etmektedir. Bu nedenle, gelecek araştırmaların bölgesel farklılıkları göz önünde bulundurarak, İHA teknolojilerinin toplumsal etkilerini daha kapsamlı değerlendirmesi önemlidir.

İHA'lara yönelik toplumsal algı çalışmalarının konu dağılımı incelendiğinde, en fazla yayın Sosyal Bilimler alanında yoğunlaşmaktadır. Bu durum, İHA teknolojilerinin toplumsal kabulü, algısı ve insan davranışları üzerindeki etkilerinin anlaşılmasında sosyal bilimlerin kritik bir rol oynadığını göstermektedir. Sosyal bilimlerin yanı sıra mühendislik, bilgisayar bilimleri ve işletme yönetimi gibi disiplinli bir yaklaşım gerektirdiğini ortaya koymaktadır; teknolojik gelişmelerin teknik boyutlarının yanı sıra, bu teknolojilerinin yönetim süreçleri ve insan faktörü üzerindeki etkileri de eş zamanlı olarak ele alınmaktadır. Bu bağlamda, İHA teknolojilerinin toplumsal entegrasyonunda disiplinler arası iş birliğinin artırılması, araştırmaların kapsamını ve uygulama alanlarını genişletmek adına önem taşımaktadır. Gelecekte özellikle sosyal bilimlerin rehberliğinde, teknik disiplinlerle birlikte yürütülecek çalışmaların artması, İHA'ların toplumsal kabulünün ve sürdürülebilir kullanımının sağlanmasına katkı sunacaktır.

Yazarların ortak atıf analizleri, İHA'lara yönelik toplumsal algı alanında Hwang, J., Davis, F.D. ve Kim, J.J. gibi belirgin araştırmacıların öncü rol oynadığını göstermektedir. Bu durum, alanda güçlü bir teorik altyapının ve bilgi paylaşımının varlığını ortaya koyarken, aynı zamanda daha geniş disiplinler arası iş birliklerinin ve yeni perspektiflerin gelişmesine olanak tanıma ihtiyacını da vurgulamaktadır. Öte yandan, "Technology in Society" dergisinin bu alanda en fazla yayına sahip platform olması, İHA teknolojilerinin toplumsal etkilerinin sosyal ve kültürel boyutlarının anlaşılması açısından bu tür disiplinler arası odaklarının önemini göstermektedir. Bu bağlamda, alandaki öncü dergilerin ve araştırmacıların desteklenmesi; yeni katılımcıların teşvik edilmesi ve disiplinler arası çalışmaların artırılması, İHA'ların toplumsal kabulü ve entegrasyonunun daha kapsamlı bir şekilde ele alınmasına katkı sağlayacaktır.

İHA teknolojisi hâlen gelişmekte olan bir alan olup, bu durum söz konusu teknolojiye ilişkin bilimsel araştırmalarda belirgin bir artışa yol açmaktadır. Hem teknik hem de toplumsal boyutlarıyla çok disiplinli bir araştırma alanı hâline gelen İHA'lar, özellikle son yıllarda artan kullanımıyla birlikte daha fazla akademik ilgi görmeye başlamıştır. Bu bağlamda, alandaki mevcut bilgi birikimini sistematik biçimde değerlendirmek ve gelecekte yapılacak araştırmalara veri temelli bir zemin sunmak amacıyla bibliyometrik analiz yöntemi tercih edilmiştir. Bu analizle, literatürdeki yayın eğilimleri, konu dağılımları, coğrafi katkılar ve

öne çıkan araştırma temaları gibi nicel veriler ortaya konularak, ileride yürütülecek akademik çalışmalara yön gösterecek bir kaynak oluşturulması hedeflenmiştir.

KAYNAKÇA

- Altıntaş, O. A., Açıklık, B. ve Turhan, U. (2024). Evaluation of the studies on unmanned aircraft system safety management systems with bibliometric analysis. *Journal of Aviation Research*, 6(2), 132-148.
- Arslan, E. (2022). Sosyal bilim araştırmalarında VOSviewer ile bibliyometrik haritalama ve örnek bir uygulama. *Anadolu Üniversitesi Sosyal Bilimler Dergisi*, 22 (Özel Sayı 2), 33-56.
- Bakır, M., Özdemir, E., Akan, Ş. ve Atalık, Ö. (2022). A bibliometric analysis of airport service quality. *Journal of Air Transport Management*, 104, 102273.
- Burak, M. F. ve Küsbeci, P. (2024). Internet of things and aviation: A bibliometric and visualization analysis. *Kybernetes*, 53(11), 4502-4521.
- Del-Real, C. ve Díaz-Fernández, A. M. (2021). Lifeguards in the sky: Examining the public acceptance of beach-rescue drones. *Technology in Society*, 64, 101502.
- Dereli, A. B. (2024). Vosviewer ile bibliyometrik analiz. *Communicata*, (28), 1-7.
- Dinçer, F. C. Y., Yirmibeşoğlu, G., Bilişli, Y., Arık, E., ve Akgün, H. (2024). Trends and emerging research directions of sustainable aviation: A bibliometric analysis. *Heliyon*, 10(11), e32306.
- Dirik, D., Eryılmaz, İ. ve Erhan, T. (2023). Post-truth kavramı üzerine yapılan çalışmaların VOSviewer ile bibliyometrik analizi. *Sosyal Mucit Academic Review*, 4(2), 164-188.
- Dixit, A. ve Jakhar, S. K. (2021). Airport capacity management: A review and bibliometric analysis. *Journal of Air Transport Management*, 91, 102010.
- Durak, M. Ş. (2024). Havayolu Sektöründeki Stratejik Eğilimler: Bibliyometrik Bir İnceleme. *İşletme Araştırmaları Dergisi*, 16(4), 2116-2131.
- Eißfeldt, H., Vogelpohl, V., Stolz, M. ve diğerleri (2020). The acceptance of civil drones in Germany. *CEAS Aeronautical Journal*, 11, 665–676.
- Falcão, V. A., da Silva, F. G. F., de Oliveira, F. H. L., Negri, N. A. R., de Andrade, M. O., Brasileiro, A., ... ve Macário, R. (2021). Scientific investigations in air transport about Brazil: A bibliometric review. *Case Studies on Transport Policy*, 9(4), 1912-1921.
- Florido-Benítez, L. (2023). A bibliometric overview of the international airports and airlines 'IAA' topic in journals and scientific community. *Logistics*, 7(3), 35
- Google Scholar. (2025). *Google Scholar*. Erişim adresi: <https://scholar.google.com>
- Komasová, S., Tesař, J. ve Soukup, P. (2020). Perception of drone-related risks in Czech society. *Technology in Society*, 61, 101252.
- Kumar, T. P., ve Dulloo, R. (2024, Şubat). *Sustainability in aviation industry—A bibliometric analysis*. In 3rd International Conference on Reinventing Business Practices, Start-ups and Sustainability (ICRBSS 2023) (ss. 848–857). Dordrecht: Atlantis Press.
- Le, N. T. C. (2024). Voluntary carbon offsets in sustainable aviation research: A bibliometric analysis. *Transportation Research Procedia*, 80, 119-126.
- Li, X., Tang, J., Li, W., Si, Q., Guo, X. ve Niu, L. (2023). A bibliometric analysis and visualization of aviation carbon emissions studies. *Sustainability*, 15(5), 4644.
- Martinez, O. A. ve Cardona, M. (2018, Ağustos). *State of the art and future trends on unmanned aerial vehicles*. In 2018 International Conference on Research in Intelligent and Computing in Engineering (RICE) (pp. 1-6).
- Okine, E. A., Zarei, E. ve Roggow, B. J. (2024). Exploring the intellectual insights in aviation safety research: A systematic literature and bibliometric review. *Safety Science*, 170, 106354.

- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... ve Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372.
- Rao, B., Gopi, A. ve Maione, R. (2016). The societal impact of commercial drones. *Technology in Society*, 45, 83-90.
- Raza, S. A., Ashrafi, R. ve Akgunduz, A. (2020). A bibliometric analysis of revenue management in airline industry. *Journal of Revenue and Pricing Management*, 19, 436-465.
- Rice, S., Tamilselvan, G., Winter, S. R., Milner, M. N., Anania, E. C., Sperlak, L. ve Marte, D. A. (2018). Public perception of UAS privacy concerns: A gender comparison. *Journal of Unmanned Vehicle Systems*, 6(2), 83-99.
- Sabino, H., Almeida, R. V., de Moraes, L. B., da Silva, W. P., Guerra, R., Malcher, C. ve Passos, F. G. (2022). A systematic literature review on the main factors for public acceptance of drones. *Technology in Society*, 71, 102097.
- Scopus. (2025). *Scopus*. Eriřim adresi: <https://www.scopus.com>
- See, K. F., Ülkü, T., Forsyth, P. ve Niemeier, H. M. (2023). Twenty years of airport efficiency and productivity studies: A machine learning bibliometric analysis. *Research in Transportation Business & Management*, 46, 100771.
- Sorsa, K. ve Bona-Sánchez, C. (2024). Corporate social responsibility trends in the airline industry: A bibliometric analysis. *Sustainability*, 16(7), 2709.
- Tanrıverdi, G. ve Durak, M. Ş. (2022). A visualized bibliometric analysis of mapping research trends of airline business models (ABMs) from 1985 to 2021. *Journal of Aviation*, 6(3), 387-403.
- Tepylo, N., Straubinger, A. ve Laliberte, J. (2023). Public perception of advanced aviation technologies: A review and roadmap to acceptance. *Progress in Aerospace Sciences*, 138, 100899.
- Uzgör, M., Savaş, S. A. ve Kafalı, H. (2024). Bibliometric analysis of environmental management literature in aviation. *Transportation Research Record*, 2678(8), 374-395.
- Wang, N., Mutzner, N. ve Blanchet, K. (2023). Societal acceptance of urban drones: A scoping literature review. *Technology in Society*, 102377.
- Web of Science. (2025). *Web of Science*. Eriřim adresi: <https://www.webofscience.com>



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Current Human Factors Approaches in Aircraft Maintenance Sector: Transformation of Dirty Dozen into Filthy Fifteen

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Abstract

In the early 1990s, aircraft accidents caused by human factors in aircraft maintenance tasks became an important agenda item in the aviation sector. In this context, as a result of studies conducted by Transport Canada employee Gordon Dupont and his teammates in 1993, twelve human factors that caused aircraft maintenance workers to make mistakes were identified, and these factors were named the Dirty Dozen. In the long process from the emergence of the Dirty Dozen model to the present day, there have been organizational and technological changes worldwide that could affect the performance of aircraft maintenance workers. For this reason, in recent years, it has been observed that some of the world's leading aircraft maintenance organizations have been using new approaches in human factors training. One of these new approaches is the Filthy Fifteen model put forward by Hawker Pacific Aerospace. However, it is seen that the studies in the literature on the Filthy Fifteen are extremely limited. In this context, the aim of this study, which is carried out theoretically, is to first examine the Dirty Dozen model, which is integrated with the concept of human factors in the aircraft maintenance sector, then to examine in detail the theoretical structure of the Filthy Fifteen model, which expands the Dirty Dozen, and to discuss the current human factors that can be added to the Filthy Fifteen model in the conclusion section. It is thought that the study will make an original contribution to the literature on human factors in the aircraft maintenance sector.

Key Words: Filthy Fifteen, Dirty Dozen, Aircraft Maintenance, Human Factors, Aviation

JEL Classification: M10, M14, M19

Uçak Bakım Sektöründe Güncel İnsan Faktörleri Yaklaşımları: Kirli Düzinenin Kirli Onbeş'e Dönüşümü

Öz

1990'lı yılların başında uçak bakım görevlerinde insan faktörlerinden kaynaklı uçak kazaları havacılık sektöründe önemli bir gündem olmuştur. Bu kapsamda 1993 yılında Transport Kanada çalışanı Gordon Dupont ve takım arkadaşları tarafından yapılan çalışmalar sonucunda uçak bakım çalışanlarının hata yapmasına neden olan on iki insan faktörü tespit edilmiş ve bu faktörlere Kirli Düzine adı verilmiştir. Kirli Düzine modelinin ortaya çıkmasından günümüze kadar geçen uzun süreç içinde uçak bakım çalışanlarının performanslarını etkileyebilecek dünya çapında örgütsel ve teknolojik değişimler yaşanmıştır. Bu nedenle son yıllarda dünyanın önde gelen bazı uçak bakım organizasyonlarının insan faktörleri eğitiminde yeni yaklaşımlar kullandığı görülmektedir. Bu yeni yaklaşımlardan biri Hawker Pacific Aerospace firması tarafından öne sürülen Kirli On Beş modelidir. Ancak Kirli On Beş ile ilgili literatürdeki çalışmaların son derece sınırlı olduğu görülmektedir. Bu kapsamda teorik olarak yürütülen bu çalışmanın amacı, öncelikle uçak bakım sektöründe insan faktörleri kavramıyla bütünleşmiş olan Kirli Düzine modelini ele almak; sonra Kirli Düzineyi genişleten Kirli On Beş modelinin teorik yapısını detaylı olarak incelemek ve sonuç kısmında Kirli On Beş modeline eklenebilecek güncel insan faktörlerini tartışmaktır. Çalışmanın uçak bakım sektöründe insan faktörleri ile ilgili literatüre özgün bir katkı yapacağı düşünülmektedir.

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Anahtar Kelimeler: Kirli On Beş, Kirli Düzine, Uçak Bakım, İnsan Faktörü, Havacılık

JEL Sınıflandırma: M10, M14, M19

INTRODUCTION

The aviation sector, which is an important part of the transportation sector worldwide, is growing in line with globalization and technological developments. The aviation sector has a respected place in the eyes of countries today as it allows people and cargo to be transported faster and safer than before (Çoban, 2019). By its nature, all operations in the aviation sector are carried out within the framework of international rules. Therefore, safety is an indispensable requirement in aviation operations. Aviation safety defines the conditions required for activities in the sector to take place in an environment where all risks are defined and minimized (Gerede, 2005). Thanks to the strict safety rules applied, air transportation has become the most reliable type of transportation worldwide today (Koornneef, Verhagen & Curran, 2016).

The aircraft maintenance sector is an important sector that directly contributes to the timely and safe performance of flight operations in airline transportation. Aircraft maintenance tasks, which are an integral part of the aviation sector, are carried out within a complex system that includes many inputs such as people, materials and technology (Çoban, 2017). Maintenance technicians, who perform many different and difficult tasks, often have to work in teams and communication. The main task of aircraft maintenance technicians is to keep aircraft in a flight-worthy condition at all times (FAA, 2008). Maintenance technicians are at the center of aircraft maintenance tasks. Technicians perform different tasks such as maintenance, repair, control, troubleshooting and revision on mechanical and avionic systems. Maintenance technicians can work in groups in closed maintenance hangars or they can work alone in dynamic and riskier environments such as flight lines (Zaharevitz, 1980).

It is possible to constantly encounter serious incidents and accidents during sectoral commercial activities around the world. As a result of these accidents, many people lose their lives or are injured. In addition, commercial enterprises suffer serious financial losses (Ergai, Cohen, Sharp, Wiegmann, Gramopadhye & Shappell 2016). When the causes of accidents in the aviation sector are examined; it is seen that accidents are caused by the interaction of environmental, technological, organizational and human factors. Technological factors that cause aircraft accidents refer to technical malfunctions in a system or part. Conditions such as weather conditions, noise, heat and lighting are included in environmental factors. Factors such as inadequate procedures, lack of training, communication problems and management style are some of the organizational factors that cause accidents (Reason, 1990).

Human factors in aviation, as a concept directly related to the job performance of aviation employees, brings a systematic perspective to aviation safety (Lyssakov & Lyssakova, 2019). Human factors is an interdisciplinary concept that attempts to examine how people interact with equipment, physical environment, organizational rules and other people in the same environment in work. As in most sectors, in the aviation sector, where the concepts of safety and security are extremely important, the concept of human factors is directly related to the performance of employees. Understanding the human factors that cause accidents

continues to be one of the biggest challenges of the aviation sector (Reason, 1990). Today, while the number of accidents caused by technological factors has decreased, the number of accidents caused by human factors has increased significantly and constitutes more than 80% of total accidents (Piwek, 2018).

Aircraft maintenance tasks are aviation activities that are mostly carried out under difficult working conditions and time pressure due to commercial concerns of airline companies and have the potential to produce many errors (Reason & Hobbs, 2003). The performance of aircraft maintenance workers is greatly affected by the scope of the task and the design of the parts to be maintained. In terms of aviation safety, maintenance errors may not be seen until the system or part being maintained fails. However, these maintenance errors, which are mostly hidden, can later cause aircraft accidents that can lead to serious loss of life and property. In 1988, the disintegration of the fuselage of a Boeing 737 commercial passenger aircraft belonging to Aloha Air in Hawaii during flight revealed that errors caused by human factors in the aircraft maintenance sector can have fatal consequences (Çoban, 2017).

After the Aloha Air accident, studies on human errors in aircraft maintenance tasks have increased worldwide since the early 1990s. The most striking of these studies is the “**Dirty Dozen**” model developed by Gurdon Dupont, who worked at Transport Canada in 1993 (Çoban & Aydoğdu, 2020). According to this model, there are 12 basic human factors that cause aircraft maintenance workers to make mistakes (Dupont, 1997). Over time, the Dirty Dozen has been accepted worldwide as a convenient and easy method for explaining human errors not only in the aircraft maintenance sector but also in other sectors.

More than thirty years have passed since the emergence of the Dirty Dozen model in the 1990s, and during this long process, organizational and technological changes have occurred worldwide that may affect the performance of aircraft maintenance workers. It is seen that these changes have been reflected in the human factors training curricula of some of the world's leading maintenance and repair training organizations in recent years. Therefore, it is possible to see human factors approaches that expand the Dirty Dozen model in recent years. One of these new approaches is the “**Filthy Fifteen**” model proposed by Hawker Pacific Aerospace (HPA) in 2016. However, it is seen that the studies in the literature on Filthy Fifteen are extremely limited.

Based on this gap in the literature, this study sought an answer to the question “*What is the content of the Filthy Fifteen model, which expands the Dirty Dozen model in the aircraft maintenance sector today, but has limited literature?*” with the theoretical review method. Theoretical reviews are studies that aim to contribute to the literature by systematically and impartially scanning, evaluating and synthesizing studies conducted on the same subject to find an answer to the research question determined on a specific subject (Çınar, 2021). The basic stages of theoretical review studies, which require a preparation process similar to research articles, are as follows in terms of method: Determining the research question and purpose, conducting a literature review from the specified databases, evaluating the data obtained from the literature, and analyzing and interpreting the findings. A classic theoretical review study has three main sections: introduction, literature review and evaluation, discussion and conclusion (Özer & Görgülü, 2020).

In this context, the study first examined the Dirty Dozen model, which is integrated with the concept of human factors in the aircraft maintenance sector, by scanning the Scopus, Web of Science, EBSCO and Google Scholar databases between September and December 2024. Then, the theoretical structure of the Filthy Fifteen model, which expands the Dirty Dozen, was examined in more detail. In the discussion and conclusion section, a discussion was made on the existing human factors that could be added to the Filthy Fifteen model, and suggestions were made for future studies. To ensure the reliability and validity of the study, the findings obtained from the literature review were presented to the reader by the researcher in an unbiased, transparent and systematic manner in line with experts' opinions in the fields of aviation and aircraft maintenance.

1. DIRTY DOZEN IN THE AIRCRAFT MAINTENANCE SECTOR

The increase in accidents and incidents caused by aircraft maintenance errors in the late 1980s and early 1990s was a notable development in the aviation industry worldwide. In 1993, during a period when aircraft maintenance errors came to the fore, Gordon Dupont, an aircraft maintenance engineer at Transport Canada, and his teammates examined nearly 2,000 incident and accident reports that had occurred in the aircraft maintenance sector in previous years due to human errors. Dupont's study was also contributed to by the Canadian Department of Defense, the Royal Canadian Air Force and members of an industry liaison committee. As a result of their seven-month study, Dupont and his teammates revealed the 12 most common human factors that cause employees in the aircraft maintenance sector to make errors and named all of these factors the Dirty Dozen (Mellema, 2018).

At the end of this study, Dupont suggested that the errors made by aircraft maintenance workers were mostly related to one or more factors in the Dirty Dozen. Dupont also stated that there was a series of safety nets related to each factor that made up the Dirty Dozen. *Safety nets are practices or procedures designed to reduce the probability of any factor turning into an actual incident or accident.* The Dirty Dozen made a big splash in the aviation industry at the time it was released. The human factors that make up the Dirty Dozen are presented in Table 1.

Table 1. Dirty Dozen in Aircraft Maintenance Sector

1	Lack of Communication	7	Lack of Resources
2	Complacency	8	Pressure
3	Lack of Knowledge	9	Lack of Assertiveness
4	Distraction	10	Stress
5	Lack of Teamwork	11	Lack of Awareness
6	Fatigue	12	Norms

Source: (Dupont, 1997).

Due to the increase in aircraft accidents due to maintenance errors worldwide, Dr. Bill Shepherd, an FAA officer, initiated a series of meetings in the early 1990s to investigate human factors-related problems in aircraft maintenance operations. In these meetings held between 1993 and 1997, Dupont presented the Dirty Dozen to an international consortium jointly supported by the USA, Canada and the UK (Dupont, 1997). The Dirty Dozen quickly

became widely accepted as a framework for examining aircraft maintenance worker errors in the aviation industry worldwide in the period following 1997 and spread rapidly. Within just a few years, Dirty Dozen posters adorned the walls of many aircraft maintenance facilities in and outside the USA and Canada. The Dirty Dozen was approved and included in the publications of world-renowned aviation authorities such as the Federal Aviation Administration (FAA), European Aviation Safety Agency (EASA), Australian Civil Aviation Safety Authority (CASA) and Transport Canada. During this period, the FAA defined the Dirty Dozen as *“twelve human factors that reduce the ability of people to perform safely and effectively in maintenance operations and that can lead to errors.”* The Dirty Dozen comprised most of the human factors section of the FAA’s Aircraft Maintenance Technician Handbook (FAA, 2008). In addition, the Dirty Dozen has become a part of the basic human factors training conducted by the world’s leading aircraft maintenance training organizations such as Delta TechOps, Lufthansa Technik, and Aveos. The rapid spread of the Dirty Dozen in the aircraft maintenance sector was due to the idea that it was based on scientific data and experience, along with effective marketing methods (posters, etc.) (Mellema, 2018).

Compared to the models developed for human factors adopted by the aviation industry, such as Edwards’ (1988) SHEL Model, Reason’s (1990) Swiss Cheese Model, Human Factors Analysis and Classification System-Maintenance Extension (HFACS-ME), Boeing’s Maintenance Error Decision Aid (MEDA), Maintenance Line Operations Safety Assessments (M-LOSA), and the intensive research behind these models, the origin and development of Dupont’s Dirty Dozen may be more modest. Although scientific studies that take the aircraft maintenance sector as an example regarding all or part of the human factors that make up the Dirty Dozen (Latorella & Prabhu, 2000; Hobbs & Williamson, 2003; Patankar & Taylor, 2008) are limited in the literature, there are scientific studies in the healthcare sector that reveal that the Dirty Dozen contributes to the solution of human performance problems in complex and highly technical surgical areas (Marquardt, Treffenstadt, Gerstmeyer & Gades-Buettrich 2015; Mellema, 2018). Despite the limitations of the Dirty Dozen regarding its scientific aspect, it is possible to say that it presents a logical and easy model to explain the mistakes and violations made by aircraft maintenance workers worldwide and therefore is closely identified with the aircraft maintenance culture. The twelve basic human factors that make up the Dirty Dozen are explained below in order.

1.1. Lack of Communication

Communication refers to the process of transferring a message or information from a sender to the target receiver. For effective communication, both the sender and the receiver must have communication skills. Communication skills include verbal behaviors such as using the right words at the right time, active listening, appropriate tone of voice and choice of communication tool, as well as body language such as gestures, facial expressions, gazes and written communication (Chatzi, Martin, Bates & Murra, 2019). Communication, which is effective in social interactions between individuals in every area of life, is also one of the most important tools for effective and safe organizational performance and preventing stress in teamwork in business sectors that carry out complex operations, involve constant risk and

work under high pressure (Vieria, Santos & Kubo, 2014). Communication is at the focal point of teamwork as one of the most important components that provide the connection between people, systems, processes, structures and technology in all sectors (Dickinson & McIntyre, 1997). A lack of communication refers to the failure to communicate, receive, and provide the information needed to complete a task. A lack of communication occurs when individuals have misperceptions about what is being said or done (Shorrocks, 2007). Effective communication is an essential element for the safety and security of aviation operations. Therefore, all aviation personnel have the responsibility to communicate effectively. Otherwise, a lack of communication can lead to disasters in aviation operations (Vieria et al., 2014).

Lack of communication is a significant human factor that can lead to faulty or inadequate maintenance. Maintenance technicians may be in contact with many employees, such as the pilot, ground handling workers, and spare part suppliers, while performing their duties. There is a potential for misunderstandings or breakdowns in communication with these employees. However, communication gaps, especially when more than one maintenance technician is working on an aircraft as a team, are riskier and can result in a maintenance error or aircraft accident (FAA, 2008). Shift change is a critical process in the aircraft maintenance sector where communication problems can occur. Often, a partially completed maintenance task during a shift is transferred from the technician who finished the job at the end of the shift to the technician who is coming to the next shift. Lack of communication that may occur during shift handovers can be seen verbally, in writing, or a combination of the two. For example, failure to communicate with the team coming to the day shift about an unfinished task during the night shift may cause technicians coming to the shift to assume that a task that was not done has been done (Dupont, 1997). Some studies in the literature show that written communication during maintenance tasks may cause more errors than verbal communication. This is because it is easy to obtain any explanation from the other party in verbal communication, but more difficult in written communication (Shukri, Millar, Gratton & Garner 2016)

As a precaution against communication deficiencies; maintenance technicians should communicate effectively with each other; never assume anything, always consult with teammates and provide feedback that messages are received and understood; keep written records to eliminate doubts about maintenance tasks; communicate to each other the tasks to be done and completed through briefings and discuss them if necessary (Dupont, 1997). In addition, during shift and task changes, continuing a task started by someone else after a face-to-face meeting, if possible, reviewing the steps related to the operations performed with checklists and always performing tasks according to approved maintenance procedures can prevent communication deficiencies (FAA, 2008).

1.2. Complacency

Complacency can be defined, in general terms, as a temporary or long-term psychological condition that causes a decrease in attention, alertness and awareness of dangers in an individual due to the confidence and satisfaction that an individual feels in himself (Dekker, 2003). Complacency is an insidious human factor that can cause judgment errors in

technicians due to the constant repetition of many maintenance tasks and controls (Dupont, 1997). Complacency is a condition that develops over time in the aircraft maintenance sector. As a maintenance technician gains knowledge and experience over time, his self-confidence and satisfaction with himself and his performance will develop. If a technician does not record the work he has done during a maintenance task or signs a task that he has not done, this is a sign of complacency. Especially in repetitive and control-based tasks, if the technician fails to find a fault several times, this may cause him to become self-confident and complacent in subsequent tasks. In such cases, the maintenance technician may think that the relevant procedure is not important, and some malfunctions and faults may be overlooked. Failure to detect the malfunction may cause an accident (FAA, 2008). Fatigue may also affect the individual's complacency behavior. For example, technicians who are tired after long maintenance tasks may gradually decrease their probability of noticing stimuli or faults in the visual fields, and this may delay the technicians' reaction times (Petrilli, Roach, Dawson & Lamond, 2006).

As a precaution against complacency in maintenance tasks; the maintenance technician should always comply with approved maintenance procedures, use checklists, train himself to find errors or faults in control tasks, focus mentally on his task, give equal importance to all control elements; never assume undone or unchecked work, never sign for these works, and learn from the mistakes of others (Dupont, 1997; FAA, 2008).

1.3. Lack of Knowledge

In the aviation sector, aircraft and the systems and equipment that support the operation of these vehicles are extremely complex and integrated. Therefore, maintenance technicians can't perform their duties effectively and safely without basic technical training, sufficient experience and current information based on documents. In addition, due to rapidly changing technology, there is a risk that technicians' technical knowledge may become outdated. In this context, lack of knowledge is a human factor that can cause errors and violations due to differences in aircraft technologies, inability to follow updates in airworthiness and maintenance procedures (EASA, 2015). In today's constantly changing world, maintenance technicians must have the necessary knowledge about the tasks they perform. Otherwise, lack of knowledge can lead the technician to misinterpret current situations and make unsafe decisions (FAA, 2008). When lack of knowledge is combined with the "***I can do this***" self-confidence of most maintenance technicians, more serious and risky results can occur (Dupont, 1997).

Different precautions can be taken against the lack of knowledge factor that may cause incorrect behaviors in maintenance technicians. First of all, receiving training on the subject in which there is a deficiency seems to be the most basic precaution against a lack of knowledge (Nzelu, Chandrahan & Pereira, 2018). In addition, performing all maintenance tasks according to approved and current maintenance documents; consulting a technician who has experience in the maintenance task in question in cases of doubt; contacting the representative of the aircraft manufacturer if there is no experienced technician; constantly emphasizing professional development; sharing your knowledge with your colleagues; avoiding working on assumptions and memorization can prevent errors and violations that

may arise from lack of knowledge (Dupont, 1997; EASA, 2015). *Rather than causing an incident or accident by performing a maintenance task incorrectly due to a lack of knowledge, delaying that task may be a more logical course of action for a technician.*

1.4. Distraction

Distraction is a situation that takes the individual away from the task they are doing, even for a moment, and can be caused by anything. Our minds work faster than our hands. Therefore, a distracting factor can quickly distract an individual from the work they are doing (Nzeli et al., 2018). Distraction is a human factor that causes a technician to leave their job both physically and mentally for any reason and is responsible for approximately 15% of all maintenance errors (Dupont, 1997). Distracting factors are inevitable in the work environment where aircraft maintenance tasks are performed. These factors can disrupt the maintenance process and cause the technician to miss details. Distracting factors can occur in physical and mental forms. For example, high noise levels in the maintenance hangar, requests for assistance from other technicians, a new aircraft being pulled into the hangar, and safety issues that require urgent attention, as well as administrative tasks, social conversations, or even responding to a phone call from the technician's wife can cause distraction (EASA, 2015). Regardless of the work environment, personal situations that are difficult to resolve, such as a family or financial problem, can also constantly occupy the technician's mind while working, causing distraction and inefficient maintenance tasks.

By nature, a technician should be aware of the many distractions that occur during an aircraft maintenance task and should take precautions against this situation. First, when attention is distracted, it is a logical practice to go three steps back from the task being performed and start from that point. It is useful to use a detailed written procedure and to sign only the tasks that have been completed, and to mark the place where the task was left off when leaving the task due to distraction (FAA, 2008). A technician should be aware that a disconnected part is a sign that the job was not completed. Similarly, when a part is installed in maintenance tasks, other technicians who perform that task tend to think that the job is done. In such cases, the installed part should be given sufficient torque and, if necessary, tied with a safety wire to avoid erroneous results. This practice will show that the maintenance task has been done correctly up to that point.

1.5. Lack of Teamwork

Teamwork can be defined as the coming together of managers and employees in an organization to perform their duties in line with the determined organizational goals (Ergün & Eyisoy, 2018). Common goals, mutual effective communication, structured relationships, leadership style, trust and common values are indispensable elements for effective and successful performance of teams (Proehl, 1996). In this context, lack of teamwork refers to the failure of a team to achieve the determined goals (Mellema, 2018). Since many tasks in aviation depend on teamwork, a single employee cannot be held solely responsible for the results of all tasks. An employee who does not contribute to teamwork can lead to unsafe situations. For this reason, for the tasks to be performed for their purpose, each member of the team must trust and support each other (<https://skybrary.aero>).

As in every field of aviation, many different and complex tasks in the aircraft maintenance sector require the teamwork of maintenance technicians within the framework of certain rules. Therefore, maintenance tasks that directly and significantly contribute to a safe flight operation must be performed in communication and based on teamwork (Çoban, 2017). In particular, information sharing between technicians, coordination of maintenance tasks, shift change process, and troubleshooting tasks in aircraft, together with the flight crew, are important maintenance activities that require teamwork. Therefore, teamwork is an important phenomenon inherent in maintenance tasks (CAP 715, 2002). Since lack of teamwork is directly related to lack of communication, it is an important human factor that can cause incorrect behavior in maintenance tasks (Dupont, 1997). The primary duty of maintenance technicians is to ensure the airworthiness of the aircraft. In this respect, airworthiness can be achieved by all maintenance technicians working as a team towards a common goal. Lack of teamwork can lead to faulty communication, which can complicate maintenance tasks and negatively impact aircraft airworthiness (FAA, 2008).

Team members should know how each other works, their performance levels, their strengths and weaknesses, and support each other when necessary to prevent maintenance errors that may arise from a lack of teamwork. To produce a fast and coordinated solution to problems, the roles and responsibilities of team members must be clearly defined (Nzeli et al., 2018). In addition, it should be ensured that the assigned tasks are accepted by each team member; communication between team members should be kept open, and the workload should be distributed equally within the team (Dupont, 1997).

1.6. Fatigue

Fatigue is a natural response of the human body to long-term physical and mental stress. Fatigue can be physical or mental (EASA, 2015). Fatigue is a human factor that does not immediately manifest itself. Because an employee usually does not realize that he is tired until it becomes excessive (Dupont, 1997). Fatigue can occur as a result of difficult physical work, intense focus on a task, emotional concentration or an overwhelming need for sleep. An individual can be said to be tired if there is a decrease or deterioration in any of their cognitive abilities, decision-making, reaction time, coordination, strength and balance abilities. Fatigue reduces alertness and the ability of the individual to focus and pay attention to the work he is doing (FAA, 2008). Maintenance technicians are at risk of fatigue due to reasons such as working night shifts, long and irregular task periods, complex tasks, sleep problems due to working conditions and stress (Hobbs, Avers & Hiles 2011). A tired maintenance technician may have symptoms such as short-term memory problems, lack of situational awareness, distraction, abnormal mood swings, poor judgment, and a decrease in performance standards. When these symptoms are seen, the maintenance technician is likely to make mistakes (FAA, 2008).

To prevent errors and violations that may arise from fatigue in the aircraft maintenance sector, the Fatigue Risk Management System (FRMS) is increasingly gaining attention from international organizations, national aviation authorities, airline companies and maintenance organizations. FRMS can be applied alone or as part of the Safety Management System (FAA, 2010). Within the scope of FRMS, inefficient periods, especially during maintenance

tasks performed during the night shift, should be determined by taking into account the reality of the circadian rhythm and long and tiring shifts that may cause maintenance technicians to make mistakes should be avoided (Çoban, 2019). As in all living things, physical, mental and behavioral changes seen in humans occur in a cycle. This cycle is called the circadian rhythm. Circadian rhythm affects many physical and mental variables such as body temperature, blood pressure, heart rate, attention, and alertness. Since the circadian rhythm drops from 2 a.m. to the early hours of the morning, it is extremely dangerous to perform during these hours. Therefore, planning complex and tiring maintenance tasks that are contrary to the circadian rhythm can lead to accidents (FAA, 2008; Çoban, 2019).

It is not a realistic goal to reduce fatigue to zero during maintenance tasks. What is important is to keep the risks of fatigue as low as possible (Stewart & Holmes, 2008). In addition, being aware of the symptoms of fatigue that occur in both yourself and your teammates during maintenance tasks, planning critical and complex tasks according to your circadian rhythm, sleeping and exercising regularly, and asking your teammates to help you control yourself during complex tasks are important measures to combat fatigue (Dupont, 1997). The main cause of fatigue is a lack of sleep. Therefore, adequate and restful sleep, free from drugs or alcohol, is a human necessity to prevent fatigue (FAA, 2008).

1.7. Lack of Resources

The main task of aircraft maintenance technicians in the aviation sector is to keep the aircraft in a commercial aircraft fleet well-maintained at all times. To perform this task safely, maintenance technicians need different resources. Resources such as labor, time, tools, equipment, and maintenance documents are vital for the performance of maintenance tasks (EASA, 2015). Lack of resources may prevent the maintenance technicians from completing their tasks due to a lack of supplies and support. In some cases, the available resources may be low in quantity, and sometimes the resources may be of poor quality. Appropriate resources in terms of quantity and quality will increase the chance of completing maintenance tasks correctly and safely the first time. On the other hand, poor quality and insufficient resources may cause serious incidents and accidents during maintenance tasks (FAA, 2008).

A maintenance organization needs to have the right and sufficient resources to do its job safely and in a planned manner. Otherwise, the work will proceed in an improvised manner and will be open to unsafe situations. Components are not the only resources needed to perform a maintenance task correctly, but they often cause frequent problems. Hand tools that are not suitable for the task during maintenance, damaged and uncalibrated are another source of problems. Such tools should be repaired or replaced with new ones as soon as possible. In addition, technical documentation is another critical resource that can cause problems in the maintenance sector. Because how maintenance tasks are to be performed is stated in technical documents (FAA, 2008; EASA, 2015). No matter which commercial maintenance organization an aircraft maintenance technician works in, there may be times when they experience a lack of resources and therefore are hesitant to complete the maintenance task. In such cases, the average technician tends to complete the task by saying ***"I can do it"*** and therefore feels proud (Dupont, 1997). However, it should not be forgotten

that such situations, where there is a lack of resources, may have negative consequences in terms of safety.

Aircraft maintenance organizations can take various precautions to prevent employee errors that may arise from a lack of resources. Since technicians are the most valuable and error-prone resource of maintenance organizations, planning a sufficient number and quality of manpower for the workload created by maintenance tasks is indispensable to prevent unsafe situations that may arise from resource insufficiency (Padil, Said & Azizan, 2018). During maintenance tasks, technicians must learn to use existing resources effectively and efficiently. If existing resources are not suitable for maintenance tasks, resource arrangements should be made proactively. In this context, first of all, suspicious areas where resource insufficiency may occur should be well identified before starting the maintenance task. Then, before starting the task, the inventory of the necessary parts should be taken, ordered and stocked if necessary. Thus, resource arrangement positively affects the airworthiness of aircraft by saving both time and money. In addition, it is necessary to keep technical documents constantly up to date and to contact the supervisor or manufacturer's representative in case of document deficiencies (FAA, 2008; Dupont, 1997).

1.8. Pressure

In civil aviation, the tight flight schedules and commercial concerns of commercial airlines, and in military aviation, the effort to immediately neutralize sudden security risks often cause aircraft maintenance technicians to work under pressure (Çoban & Aydoğdu, 2020). In the aviation sector, to ensure that scheduled flights can be carried out without disruption and in a sustainable manner, periodic maintenance must be carried out on time, unplanned maintenance is resolved immediately, and the aircraft is returned to flight as soon as possible. To reduce costs during economic crises, airlines prefer to fly aircraft more intensively rather than having them remain in maintenance for a long time. Due to such commercial concerns, the aircraft maintenance sector is constantly under time pressure (Yazgan & Kavsaoğlu, 2017).

Time pressure is a psychological condition that occurs when an individual has little time to perform their job (Çoban & Aydoğdu, 2020). Time pressure occurs as a natural consequence of working in a dynamic work environment, and some pressure can motivate employees to do their job. However, when time pressure begins to hinder the ability to complete tasks correctly, it becomes overwhelming. This pressure can be caused by a lack of resources, especially in the maintenance sector, and makes it difficult to cope with the workload (FAA, 2008). Maintenance technicians working under time pressure may experience negative behaviors such as stress, decreased performance in complex tasks, filtering important information, forgetfulness, and incorrect evaluation (Zakay, 1993). The majority of studies on time pressure reveal that time pressure negatively affects the decision-making process. When the literature is examined, it is seen that increased and perceived time pressure reduces teamwork, creativity, self-efficacy, motivation, performance, and negotiation efficiency; It has been observed that it increases burnout, stress and physical problems (Dreu, 2003; Güran & Güler, 2019; Bozacı, 2019). In a study conducted by Çoban and Aydoğdu (2020), it was seen that time pressure increases the technostress level of aircraft maintenance technicians.

The aircraft maintenance sector is a sector where technicians need to make fast and accurate decisions without making mistakes, and is directly responsible for flight safety. In this context, maintenance technicians working under pressure can prevent unsafe situations by taking some precautions. First of all, from an organizational perspective, a maintenance organization should not compromise on work quality and safety due to time pressure. Technicians should be aware that they can make mistakes while working under pressure. Unrealistic maintenance tasks, which put safety at risk and need to be done in a certain time frame, should be shared with managers, and a different action plan should be created if necessary (FAA, 2008; EASA, 2015). Maintenance technicians experiencing time pressure should express their concerns, ask for help from their teammates, and, if necessary, be able to say “No” in unsafe situations (Dupont, 1997). In addition, maintenance organizations should distribute the workload equally so that technicians do not experience time pressure, and plan a sufficient number of technicians and resources for each task (Çoban, 2019).

1.9. Lack of Assertiveness

Assertiveness can be defined as the ability to express our thoughts, feelings, beliefs and needs positively and productively. Being assertive is a human characteristic that is different from being aggressive. Lack of assertiveness is the inability of an individual to express their feelings and thoughts with self-confidence (EASA, 2015). The average maintenance technician is not an assertive person, and most of the time, their job does not require being assertive. However, when something goes wrong with their job and they encounter problems, technicians need to be assertive (Dupont, 1997). Being assertive requires talking about problems when things are not going well, especially in hierarchical organizational structures (Nzulu et al., 2018). Assertiveness is not a skill that comes naturally to every individual. However, it is a critical skill for maintenance tasks to be performed effectively and safely. Maintenance technicians need to be assertive in expressing problems, unsafe situations, or concerns about the job they encounter. In this context, a lack of assertiveness may cause maintenance technicians not to convey a concern about instructions, processes, or the actions of others. Failure to warn about a wrong or incorrect application due to timidity can lead to fatal consequences (FAA, 2008).

To be assertive in maintenance tasks, technicians can exhibit some positive behaviors. Addressing maintenance managers by stating the problem, explaining what the consequences of the problem will be, producing possible solutions to the problem, and getting feedback from teammates about the problem can be seen as assertive behaviors. Instead of dealing with multiple problems with management or teammates, it is necessary to focus on one problem at a time. It is also important to support the problem you are trying to explain to people with visual documentation and real evidence (FAA, 2008). Establishing direct, honest and open communication and respecting the thoughts and needs of others can only be achieved by not deviating from our standards. Unassertive maintenance technicians may have to comply with the decision of the majority, knowing that they are wrong or risky (Dupont, 1997). In addition, maintenance technicians should allow their teammates to voice the problems they see and should always be open to constructive criticism. As technicians exhibit assertive behaviors, they will contribute to the emergence and resolution of problems

in maintenance tasks, as well as realize that their self-confidence has improved and will contribute to the safety of maintenance tasks.

1.10. Stress

Selye (1956), one of the pioneer scientists on stress, defined stress as the general reaction of an individual to various environmental stimuli. Selye defined stimuli that create a series of reactions in an individual as stressors. In other words, stress is the effort that a person exerts beyond their physical and psychological limits due to negative conditions in the social and physical environment (Cüceloğlu, 1994). Stress is a phenomenon that has become a part of daily life in today's modern world, and it can become excessive. The important thing is to be able to recognize when stress has become excessive (Dupont, 1997). Most people encounter stressful situations while doing their daily routines. Stress is a factor that affects human behavior and their interactions with other people. Stress is not a situation that occurs on its own. For stress to occur, the environmental conditions in which a person is located must affect the person (Güçlü, 2001).

Aircraft maintenance technicians in the aviation sector are professional workers working under stress. One of the most important sources of this stress is the financial concerns of commercial airline companies. Maintenance technicians must perform their tasks flawlessly and on time, against any delays or cancellations that may occur in commercial flights. This commercial pressure often stresses technicians (Yazgan & Kavsaoğlu, 2017). The constantly changing technological environment, the need to receive training on new equipment, working in dark and narrow spaces, insufficient resources for maintenance tasks, shift work and long working hours are significant sources of stress in the aircraft maintenance sector. In addition, a serious accident that may occur due to faulty maintenance is always a significant source of stress for maintenance technicians (FAA, 2008).

It is possible to categorize the stress sources that may affect aircraft maintenance technicians under three headings: physical, psychological and physiological. Inappropriate ambient temperature, high noise, inadequate lighting, and limited, closed, and dark spaces are important physical environmental stress sources. (CAP 715, 2002). Problems experienced with managers and other employees at work, communication conflicts, financial problems, marital and private life issues are among the psychological stress sources. Poor physical condition, illness, malnutrition, lack of sleep, fatigue, and unplanned shift systems are factors that create physiological stress in maintenance technicians (EASA, 2015). Aircraft maintenance technicians can manage the stress they are exposed to by taking various precautions. Being aware of how stress affects your job; stopping during work and looking at the problem that causes stress logically; preparing a logical action plan and implementing this plan; temporarily leaving work and taking a break; asking for help from your colleagues, exercising; sleeping regularly, eating a balanced diet and establishing a work-life balance can reduce stress in the workplace (Dupont, 1997; FAA, 2008).

1.11. Lack of Awareness

Awareness can be defined as the ability of an individual to correctly identify factors related to themselves and their environment, to comprehend the meanings of these factors, and to

predict their effects shortly (CAP 715, 2002). Situational awareness is the awareness of the aircraft system and environmental conditions in which a technician is working in aircraft maintenance. Maintenance technicians must be aware of visual conditions such as metal fatigue, loose or missing parts, oil or fluid leaks, tire wear, and improperly functioning parts, as well as the status of the observed systems while working (Endsley & Robertson, 2000). Lack of awareness can be defined as the inability to recognize all the consequences of an action or the lack of foresight. Lack of awareness is frequently seen in experienced maintenance technicians who cannot fully consider the possible consequences of the tasks they perform. Because there are many repetitive tasks in the aircraft maintenance sector. Doing repetitive tasks over and over can eventually lead to problems such as complacency, lack of attention, and failure to recognize environmental conditions in experienced technicians. These problems can cause maintenance technicians to act incorrectly (Dupont, 1997; FAA, 2008). Not being aware of the full consequences of your situation and actions can lead to narrow-mindedness and a lack of understanding of the impact of your actions on others.

Maintenance technicians can prevent incorrect behaviors that may be caused by a lack of awareness by taking some precautions. First of all, since attention is closely related to situational awareness, technicians can maintain their attention by following workplace procedures such as checklists and effective communication. Constantly monitoring the work environment, creating possible task scenarios, thinking about what could happen in the event of an accident, asking your teammates to check your work, and approaching each task as if it were the first time can increase maintenance technicians' situational awareness (Dupont, 1997; EASA, 2015).

1.12. Norms

A human being, who is a social being, continues their life as a part of a certain community or group. For relationships to proceed in an orderly manner in the societies to which people belong, it is necessary to comply with the norms (Eroğlu, 2015). Norms are general rules that guide the behaviors of people belonging to a group or community. Norms can be in two forms: formal and informal. While formal norms are written, such as laws, regulations and procedures, informal norms are unwritten (İçli, 2002). It is also possible to see many written and unwritten norms that guide the behaviors of employees in the aircraft maintenance sector. Unwritten norms, in particular, normally show the shortcut of doing things. Unwritten norms are generally developed to solve problems with uncertain solutions. As the norms become increasingly fixed over time, new members who join the group accept the norms. Although norms are rarely changed, the experiences gained by technicians over time can shape norms (FAA, 2008).

Unsafe norms can be seen in the aircraft maintenance sector that negatively affect the behavior of employees and lead to inefficiency. Working from memory without complying with maintenance documents, resorting to shortcuts, not following procedures, and signing uncompleted maintenance tasks are some of the unsafe norms. However, a behavior generally accepted by technicians can be accepted as a norm even if it is not a standard procedure (EASA, 2015). In order not to encounter an unsafe situation caused by norms,

maintenance technicians must always work according to maintenance documents and be aware that not every norm is correct (Dupont, 1997).

2. TRANSFORMATION OF DIRTY DOZEN INTO FILTHY FIFTEEN

Years after the Dirty Dozen was proposed by Gordon Dupont in 1993, three more human factors were added to the Dirty Dozen in the human factors training provided to aircraft maintenance personnel by HPA in 2016, and the concept of the “**Filthy Fifteen**” emerged (Maggie & Grower, 2016). HPA is an aircraft maintenance company that provides maintenance, repair and overhaul services on landing gear and hydraulic systems for all major aircraft types, including models of major aircraft manufacturers such as Airbus, Boeing, Bombardier and Embraer, as well as helicopters. HPA has been operating under Lufansa Technik, a subsidiary of Lufansa, the flag carrier airline of Germany, since 2002 (<https://en.wikipedia.org>).

The three human factors that HPA added to the Dirty Dozen and created the Filthy Fifteen are: *not admitting limitations*, *lack of operational integrity*, and *lack of professionalism*. These three human factors are seen as typical reasons why aircraft maintenance technicians deviate from company processes and procedures and make mistakes or violations, just like the components that make up the Dirty Dozen (Maggie & Grower, 2016). It is thought that the Filthy Fifteen model (Figure 1), which HPA developed and uses in human factors training to promote aviation safety, will help identify and prevent risks that may arise from new technological changes, regulations, and human resources changes in the aircraft maintenance sector. This updated framework can be seen as a tool that lists the basic job responsibilities of professional employees, especially in aircraft maintenance and aviation, as well as in other maintenance and repair sectors. The three human factors that were added to the Dirty Dozen and created the Filthy Fifteen are explained below.



Figure 1. Filthy Fifteen in Aircraft Maintenance Sector

2.1. Not Admitting Limitations

People exhibit performance while performing a certain job or task in their daily lives. Performance can be expressed as the ability to perform a task according to set standards. According to another definition, performance is a concept aimed at determining the outputs of a targeted task in terms of quantity or quality (Doğan, 2020). The component of Filthy

Fifteen, not accepting limitations, emphasizes that every person has some limits that affect their performance while performing their activities or jobs in both daily and business life (<https://skybrary.aero>).

There are many components, both mechanical and electronic, such as systems, equipment or parts that make up a large aircraft or an ordinary small technological device. Each of these components has a certain capacity, performance level and some limitations while performing their duties. Similar to mechanical devices, some factors limit the performance of people while performing their duties. When compared to the performance values of a device with certain limits, it may be difficult to determine exactly which values a person's performance and limitations are between. However, it is possible to say that exposure to extreme situations will cause limitations in human performance. Aircraft maintenance technicians and managers need to consider the physical and cognitive abilities and limitations of a person when evaluating their own and others' performance (CAP 715, 2002).

People perceive the outside world using their senses of sight, hearing, touch, smell and taste and direct their behaviors accordingly. However, the two most important senses in aviation activities are sight and hearing. Most of the data required to evaluate the position and balance of a flier in the sky or to direct the interaction and behavior of aviation workers, such as air traffic controllers and maintenance technicians, with the environment is obtained through the eyes and ears. There is a certain threshold point for the sensory organs to activate. For example, a minimum light level is required for the eyes to see. Ears, on the other hand, cannot hear sounds below a certain pressure level. The sensory threshold can vary from sense organ to sense organ and from person to person, and can also be affected by environmental factors. Incorrect or misleading data transmitted to us by our eyes and ears is a significant source of concern for aviation sector workers (Campbell & Bagshaw, 2002). Both the need for a certain threshold point for the senses to be activated and the fact that the sensory threshold is affected by individual factors and environmental conditions can be considered as factors limiting individual performance.

As in many aviation activities, maintenance technicians must have a certain level of vision to perform maintenance tasks that rely on visual inspection safely. Many maintenance tasks require the use of both distance and near vision. However, eye defects such as myopia, hyperopia, astigmatism, and cataracts, which personnel experience especially due to the aging process, can cause limitations in performance (CAP 715, 2002). In addition to visual performance, some factors affect hearing performance. The hearing performance of the human ear varies according to the frequency and intensity of the sound. The sound frequency range that a young person can hear varies between 20-20,000 hertz, while the highest sensitivity is approximately 3,000 hertz. However, people can normally hear between 20-120 decibels. However, sounds between 50-70 decibels are the sound intensity that is more easily heard by the ear. Ear infections, earwax, eardrum damage, and especially the aging process are important factors that limit hearing performance caused by the person. However, noise is an important environmental factor that limits hearing performance (Campbell & Bagshaw, 2002).

Data provided by the sensory organs is analyzed through the information processing process and converted into meaningful information. Information processing is a process consisting of five stages: detection, perception, decision making, behavior, and feedback. According to information processing theory, people not only react to stimuli from their environment, but also process the data they receive. The scope and capacity of the brain and nervous system are extremely effective in the information processing process (Wang, Liu & Wang, 2003). In the aircraft maintenance sector, where there are many risks and complex tasks, information processing is a process in which personnel are prone to making mistakes. In addition to cognitive problems such as memory problems, lack of attention, and insufficient perception, many factors such as lack of education, inexperience, anxiety, psychological problems, physical illnesses, lack of communication, lack of motivation, and environmental conditions can limit the information processing of personnel in aircraft maintenance tasks (Salas, Jentsch & Maurino, 2010). If maintenance technicians ignore these limitations and try to quickly evaluate environmental inputs and take action, and therefore overlook a small detail, the consequences can lead to serious accidents.

One of the reasons behind aircraft maintenance technicians' refusal to accept their physical and cognitive limitations may be their professional mindset. Aircraft maintenance technicians are known for having an **"I can do this"** mindset that motivates them to perform exceptionally due to the challenging tasks and environmental conditions they face. *"I didn't receive proper training in this subject. However, I have a lot of experience. I can figure out how to do this job without formal training. How difficult can this job be? After all, I have a maintenance license. Having a license shows that I can do this. I am strong. I can work for days, months, and long hours without much sleep. I will sleep only when I am dead"* is a dominant mindset that often motivates aircraft maintenance technicians regardless of the difficulties they face while doing their job. However, this mindset can backfire in some cases and cause the maintenance technician to go beyond their limits (Maggie & Grower, 2016).

The reason why aircraft maintenance technicians do not accept limitations may also be due to national and professional culture. In a qualitative study conducted by Bukeç and Çoban (2023) on aviation employees on the factors affecting a just culture, it was observed that the fatalistic approaches (***God willing, nothing will happen to me***) exhibited by employees in Turkish and Middle Eastern cultures due to their national culture and religious beliefs encouraged aircraft maintenance technicians to go beyond the rules; at the same time, aircraft maintenance technicians tried to solve unsafe situations within themselves due to their professional culture and therefore avoided reporting behavior. Aircraft maintenance employees often perform by being exposed to intense physical and cognitive workload in a work environment dominated by challenging environmental conditions, time pressure, shift work, sleeplessness, fatigue and insufficient resources (Çoban, 2019). When working in challenging work conditions and organizational and individual resources are insufficient, technicians may take the initiative and go beyond existing limits. The successful completion of the performance exhibited by going beyond the limits will prepare the ground for the maintenance technician to go beyond the limits again in similar situations and will increase their self-confidence. As a result, in such a situation, the maintenance technician will probably tend to go beyond the limits. In this context, for aircraft maintenance tasks to be

performed effectively and safely, employees must be transparent and honest, free from ego in accepting their limits. Not accepting the limits can decrease individual performance and can cause serious damage to teammates and expensive aircraft and equipment in various, risky and crowded work environments such as aircraft maintenance hangars and flight lines (<https://skybrary.aero>).

The examination and analysis of the physical, emotional and cognitive limits of humans are a vital part of human factors training. According to the EASA Part-147 regulation in the European Union countries and the Aircraft Maintenance Training Organizations Instruction (SHT-147, 2022) in Turkey, to obtain an aircraft maintenance license, it is necessary to take Module 9-Human Factors Training specified in the Aircraft Maintenance Personnel License Instruction (SHT-66, 2013). The second part of this module addresses the physical and cognitive performance and limits of a person and covers topics such as vision, hearing, information processing, attention, perception, memory, claustrophobia and physical access.

In addition to human factors training, aircraft maintenance technicians themselves can take some precautions to accept their individual and environmental limitations. *“Being aware of physical, cognitive and technical limitations; watching for warning signs from your body while working; keeping your ego under control; accepting your lack of knowledge about your job; always working according to correct work procedures; taking breaks while working; getting work-related support when needed and living a healthy lifestyle”* can help an employee accept and manage their limitations at work (<https://skybrary.aero>).

2.2. Lack of Operational Integrity

Integrity is a virtuous person characteristic that includes behaviors such as expressing the truth by leaving individual interests aside and prioritizing social benefit, doing the right thing under all circumstances, being reliable and avoiding harm (Selim, 2022). Integrity means doing the right thing every time, regardless of whether others are watching or not. Operational integrity, or in other words, “business ethics,” generally refers to being aware of what is right and wrong in the workplace and always doing the right thing. Business ethics also reveal what is right and wrong in the process of producing goods and services by businesses (Doğan, 2009). In an approved maintenance organization, business ethics means complying with the regulatory requirements and approved maintenance procedures of international and national authorities that guide the aviation sector, and also strictly adhering to moral values (Maggie & Grower, 2016). Deviating from these procedures, rules and values can be defined as a lack of operational integrity.

Lack of operational integrity and business ethics can lead to routine and spontaneous situational violations, which are frequently seen in maintenance technicians. In cases where challenging organizational conditions such as time pressure, insufficient equipment, lack of resources and excessive workload arise, an approach lacking in operational integrity such as ***It was a little out of tolerance last time but it worked; I can go out of tolerance again, no problem”*** will bring about violations and unsafe behaviors (Maggie & Grower, 2016). In the aircraft maintenance sector, it is common for maintenance technicians and engineers to take part in more than one task and be responsible for those tasks without knowing whether they have been completed completely. For example, a technician may have a control task in

another maintenance task while performing a maintenance task. Often, due to personnel and time constraints, the responsible technician may tend to risky behavior such as approving the maintenance exit without checking how the work done in control tasks has been completed. In such a case, due to operational integrity, the technician must fully check whether the work has been done according to the procedures. In this context, business integrity can be seen as a professional employee characteristic that eliminates risky behavior (CASAA, 2013).

There may be different reasons that lead employees to unethical behavior in commercial organizations. The pressure to achieve certain organizational goals due to commercial concerns, the failure of the top management of the organization to prioritize ethical values, conflicts of interest between functional departments and employees within the organization, excessive self-confidence and arrogance seen in employees, etc. may cause both the organization itself and the employees individually to deviate from ethical rules and honesty (Doğan, 2009). In this context, when because aircraft maintenance organizations, as commercial organizations, have certain organizational goals and profit expectations, often work under time pressure, and maintenance technicians may act in line with their interests, it should not be forgotten that behaviors that deviate from business ethics and may put safety at risk may be seen in the aircraft maintenance sector.

In the aircraft maintenance sector, the negative consequences of behaviors that are far from organizational procedures and ethical values may not be immediately visible, as they are in the flight crew. The flight crew's work environment is extremely variable during the flight process, from the aircraft leaving the apron to completing its flight and parking on the apron again. During this process, the flight crew's mistakes can be actively and immediately seen, while the consequences of their mistakes and violations can be extremely fatal. Compared to the flight crew, maintenance technicians work individually or as a team, especially in maintenance hangars, in more stable environmental conditions (Sian, Robertson & Watson, 2017). The fact that they are mostly alone while performing maintenance on a part or device can cause the technicians' possible mistakes and violations to be overlooked and remain hidden. The consequences of technicians' unsafe behaviors are mostly hidden, as they can be seen either during quality checks at the end of maintenance or during flight. In addition, if maintenance errors are noticed in a process before the aircraft is released for flight, these errors are easier to compensate for and less damaging in terms of their consequences, and erroneous behaviors can be tolerated. The nature of aircraft maintenance tasks can lead to complacency, overconfidence, and the belief that deviation from organizational and ethical rules poses little risk to maintenance technicians. In this case, deviation from operational integrity can insidiously permeate maintenance technicians' behaviors.

In aircraft maintenance organizations, measures can be taken against a lack of operational integrity at both organizational and individual levels. At the organizational level, organizations should determine their own business and ethical values and share them with their employees. When the corporate websites of many traditional and low-cost airlines such as United Airlines, Air France, Air China, Japan Airlines, Turkish Airlines, Lufthansa, Easy Jet and Southwest are examined in the aviation sector, it is possible to see that business and

ethical values are shared with both society and employees. However, simply sharing these values is not enough. In the next process, whether employees act according to these values should be checked by organizational control mechanisms. For this mechanism to work, a senior management approach that prioritizes ethical values and strong organizational policies and processes is needed. According to Maggie and Grower (2016), employees can take some individual measures to ensure operational integrity in the aviation sector. *“Knowing what integrity is and displaying honest behavior, being consistent with what is said and what is done, reporting mistakes honestly, always thinking about the safety and security of those we are in contact with and responsible for, and acting according to organizational and correct procedures under all circumstances”* are some of the measures.

2.3. Lack of Professionalism

The third human factor that HPA included in the Filthy Fifteen is a lack of professionalism. Professionalism can be defined as the expertise, knowledge, skills and behaviors exhibited in a certain field. The nature of professionalism includes dynamism and effort. In addition, professional employees are people who do a job for money. To evaluate whether a person is a professional, it is necessary to look at whether they meet certain criteria in the field they are interested in (Altıok & Üstün, 2014). According to Pavalko (1971), theoretical knowledge load, connection with basic social values, commitment to the profession, education period, cooperation awareness, serving the community and work ethics are defined as the basic criteria of professionalism. Professionalism can develop as long as professional employees fulfill their job responsibilities at the highest level.

Although technological tools and equipment are widely used in aircraft maintenance tasks, the main determining factor in the correct and safe performance of maintenance and repair tasks is maintenance technicians (Padil et al. 2018). Individuals who want to work in the aircraft maintenance sector, after completing the training required by international or the aviation authorities of the country they are in, are authorized to work on a certain type of aircraft, engine or aircraft system with the license or certification they earn (Zaharevitz, 1980). SHY-66, SHY-145 and SHY-147 regulations published by the General Directorate of Civil Aviation in Turkey are the basic national regulations that guide the theoretical training, professional experience and licensing processes of aircraft maintenance technicians. Factors such as the fact that aviation operations are subject to strict international regulations, that safety and security are the two main priorities of aviation activities, that errors and violations lead to fatal and major financial consequences, that expensive technological tools are used in the aviation sector, and that aviation employees are required to perform their duties by receiving legal and valid training have turned aircraft maintenance technicians, as well as all aviation sector employees, into professional employees.

Many professional jobs have their rituals, cultures, norms and jargon. Since ancient times, taking an oath has been one of the rituals practiced to start many traditional and professional professions worldwide. Taking an oath means making a promise on a certain subject or confirming the truth of a certain statement by presenting a sacred value or being as a witness. In addition to public duties such as membership in parliament, presidency, and military service, taking an oath is frequently seen when starting traditional professions such as

lawyers, doctors and pharmacists. In many Western countries, doctors take the Hippocratic Oath as a symbol of their commitment to maintaining a set of ethical rules and standards when starting their profession (Avşar, 2012). Similar to the Hippocratic Oath of doctors, the *Maintenance Technician Oath*, written in 1941 by American Jerome Lederer, a pioneer in aviation safety, is known to be extremely effective in the professional behavior of technicians in the aircraft maintenance sector. The text of this oath first appeared on the back cover of the first issues of the Flight Safety Foundation's Aviation Technicians Bulletin in 1953 and became extremely popular. At that time, many technicians from Tokyo to Frankfurt, Canada to Puerto Rico wrote letters asking for copies of this oath to hang on the walls of their workplaces and offices. This can certainly be seen as evidence that aircraft maintenance technicians are a professional profession (Maggie & Grower, 2016). The text of the maintenance technician oath written by Jerome Lederer is presented below.

“Upon my honor, I swear that I shall hold in sacred trust the rights and privileges conferred upon me as a certified mechanic. Knowing full well that the safety and lives of others are dependent upon my skill and judgment, I shall never knowingly subject others to risks which I would not be willing to assume for myself, or for those dear to me. In discharging this trust, I pledge myself never to undertake work or approve work which I feel to be beyond the limits of my knowledge, nor shall I allow any non-certificated superior to persuade me to approve aircraft or equipment as airworthy against my better judgment, nor shall I permit my judgment to be influenced by money or other personal gain, nor shall I pass as airworthy aircraft or equipment about which I am in doubt, either as a result of direct inspection or uncertainty regarding the ability of others who have worked on it to accomplish their work satisfactorily. I realize the grave responsibility which is mine as a certified airman to exercise my judgment on the airworthiness of aircraft and equipment. I therefore pledge unyielding adherence to these precepts for the advancement of aviation and for the dignity of my vocation.” (<https://skybrary.aero>).

Professionalism is a phenomenon that reveals the basic professional character of all aircraft maintenance workers, especially technicians. Professionalism is also a combination of expert skills, personal feelings and attitude towards the job for an aircraft maintenance worker. Professionalism in the aircraft maintenance sector can be interpreted as the desire to take responsibility for the safety of passengers traveling on aircraft and the airworthiness of aircraft above individual interests (CASAA, 2013). From this perspective, business integrity and professionalism are two concepts that are interconnected like symbiotic twins. Integrity is the cornerstone of professionalism, and it is not possible to achieve professionalism without integrity. The factors that can be seen as the basic components of professionalism in the aircraft maintenance sector are listed in Table 2.

Table 2. Basic Components of Professionalism in the Aircraft Maintenance Sector

1	Discipline	Following approved procedures to perform a given task.
2	Communication	Keeping team members informed of progress and developments.
3	Teamwork	Working together well to resolve problems and maintain control.
4	Knowledge	Having deep understanding of aircraft systems and their operation.
5	Expertise	Retaining and transferring knowledge and skills
6	Situational Awareness	Knowing what is happening around you.
7	Experience	Calling upon prior training and knowledge to assess new situations.
8	Decision Making	Taking correct decisive actions.
9	Resource Management	Allocating resources to ensure control of the larger situation while specific problems are being addressed.
10	Prioritization	Setting safety above personal concerns.

Source: (CASAA, 2013).

The physical and technical aspects of aircraft maintenance tasks seem relatively simple and can be easily understood. However, it can be difficult to define and understand the concept of professionalism that separates a superior maintenance worker from an average one. Professionalism is a situation that is obvious when seen. It is possible to understand the professionalism of an aircraft maintenance technician not only from their technical skills but also from their situational awareness, coordinated teamwork and ability to make the right decisions. Professionalism also emphasizes the individual's self-control over themselves to avoid and protect themselves from risky behaviors. Maintenance technicians with high self-control can make conscious and correct decisions for safety (Maggie & Grower, 2016).

Professionalism is of central importance for the integrity of aircraft maintenance processes, production quality, and safe and successful results. The **4C Concept**, which reflects four basic characteristics that stand out for aviation professionals, is taught in the human factors training provided by HPA. The components that make up the 4C Concept are: Having sufficient knowledge and skills in one's field (**Competence**), Commitment to a higher goal (**Commitment**), Being in control of one's work (**Control**), and Communication, whether written, verbal or in any form (**Communication**). HPA emphasizes that the internalization and application of these basic competencies are of vital importance and offers a series of recommendations to maintenance technicians to protect against a lack of professionalism. These recommendations are: “*Work with passion in your work, share your knowledge, use approved parts, materials and technical documents/data; use appropriate equipment, tools and vehicles; be extremely meticulous about quality and always follow the right procedures.*” (Maggie & Grower, 2016).

A maintenance technician must know and apply the countermeasures that correspond to each item of the Filthy Fifteen while performing their job to be a complete professional. For example, the technician must not hesitate to be assertive and manage stress, as well as avoid distractions and complacency. A technician should not take any maintenance task for granted and should give each task the same attention and care as he does to complex tasks. It is known that most accidents in the aircraft maintenance sector are not caused by complex technical problems, but by simple and preventable mistakes, such as not tightening a nut enough. Professional technicians readily admit their mistakes. A technician who is trained

and licensed to perform maintenance tasks is disciplined and assertive in his work, which demonstrates his professionalism. In addition, a professional technician should share this situation with his managers without hesitation when he has doubts about whether he can perform his job safely and effectively. In this way, management can ensure that the technician receives the necessary support or training when needed. In this context, each technician is encouraged to always do their best through continuous learning and professional development (Maggie & Grower, 2016).

Professionalism is a charismatic situation that can both guide the safety culture of the maintenance organization and be guided by the safety culture, and adds value to the maintenance technician. Professionalism in aircraft maintenance operations can be developed in single-person maintenance tasks as well as in team or inter-team tasks. It is a sign of professionalism that each technician involved in maintenance tasks is aware of the stage of their task and how far they have progressed since the beginning of the task. Good communication among professional employees reduces the possibility of making risky decisions. However, making a risky decision should not be seen as a lack of professionalism. Because there is always a risk in the nature of aviation activities. What is important is to minimize these risks and carry out the activities safely. The trust that a professional employee has in his teammate should not replace good communication, situational awareness and control. A professional maintenance technician should always keep the motto ***“trust does not prevent control”*** alive in his mind. In this context, a professional technician should never sign a job that he has not done, examined or checked.

As a result, both operational integrity and professionalism should be important topics in the human factors training curriculum for aircraft maintenance technicians. However, the implementation of professionalism in the workplace is largely the responsibility of each individual. Maintenance technicians need to embrace operational integrity and professional values and take pride in their practice. This is a process that begins in the technician's heart and is instilled in his mind by the hands that touch and work on the aircraft and its components (Maggie & Grower, 2016).

3. DISCUSSION AND CONCLUSION

In the aviation sector, where the concept of safety is extremely important, aircraft accidents caused by the errors of aircraft maintenance technicians became an important agenda item worldwide in the early 1990s. In this context, as a result of studies conducted by Transport Canada employee Gordon Dupont and his teammates in 1993, 12 human factors that cause employees in the aircraft maintenance sector to make mistakes were identified, and these factors were named the Dirty Dozen. After the Dirty Dozen model emerged, it was accepted worldwide as a simple and widespread model for understanding and solving accidents caused by human errors, first in the aircraft maintenance sector and then in other sectors where safety and security are extremely important.

In the nearly thirty years since the Dirty Dozen model emerged, the conditions brought about by globalization and technological changes have also been reflected in the working environment and work behaviors of aircraft maintenance technicians. In this context, HPA,

one of the world's leading aircraft maintenance, repair and training organizations, has updated and expanded the factors that cause aircraft maintenance workers to make mistakes while doing their job and has proposed the Filthy Fifteen model. In this model, three more human factors have been added to the human factors in the Dirty Dozen. These factors are: *Not Admitting Limitations, Lack of Operational Integrity and Lack of Professionalism*.

It can be said that the human factors in the Filthy Fifteen cause aircraft maintenance technicians to make mistakes, and these factors are interrelated. First of all, aircraft maintenance tasks are an aviation operation based on teamwork and effective communication. Therefore, it is likely that a lack of communication will reduce the team performance of maintenance technicians and cause fatal errors. The experience that technicians gain over time can cause complacency in maintenance tasks, and complacency can reduce assertiveness and awareness, causing unsafe situations to be overlooked. Commercial concerns of airline companies and workplace norms that encourage unsafe practices will increase pressure, stress and fatigue in maintenance workers and cause errors. This fatigue can be physical and mental. Distracting factors commonly seen in the aircraft maintenance work environment can reduce the situational awareness of technicians and trigger erroneous behaviors. The variable structure of the aircraft maintenance work environment and constant exposure to technological changes can cause a lack of knowledge and awareness in technicians.

Human factors such as norms, stress, lack of resources, lack of knowledge, fatigue, pressure, and lack of assertiveness included in the Filthy Fifteen can mostly be seen as factors originating from organizational policies and commercial concerns. Human factors such as lack of communication, complacency, distraction, lack of teamwork and lack of awareness can mostly be seen as individual factors originating from technicians. However, it can be said that some human factors originate from both organizational and individual reasons. When the last three human factors that are added to the Dirty Dozen and form the Filthy Fifteen are examined, factors such as pressure, stress, complacency, lack of information and resources can cause technicians to go beyond their limits and compromise their work integrity. It is a fact that operational integrity forms the basis of professionalism. When a maintenance technician acts with awareness of the factors that cause them to make mistakes, they exhibit professional behavior.

Maintenance technicians can make their work environment safer by taking some precautions against the human factors in the Filthy Fifteen. Effective communication, emphasis on teamwork, working according to organizational procedures and maintenance documents, not signing a job that has not been done, paying attention to physical and mental health, sharing problems with managers, working within the framework of ethical rules and integrity, and always acting professionally can prevent or minimize the misconduct of aircraft maintenance technicians.

The Filthy Fifteen, which has offered a current perspective in recent years to explain human factors seen in the aircraft maintenance sector, can be updated according to the changes experienced in today's business life. In this context, *technostress* can be seen as a source of stress affecting the performance of many employees in the modern age and as a current

human factor that can cause aircraft maintenance workers to make mistakes. Technostress refers to the stress experienced by employees due to problems such as the effort to perform many tasks using information and communication systems, constant exposure to excessive workload due to these technologies, system updates, constant need for relearning, software and hardware failures (Tarafdar, Tu & Nathan, 2011). Factors such as technological complexity in the workplace, increasing workload, adaptation process to changing technology, age and experience of the technology user, organizational pressures, and changing job roles are among the factors affecting technostress (Türen, Erdem & Kalkın, 2015). Techno-overload, techno-invasion, techno-complexity, techno-insecurity and techno-uncertainty can affect the job performance of aircraft maintenance technicians as sub-dimensions of technostress (Tarafdar et al., 2011).

Aircraft maintenance technicians have to navigate more complex interfaces and dense data flows in maintenance tasks today due to developing technology. In addition, the flow of information from multiple sources through maintenance manuals, digital dashboards and communication tools can overwhelm technicians. In this context, overload and information flow resulting from the use of technology can create technostress in maintenance technicians and limit their ability to see critical maintenance stages and faults (Reason & Maddox, 1995; Çoban & Aydoğdu, 2020). When the literature is examined, it is possible to see studies on the relationship between technostress and job performance in the aircraft maintenance sector. In a study conducted by Alam (2016) on pilots and maintenance technicians in Pakistan, it was found that technostress reduces team performance; in a study conducted by Çoban and Aydoğdu (2020) on 177 aircraft maintenance technicians in Turkey, time pressure increased technostress; and in another study conducted by Türen et al., (2015) in Turkey, it was seen that 32% of employees in the aviation sector experienced technostress. In a quantitative study conducted by Erdem and Sökmen (2022) on 331 aircraft maintenance technicians working in four different cities in Turkey, it was reported that the technological complexity dimension of technostress negatively affected the work efficiency of the technicians. However, in another quantitative study conducted by Kızılcan, Hoşgör and Güngördü (2023) with the participation of 112 personnel working in ground services at Antalya Airport in Turkey, it was found that moderate perceived technostress did not affect work performance.

In addition to the technostress studies mentioned above, it has been observed that significant technological changes and innovations have recently been experienced in the aircraft maintenance sector to perform maintenance tasks more efficiently. One of these technological innovations, predictive maintenance, focuses on proactively predicting failures and increasing efficiency in maintenance tasks by using data analytics, machine learning, advanced algorithms and sensor technologies (Daily & Peterson, 2017). Aircraft maintenance companies face great difficulties, especially when examining aircraft exterior surfaces during the maintenance needs assessment process. The aircraft maintenance sector, which wants to solve this difficulty, equips maintenance hangars with specially designed robotics and automation systems. One of the notable developments is the use of drones for efficient and fast aircraft inspections. The use of drones in maintenance tasks can reduce maintenance times by up to 90%. Easyjet has saved significant time by using Blue Bear drones in maintenance tasks. Airbus uses visual cameras and obstacle detection sensors in

addition to special drones in maintenance tasks (Reed, 2019). Developed by New Zealand-based Invert Robotics, a versatile and crawling robot can cling to wet and dry aircraft surfaces and provide maintenance engineers with high-resolution images of the aircraft's condition. It is possible to see that the world's leading aircraft engine manufacturers and maintenance companies, such as Rolls-Royce, Pratt & Whitney, GE Aviation, and Lufthansa Technik, are turning to environmentally friendly robotic technologies in engine maintenance and inspection. In addition, big data analytics and blockchain technology are important technological innovations used in aircraft maintenance processes to make optimum resource allocation, reduce risks, perform safe maintenance, and provide transparent maintenance records (Olaganathan, 2024).

It is thought that the current and intense technological changes seen in the aircraft maintenance sector will contribute to the more effective, efficient and safe performance of maintenance tasks and that these technological changes will increase in the coming years. However, these changes are likely to create a need for more technological skills and training for aircraft maintenance technicians compared to the past. In this context, many factors such as not being able to follow rapidly changing and updated technological innovations, being constantly exposed to technological complexity, the need for frequent updates of technological tools, the need to analyze intensive data under time pressure, and software and hardware problems can come together to create technostress in maintenance technicians.

Technostress can indirectly lead to perceptions of excessive workload, cognitive fatigue, loss of motivation, burnout, low job performance, intention to leave the job, and job dissatisfaction in maintenance technicians (Tarafdar, Tu, Ragu-Nathan & Ragu-Nathan, 2007). Moreover, technostress can be related to many human factors included in the Filthy Fifteen. First of all, a maintenance technician experiencing technostress is likely to have problems with communication, teamwork, attention, and situational awareness. The time pressure caused by the commercial pressures of the airline company can increase technicians' perception of technostress. Constant exposure to intense technological processes and complexity can exhaust technicians mentally and physically, as well as push them beyond their limits and lead them to unprofessional behaviors.

Within the scope of the research in the literature, it is possible to see technostress in the aircraft maintenance sector as a human factor that is independent of other stress sources and negatively affects employee performance. In this context, the **“Dirty Sixteen”** model, which can be created by adding technostress to the Filthy Fifteen, can be a current approach to understanding errors caused by human factors in the aircraft maintenance sector. The development of the Dirty Sixteen model, including the Dirty Dozen and Filthy Fifteen, is presented in Figure 2.

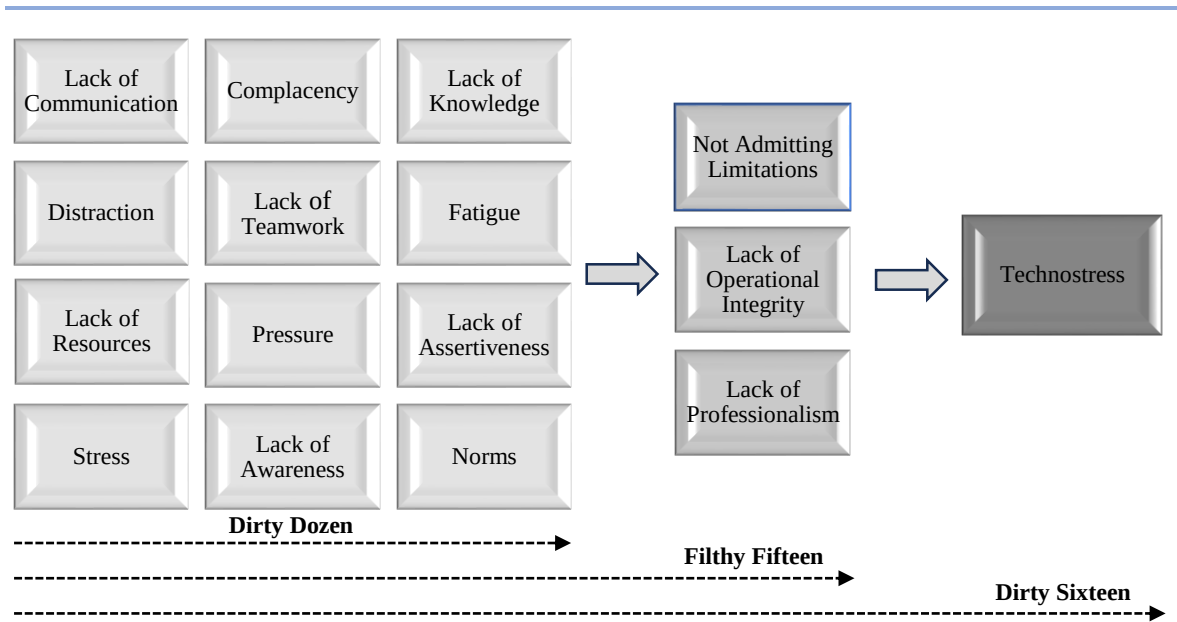


Figure 2. Dirty Sixteen Model in Aircraft Maintenance Sector

The Dirty Sixteen model, which also includes technostress, can be an important human factors examination model not only in the aircraft maintenance sector but also in the flight, maintenance and air traffic operations of civil and military aviation. The use of technology in both the civil and military aviation sectors is quite high. In particular, technological materials, devices and equipment are frequently used in military aircraft maintenance activities, where maintenance technicians are at the center (Çoban & Aydoğdu, 2020). In addition, the advanced avionics features of military jet aircraft and the high technology of today's advanced smart ammunition can create technostress in military aviation, especially in flight, maintenance and ammunition loading teams. It can be said that technostress is affected by many human factors and affects many human factors. In this context, apart from the aviation sector, the Dirty Sixteen model can be used as an important tool to examine human factors in sectors such as energy, software, automotive and health, which involve high technology and where employee errors have extremely serious negative consequences.

This study, which examines the Dirty Dozen and Filthy Fifteen models developed to examine human factors in the aircraft maintenance sector in light of literature review, may have limitations due to being a theoretical review. To overcome these limitations, this theoretical review can be supported by conducting quantitative and qualitative studies on the effects of the three new human factors added to the Dirty Dozen and current human factors, such as technostress, on aircraft maintenance technicians. In this context, which of the sixteen human factors, including technostress, affect the performance of maintenance technicians the most and whether technicians and maintenance managers are aware of the four newly added human factors to the model, can be investigated through face-to-face interviews. In addition, scale studies can be conducted on whether the Filthy Fifteen and Dirty Sixteen can be separated into dimensions within themselves. It is thought that this study will bring a current perspective to the literature on human factors in the aircraft maintenance sector and shed light on future research.

REFERENCES

- Alam, M. A. (2016). Tekno-stres and productivity: Survey evidence from aviation industry. *Journal of Air Transport Management*, 50, 62-70. <https://doi.org/10.1016/j.jairtraman.2015.10.003>
- Altıok, H. Ö., & Üstün, B. (2014). Profesyonellik: Kavram analizi. *Dokuz Eylül Üniversitesi Hemşirelik Yüksekokulu Elektronik Dergisi*, 7(2), 151-155.
- Avşar, B. Z. (2012). Biat'tan Yemin'e... Kamusal sorumluluk üstlenenlerin ve temsilcilerinin and içmesi. *Gazi Türkiyat Dergisi*, 10, 15-61.
- Bozacı, İ. (2019). Bireysel zaman baskısının satın alma sonrası pişmanlığa etkisinde alışverişte zaman baskısının aracı rolü üzerine bir araştırma. *Uluslararası Toplum Araştırmaları Dergisi*, 10(17), 653-676. <https://doi.org/10.26466/opus.518712>
- Bükeç, C. M., & Çoban, R. (2023). A qualitative research on factors affecting just culture in airlines. *Anadolu University Journal of Economics and Administrative Sciences*, 24(4), 495-524. <https://doi.org/10.53443/anadoluibfd.1291531>
- Campbell, R. D., & Bagshaw, M. (2002). *Human Performance and Limitations in Aviation*. Third edition, Iowa, USA: Iowa State University Press.
- CAP 715, (2002). An Introduction to Aircraft Maintenance Engineering Human Factors for JAR 66. Retrieved from <https://www.caa.co.uk/publication/download/12244>, 02.01.2025.
- CASAA, (2013). Civil Aviation Safety Authority of Australia Safety Behaviours Human Factors -Resource Guide. Retrieved from <https://www.casa.gov.au/operations-safety>, 29.12.2024.
- Chatzi, A. V., Martin, W., Bates, P., & Murray, P. (2019). The unexplored link between communication and trust in aviation maintenance practice. *Aerospace*, 6(66), 1-18. <https://doi.org/10.3390/aerospace6060066>
- Çınar, N. (2021). İyi bir sistematik derleme nasıl yazılmalı? *Online Türk Sağlık Bilimleri Dergisi*, 6(2), 310-314. <https://doi.org/10.26453/otjhs.888569>
- Çoban, R. (2017, 12-13 Nisan). Bakım kaynak yönetimi: Uçak bakımda insan faktörü üzerine bir araştırma. *Havacılık Emniyeti Yönetim Sistemi Sempozyumu Bildiri Kitabı* (ss. 88-113), Hava Kuvvetleri Komutanlığı, Ankara.
- Çoban, R. (2019). Uçak bakım sektöründe iş yükü ve zaman baskısı üzerine bir örnek olay araştırması. *Journal of Aviation*, 3(1), 45-60.
- Çoban, R., & Aydoğdu, T. (2020). Havacılık sektöründe zaman baskısının teknostrese etkisi: Uçak bakım teknisyenleri üzerine bir araştırma. *İşletme Araştırmaları Dergisi*, 12(3), 2442-2460. <https://doi.org/10.20491/isarder.2020.985>
- Cüceloğlu, D. (1994). *İnsan ve Davranışı. Psikolojinin Temel Kavramları*. İstanbul: Remzi Kitabevi.
- Daily, J. & Peterson, J. (2017). Predictive maintenance: How big data analysis can improve maintenance. In K. Richter & J. Walther (Eds.), *Supply Chain Integration Challenges in Commercial Aerospace*. Springer, Cham. https://doi.org/10.1007/978-3-319-46155-7_18.
- Dekker, S. W. A. (2003). Human Factors in Aviation-A natural history. Technical Report 2003-02, Retrieved from

- <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=415e1474da0d3bca2ee3df4d4c23df8cfca1f467>, 15.12.2024.
- Dickinson T. L., & McIntyre, R. M. (1997). A conceptual framework for teamwork measurement. In M. T. Brannick, E. Salas & C. Prince (Eds.), *Team Performance Assessment and Measurement, Theory, Methods, and Applications* (pp. 19-43). Mahwah, NJ, Lawrence Erlbaum Associates.
- Doğan, H. (2020). İş performansı ve performans değerlendirme sistemi üzerine kavramsal bir değerlendirme. *International Journal of Business and Economic Studies*, 2(1), 44-55.
- Doğan, N. (2009). İş etiği ve işletmelerde etik çöküş. *Sosyal Ekonomik Araştırmalar Dergisi*, 16, 179-200.
- Dreu, C. K. D. (2003). Time pressure and closing of the mind in negotiation. *Organizational Behavior and Human Decision Processes*, 91(2), 280-295. [https://doi.org/10.1016/S0749-5978\(03\)00022-0](https://doi.org/10.1016/S0749-5978(03)00022-0)
- Dupont, G. (1997). The dirty dozen errors in aviation maintenance. In *meeting proceedings of 11th Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection: Human Error in Aviation Maintenance* (pp. 45-49). Washington, D.C.: Federal Aviation Administration/Office of Aviation Medicine.
- EASA, (2015). Modüle 9, For Level B-1 and B-2 Certification, Human Factors. Aviation Maintenance Technician Certification Series. Retrieved from <https://www.iaepune.org/myimg/EASA%20Module%2009%20Human%20Factors.pdf>, 16.12.2024.
- Edwards, E. (1988). Introductory overview. In E. L. Wiener & D.C. Nagel (Eds.). *Human Factors in Aviation* (pp. 3-25). San Diego, CA: Academic Press.
- Endsley, M. R., & Robertson, M. M. (2000). Situation awareness in aircraft maintenance teams. *International Journal of Industrial Ergonomics*, 26(2000), 301-325. [https://doi.org/10.1016/S0169-8141\(99\)00073-6](https://doi.org/10.1016/S0169-8141(99)00073-6)
- Erdem, E., & Sökmen, A. (2022). Havacılıkta teknostresin verimlilik üzerine etkisinde öğrenen örgütlerin aracılık rolü: Hava aracı bakım personeli tutumları üzerine bir alan araştırması. *İşletme Araştırmaları Dergisi*, 14(4), 3105-3122. <https://doi.org/10.20491/isarder.2022.1552>
- Ergai, A., Cohen, T., Sharp, J., Wiegmann, D. Gramopadhye, A., & Shappell, S. (2016). Assessment of the human factors analysis and classification system (HFACS): Intra-rater and inter-rater Reliability. *Safety Science*, 82, 393-398. <https://doi.org/10.1016/j.ssci.2015.09.028>
- Ergün, E., & Eyisoy, M. E. (2018). Takım çalışması özelliklerinin takım performansına etkisi üzerine bir araştırma. *BMIJ*, 6(4), 1455-1475. <https://doi.org/10.15295/bmij.v6i4.406>
- Eroğlu, E. (2015). Geçmişten günümüze sosyal normlar. *Akademik Bakış Dergisi*, 50, 299-308.
- FAA, (2008). AMT Handbook Addendum Human_Factors Chapter 14 Human Factors. Retrieved from <https://www.faa.gov/files/gslac/courses/content/1097/AMT>, 23.12.2024.

- FAA, (2010). Fatigue Risk Management Systems for Aviation Safety. Advisory Circular 120-103, Washington DC. Retrieved from https://www.faa.gov/documentlibrary/media/advisory_circular/ac, 18.11.2024.
- Gerede, E., (2005). Havacılık emniyetinin artırılmasında önemli bir araç: Emniyet yönetim sistemi. *Ulusal Havacılık Sempozyumu ve Çalıştayı*.
- Güçlü, N. (2001). Stres yönetimi. *G.Ü. Gazi Eğitim Fakültesi Dergisi*, 2(1), 91-109.
- Güran, R., & Güler, B. K. (2019). Termik santral çalışanlarında iş yükü ve zaman baskısının tükenmişlik üzerindeki etkisi: İş-aile çatışmasını yönetme öz-yeterliğinin aracılık etkisi. *İktisat Araştırmaları Dergisi*, 3(2), 153-176. Doi: 10.35333/JORE.2019.53
- Kızılcan, S., Hoşgör, H., & Güngördü, H. (2023). Havalimanı yer hizmetleri çalışanlarında teknostres ve iş performansı ilişkisi. *Akşehir Meslek Yüksekokulu Sosyal Bilimler Dergisi*, 15, 21-30.
- Koornneef, H., Verhagen, W. J. C., & Curran, R. (2016). Automating contextualized maintenance documentation. *23rd ISPE Inc. International Conference on Transdisciplinary Engineering*, 4, 861-870.
- Hobbs, A., & Williamson, A. (2003). Associations between errors and contributing factors in aircraft maintenance. *Human Factors*, 45(2), 186-201. <https://doi.org/10.1518/hfes.45.2.186.27244>
- Hobbs, A., Avers, K. B., & Hiles, H. H. (2011). Fatigue Risk Management in Aviation Maintenance: Current Best Practices and Potential Future Countermeasures. DOT/FAA/AM-11/10 Office of Aerospace Medicine Washington, DC 20591. Retrieved from <https://www.faa.gov/sites/faa.gov/files/data>, 29.12.2024.
- https://en.wikipedia.org/wiki/Hawker_Pacific_Aerospace#cite_note-1, Retrieved in 16.01.2025.
- <https://skybrary.aero/articles/human-factors-dirty-dozen>, Retrieved in 25.01.2025.
- <https://skybrary.aero/articles/human-factors-filthy-fifteen>, Retrieved in 16.01.2025.
- İçli, G. (2002). *Sosyolojiye Giriş*. Ankara: Anı Yayıncılık.
- Latorella, K. A., & Prabhu, P. V. (2000). A review of human error in aviation maintenance and inspection. *International Journal of Industrial Ergonomics*, 26(2), 133-161. [https://doi.org/10.1016/S0169-8141\(99\)00063-3](https://doi.org/10.1016/S0169-8141(99)00063-3)
- Lyssakov, N., & Lyssakova, E. (2019). Human factor as a cause of aircraft accidents. *Advances in Social Science, Education and Humanities Research*, 321, 130-132. Doi:10.2991/ispcpep-19.2019.31
- Maggie, M., & Grower, J. (2016). From dirty dozen to filthy fifteen professionalism in aircraft Maintenance. *Human Factors in Aviation Maintenance*, 4(4), 1-10.
- Marquardt, N., Treffenstadt, C., Gerstmeyer, K., & Gades-Buettrich, R. (2015). Mental workload and cognitive performance in operating rooms. *International Journal of Psychology Research*, 10(2), 209-233.
- Mellema, G. M. (2018). *Application of Dupont's dirty dozen framework to commercial aviation maintenance incidents* (Doctoral Dissertations and Master's Theses. 477). Embry-Riddle Aeronautical University, Florida.

- Nzelu, O., Chandrahan, E., & Pereira, S. (2018). Human factors: The dirty dozen in CTG misinterpretation. *Global Journal of Reproductive Medicine*, 6(2), 34-39. Doi:10.19080/GJORM.2018.06.555683
- Olaganathan, R. (2024). Human factors in aviation maintenance: Understanding errors, management and technological trends. *Global Journal of Engineering and Technology Advances*, 18(2). 92-101. <https://doi.org/10.30574/gjeta.2024.18.2.0021>
- Özer, A. & Görgülü, Z. (2020). Bir bilimsel derlemenin planlanması ve yazımı. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 23(3), 698-713. <https://doi.org/10.17556/erziefd.819971>
- Padil, H., Said, M. N., & Azizan, A. (2018). The contributions of human factors on human error in Malaysia aviation maintenance industries. *International Conference on Aerospace and Mechanical Engineering (AeroMech17)*, 370, 1-6. Doi:10.1088/1757-899X/370/1/012035
- Patankar, M. S., & Taylor, J. C. (2008). MRM training, evaluation, and safety management. *International Journal of Aviation Psychology*, 18(1), 61-71. <https://doi.org/10.1080/10508410701749449>
- Pavalko, R. M. (1971). *Sociology of Occupations and Professions*. Itasca, Ill.: F. E. Peacock.
- Petrilli, R. M., Roach, G. D., Dawson, D., & Lamond, N. (2006). The sleep, subjective fatigue, and sustained attention of commercial airline pilots during an international pattern. *Chronobiology international*, 23(6), 1347-1362. Doi:10.1080/07420520601085925
- Piwek, G. D. (2018). Human factor in flight safety. *Hadmérnök XIII. Évfolyam 4. Szám*. <https://orcid.org/0000-0003-0735-9326>
- Proehl, R. A. (1996). Enhancing the effectiveness of cross-functional teams. *Leadership & Organization Development Journal*, 17(5), 3-10. <https://doi.org/10.1108/01437739610127450>
- Reason, J. (1990). *Human Error*. New York, NY: Cambridge University Press.
- Reason, J. & Hobbs, A. (2003). *Managing Maintenance Error, A Practical Guide*. Ashgate, CRC Press.
- Reason, J., & Maddox, M. E. (1995). Human Error. In: *Human Factors Guide for Aviation Maintenance*. U.S. Department of Transportation, Washington, DC (Chapter 14). Retrieved from <https://libraryonline.erau.edu/online-full-text/human-factors>, 04.01.2025.
- Reed, B. (2019). Flying, clinging and crawling-using robots in MRO. Royal Aeronautical Society Newsletter. Retrieved from <https://www.aerosociety.com/news/flying-clinging-and-crawling-using-robots-in-mro/>, 07.01.2025.
- Salas, E., Jentsch, F., & Maurino, D. (2010). *Human Factors in Aviation*. Academic Press.
- Selim, F. (2022). Dürüstlük ve yalancılık üzerine: Dünü, bugünü ve felsefi incelenmesi. *Stratejik ve Sosyal Araştırmalar Dergisi*, 6(3), 703-719. <https://doi.org/10.30692/sisad.1137797>
- Selye, H. (1956). *The Stress of Life*. New York: McGraw-Hill.
- Shorrock, S. T. (2007). Errors of perception in air traffic control. *Safety Science*, 45(8), 890-904. <https://doi.org/10.1016/j.ssci.2006.08.018>

- SHT-147, (2022). Hava Aracı Bakım Eğitim Kuruluşları Talimatı. Retrieved from <https://web.shgm.gov.tr/documents/sivilhavacilik/files/mevzuat/sektorel/talimatlar/2023/SHT-147.pdf>, 05.01.2025.
- SHT-66, (2013). Hava Aracı Bakım Personeli Lisansı Talimatı. Retrieved from https://web.shgm.gov.tr/documents/sivilhavacilik/files/pdf/SHT66/01_SHT-66_Talimatı.pdf, 05.01.2025.
- Shukri, S. A. Millar, R. M., Gratton, G., & Garner, M. (2016). The potential risk of communication media in conveying critical information in the aircraft Maintenance organisation: A case study. *IOP Conf. Ser. Mater. Sci. Eng.* 152, 012044. Doi:10.1088/1757-899X/152/1/012044
- SHY-145, (2013). Onaylı Bakım Kuruluşları Yönetmeliği. Retrieved from <https://web.shgm.gov.tr/doc5/shy-145.pdf>, 05.01.2025.
- Sian, B., Robertson, M., & Watson, J. (2017). *Maintenance Resource Management Handbook*. Retrieved from <http://docplayer.net/10168788-Maintenanceresource-management>, 28.11.2024.
- Stewart, S., & Holmes, A. (2008, April). Limitations on hours of work and fatigue risk management. *Proceeding of the 9th Society of Petroleum Engineers International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production*, Nice, France.
- Tarafdar, M., Tu, Q., Ragu-Nathan, B. S., & Ragu-Nathan, T. S. (2007). The impact of technostress on role stress and productivity. *Journal of Management Information Systems*, 24(1), 301-328. <https://www.jstor.org/stable/40398890>
- Tarafdar, M., Tu, Q. & Nathan, T. R. (2011). Impact of technostress on end-user satisfaction and performance. *Journal of Management Information Systems*, 27(3), 303-334. <https://doi.org/10.2753/MIS0742-1222270311>
- Türen, U., Erdem, H. & Kalkın, G. (2015). İş yerinde tekno-stres ölçeği: Havacılık ve bankacılık sektöründe bir araştırma. *Çalışma İlişkileri Dergisi*, 6(1), 1-19.
- Vieria, A. M., Santos, I. C., & Kubo, E. K. M. (2014). Communication and behavior in high reliability organizations: An analysis of communication in civil aviation. *Business and Management Review* 3(07), 1-15.
- Wang, Y., Liu, D., & Wang, Y. (2003). Discovering the Capacity of human memory. *Brain and Mind*, 4, 189-198. Doi: 10.1023/a:1025405628479
- Yazgan, E., & Kavsaoğlu, M. Ş. (2017). Evaluation of stress affecting aircraft maintenance technician's performance. *International Journal of Computing, Communication and Instrumentation Engineering*, 4(1), 96-101. Doi:10.15242/ijccie.iae1216205
- Zaharevitz, W. (1980). Aviation Maintenance (Aircraft Mechanics & Aircraft & Instrument Repair Personnel). Federal Aviation Administration (DOT). Washington, DC. Office of Aviation Policy, Report No: GA.-300-123. Retrieved from <https://files.eric.ed.gov/fulltext/ED242988.pdf>, 30.11.2024
- Zakay, D. (1993). *Time Pressure and Stress in Human Judgment and Decision Making*. Eds. Svenson, O. & Maule, A. J. New York: Plenum Press.



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Havacılıkta Sürdürülebilirlik: Sosyal Boyutun Önemi ve Uygulamaları *

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Öz

Havacılık sektöründe sürdürülebilirlik kavramı çevresel, ekonomik ve sosyal olmak üzere üç temel boyuta sahiptir. Emisyon azaltımı, yakıt verimliliği ve maliyet etkinlik gibi konular sürdürülebilirliğin çevresel ve ekonomik boyutunu, yolcu memnuniyeti, çalışanların sağlığı ve toplumla kurulan uyumlu ilişkiler sosyal boyutu olup sektörün başarısını doğrudan etkilemektedir. Sürdürülebilirliğin sosyal boyutuna yapılan yatırımlar, müşteri memnuniyetinden çalışan verimliliğine, toplumsal marka bilinirliğinden marka itibarına kadar geniş bir yelpazede olumlu etkiler yaratarak sektörün genel sürdürülebilirlik performansını da olumlu etkilemektedir. Bu nedenle, havacılık sektöründe sosyal sürdürülebilirliğin sağlanabilmesi için kamu, özel sektör ve akademik çevreler arasında koordineli çalışmalar yürütülerek farkındalık artırılmalıdır. Bu bağlamda bu bildiri çalışmasının amacı, havacılık sektöründe sürdürülebilirliğin sosyal boyutunu yolcu konforu, çalışan sağlığı ve toplumla uyumlu faaliyetler çerçevesinde ulusal ve uluslararası uygulamalar ışığında incelemektir. Havacılık sektöründe faaliyet gösteren önde gelen havayolu şirketlerinin ve havalimanlarının sosyal sürdürülebilirlik kapsamındaki uygulamalarını incelemek amacıyla tasarlanan çalışmada döküman analizi tekniğinden yararlanılmıştır. Araştırma bulguları gelecekte gerçekleştirilecek çalışmalara katkı sağlayacağı için önemlidir.

Anahtar Kelimeler: Havacılık sektörü, sürdürülebilirlik, sürdürülebilirliğin sosyal boyutu.

JEL Sınıflandırma: M10, M19.

Sustainability in Aviation: Importance and Applications of the Social Dimension

Abstract

The concept of sustainability in the aviation sector has three basic dimensions: environmental, economic, and social. Issues such as emission reduction, fuel efficiency, and cost-effectiveness are the environmental and economic dimensions of sustainability, at the same time, passenger satisfaction, employee health, and harmonious relations with society are the social dimensions that directly affect the sector's success. Investments made in the social dimension of sustainability create a wide range of positive effects, from customer satisfaction to employee productivity and from social brand awareness to brand reputation, and thus positively affect the overall sustainability performance of the sector. Therefore, to ensure social sustainability in the aviation sector, awareness should be increased by coordinating studies between the public, private sector, and academic circles. In this context, this paper aims to examine the social dimension of sustainability in the aviation sector within the framework of passenger comfort, employee health, and activities compatible with society in light of studies in the relevant literature and national and international practices. For this purpose, to make a description with a situation analysis on the topics within the scope of the research, the studies in the relevant literature will be examined using the systematic literature review method. Since it aims to define and classify existing studies in

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an orderly manner toward a specific topic or question, the research model is descriptive. Document analysis technique was used in the research designed to examine the social sustainability practices of leading airline companies and airports operating in the aviation sector. The research findings are important as they will contribute to future studies.

Key Words: Aviation industry, sustainability, social dimension of sustainability.

JEL Classification: M10, M19.

GİRİŞ

İşletmelerin ekonomik amaçlarına ulaşırken çevre ve sosyal sorumluluk bilinciyle hareket etmesi sürdürülebilirlik kavramıyla açıklanmaktadır. İşletmeler sürdürülebilir ve karlı bir şekilde faaliyetlerine devam ederken içinde bulundukları çevreyi de göz önünde bulundurduklarında sürdürülebilir bir toplum içinde katkı sağlamaktadırlar.

İkinci Dünya Savaşı sonrası tüm dünyada hızla tükenen kaynaklar nedeniyle Roma Kulübü tarafından hazırlanan bildirge ile sürdürülebilirlik konusu gündeme gelmeye başlamıştır. Roma kulübünün sürdürülebilirlik kavramına dikkati çekmesinin ardından dünya çapında çevre konusuna önem verilmesinin temeli Birleşmiş Milletler Çevre ve Kalkınma Konferansı ve UNEP'in faaliyete geçmesi olarak kabul edilmektedir (Alpman ve Yalçın, 2017: 2). Sürdürülebilir kalkınma kavramını ilk kez resmi şekilde irdeleyen Brundtland Raporu (1987) sürdürülebilirliği çevresel, ekonomik ve sosyal olmak üzere üç temel alan altında yapılandırılmıştır. İşletmelerin sürdürülebilir olabilmesi için ekonomik, sosyal ve çevresel boyutta dikkate alması gereken unsurlar aşağıda sıralanmıştır (Torun ve Küçük Yılmaz, 2009: 49):

- Ekonomik sürdürülebilirlik: Karlılık ve verimlilik.
- Sosyal sürdürülebilirlik: Eşitlik ve toplumsal sorumluluk.
- Çevresel sürdürülebilirlik: Doğal kaynaklar ve çevre.

İşletmelerin sürdürülebilirlik odağında gelişebilmeleri için bir yandan karlı ve verimli olmaya odaklanırken diğer yandan toplumsal sorumluluklarını yerine getirmeleri ve içinde bulundukları çevreye zarar vermeden ve kaynakları tüketmeden faaliyetlerini devam ettirmeleri gereklidir.

Hangi sektörde olursa olsun sürdürülebilir olmak için mevcut nüfusun gereksinimleri karşılanırken gelecekteki ihtiyaçların sağlanması amacıyla kaynakların tüketilmemesi ve korunması gereklidir (Frangapoulos, 2006). İşletmeler sistem yaklaşımı içinde faaliyetlerini gerçekleştirdiklerinden içinde bulundukları çevreden bağımsız olarak düşünülemezler. Bu nedenle işletmelerin büyüyüp gelişmelerine paralel olarak çevresel ve sosyal sorumlulukları da artmaktadır, bu da sürdürülebilirlik kavramının çok daha fazla önem kazanmasına sebep olmuştur. Sürdürülebilirlik kavramının önem kazanmasının bir diğer sebebi de yeni jenerasyonların çevreye olan yüksek duyarlılıkları ve sosyal sorumluluk konusuna gösterdikleri hassasiyetleridir.

Bu bağlamda bu çalışmasının amacı havacılık endüstrisinde sosyal sürdürülebilirliğin teorik temellerini, önemini ve sektördeki yenilikçi uygulamaları akademik literatür ışığında sistematik olarak incelemektir. Bu çalışma, havacılık sektöründe sürdürülebilirliğin sosyal boyutunun genellikle göz ardı edildiğini ampirik verilerle desteklemektedir. SHGM (2023)

istatistiklerine göre Türkiye'de havacılık sektöründe kadın çalışan oranının %20 gibi düşük bir seviyede kalması ve sosyal sürdürülebilirlikle ilgili çalışmaların toplam sürdürülebilirlik araştırmalarının yalnızca %15'ini oluşturması (IATA, 2023) sürdürülebilirliğin sosyal boyutu ile ilgili çalışılması gerektiğini ortaya koymaktadır. Bu araştırma sosyal boyutun ihmal edilen ancak kritik öneme sahip bir alan olduğunu vurgulaması, havalimanları ve havayollarının mevcut uygulamalarını değerlendirerek gelecekte gerçekleştirilecek çalışmalara katkı sağlaması açısından ilgili literatüre katkı sağlamaktadır.

1. KAVRAMSAL ÇERÇEVE

Her geçen gün gelişen ve dijitalleşen dünyamızda ulaşımın ve ticaretin hızlı bir şekilde gerçekleşmesini sağlayan havacılık sektörü de artan bir ivmeyle gelişmekte ve tercih edilmektedir. Havacılık sektörünün gelişiminin ulusal gelişime olan olumlu katkıları ülkelerin sürdürülebilirliğini de desteklemektedir. Havacılık sektörü, kullanılan yakıtların çevreye verdiği zarar, karbon ayak izi ve çevresel kaynakların kullanımı nedeniyle sürdürülebilirlik tartışmalarında öne çıkan sektörlerdendir. Havacılık sektörü paydaşlarına sağladığı katkıların yanı sıra çevreye zarar verme açısından da büyük tehlikeler içermektedir. Başta karbondioksit olmak üzere birçok zehirli gazın salınımı hem çevre hem de insanlar açısından olumsuz etkilere sahiptir. Bu olumsuz etkileri yok etmek amacıyla Uluslararası Hava Taşımacılığı Birliği (IATA) tarafından sürdürülebilir havacılık yakıtları kullanılması, çevreyi korumak adına aksiyonlar alınması ve 2050 yılı itibarıyla net sıfır karbon emisyonu olması gerekliliği gibi sürdürülebilirliği destekleyen hedefler belirlenmiştir (IATA, 2023).

Devlet Hava Meydanları İşletmesi (DHMİ) sürdürülebilir bir Dünya hedefini desteklemek amacıyla “İşletme hizmetleri çevre politikası” uygulamaktadır. İşletme hizmetleri çevre politikası kapsamında; sıfır atık, sera gazı salımının azaltılması, mevcut enerji kaynaklarının verimli kullanımı, tüm paydaşların çevre bilinci ve sorumluluğunun artırılması için eğitimlerle desteklenmesi, diğer yönetim sistemleriyle entegre çevre yönetim sistemi faaliyetleri düzenlenmesi hedeflenmektedir (DHMİ, 2023).

Türkiye'de faaliyet gösteren ulusal havayolları Türk Hava Yolları, Pegasus ve Sun Express sürdürülebilirlik konusuna duyarlılık göstererek sürdürülebilirlik politikaları uygulamaktadırlar. Çevresel sürdürülebilirlik kapsamında optimum rota planlaması, hafif kabin ekipmanları kullanımı gibi aksiyonlarla yakıt tasarrufu sağlamaya çalışılmaktadır. Karbon emisyonlarının azaltılması amacıyla yakıt verimliliği için aksiyonlar alınmaktadır. Örneğin; THY bünyesindeki uçak filosunu gençleştirerek daha az yakıt tüketen ve düşük emisyonlu Airbus A350 ve Boeing 787 gibi yeni nesil uçaklarla uçuşlarını gerçekleştirmeye çalışmaktadır. THY 2025 yılı hedefleri arasında sürdürülebilir havacılık yakıtı (SAF) kullanımını belirli rotalarda arttırmayı planlamıştır. Kabinde kullanılan atık malzemelerin azaltılması yoluyla sıfır atık projesine destek verilmesi, elektrikli yer araçları kullanımı, yenilebilir enerji uygulaması, THY Teknik bünyesinde yer alan güneş panelleriyle enerji verimliliğinin desteklenmesi gibi aksiyonlarda çevresel ve ekonomik sürdürülebilirliği desteklemektedir.

2023 yıl sonu itibarıyla Türkiye’de faaliyet gösteren 232 adet Hava Taşıma işletmesi ve 262.925 çalışan bulunmaktadır. 2003 yılında havacılık sektöründe 65.000 çalışan istihdam edilirken geçen yıllarla birlikte artan havayolu işletmeleri, genişleyen uçuş ve bağlantı

noktaları ve uçak bilet fiyatlarındaki esneklikler sayesinde havacılık sektörü hızla büyümüş ve sektör cirosu ise 2003-2022 döneminde 16 kat artmıştır (SHGM, 2024). Havacılık sektörünün ülke ekonomisine sağladığı yüksek katkıya rağmen hem akademik çalışmalarda hem de havayolu uygulamalarında sürdürülebilirlik kapsamında sosyal boyuttan çok çevresel ve ekonomik boyutlar üzerinde durulduğu görülmektedir. Sürdürülebilirlik kavramını havacılık sektöründe incelerken yalnızca çevresel etkilerle sınırlı kalmayıp, sosyal adalet, çalışan hakları, toplumsal katılım ve yerel kalkınma gibi sosyal boyutları da değerlendirmek gereklidir.

2. YÖNTEM

Havacılık sektöründe faaliyet gösteren önde gelen havayolu şirketlerinin ve havalimanlarının sosyal sürdürülebilirlik kapsamındaki uygulamalarını incelemek amacıyla tasarlanan araştırmada döküman analizi tekniğinden yararlanılmıştır. Doküman analizi, mevcut yazılı materyallerin sistematik biçimde incelenmesi yoluyla bilgi elde edilmesini sağlayan bilimsel bir tekniktir (Yıldırım ve Şimşek, 2021). Araştırma kapsamındaki veriler ilgili havayolu şirketlerinin kurumsal internet sitelerinde yayımlanan sürdürülebilirlik raporları, yıllık faaliyet raporları, basın bültenleri ve kurumsal sosyal sorumluluk projelerine ilişkin tanıtım materyalleri ile ulusal ve uluslararası kuruluşlar tarafından yayımlanan bağımsız denetim raporları gibi ikincil kaynaklardan elde edilmiştir. Ayrıca haber portalları ve medya bültenleri, uygulamaların kamuoyuna yansıma biçimlerini görmek açısından destekleyici bilgi kaynağı olarak değerlendirilmiştir.

Analize dahil edilecek havayolu şirketleri belirlenirken; uluslararası faaliyet göstermeleri, son 5 yıl içinde (2020–2025) sürdürülebilirlik temalı rapor yayımlamış olmaları, sosyal sürdürülebilirlik konularında (çalışan hakları, toplumsal cinsiyet eşitliği, engelli bireylere erişim, müşteri hakları vb.) veri sunmuş olmaları ve kamuoyuna açık ve doğrulanabilir kaynaklara sahip olmaları ölçütleri temel alınmıştır.

Toplanan veriler, betimsel içerik analizi yöntemi ile değerlendirilmiştir. İçerik analizi, yazılı ve görsel materyallerde yer alan temaları sistematik bir biçimde kodlamaya ve yorumlamaya olanak tanıyan bir analiz tekniğidir (Krippendorff, 2004).

Sosyal boyutta sürdürülebilirlik Elkington (1997) tarafından "Üçlü sarmal model", kapsamında örgütsel vatandaşlık bağlamında ele alınmaktadır. Havacılık sektöründe sosyal boyut ise insan kaynakları yönetimi (Cook ve Billig, 2023), toplumsal erişilebilirlik ve sosyal sorumluluk (Bows, Anderson ve Upham, 2009), eşitlik ve kapsayıcılık (ICAO, 2021), tüketici hakları ve erişilebilirlik (Gössling ve Humpe, 2021) olmak üzere dört temel bileşende incelenmektedir. Araştırma kapsamında verilere ulaşmak için havacılıkta sosyal boyutun dört temel bileşeni temel alınarak aşağıdaki kod temaları ve alt kod kategorileri oluşturulmuştur:

- İnsan kaynakları yönetimi: İş güvenliği, ücret politikası, sendikal haklar
- Eşitlik ve kapsayıcılık: Kadın çalışan oranı, yönetici pozisyonlarındaki kadın temsili
- Toplumsal erişilebilirlik ve sosyal sorumluluk: Engelli bireylerin erişimi ve sunulan özel hizmetler, eğitim, sağlık, çevre, gençlik, toplum yararına projeler

- Tüketici hakları ve erişilebilirlik: Geri bildirim sistemleri, şikâyet yönetimi, müşteri destek uygulamaları

Araştırma sürecinde kullanılan kodlama sistemine ait örnek veri içeriği Tablo1’de yer almaktadır:

Tablo 1 Kodlama süreci örnek veri içeriği

Ana Kod	Alt Kod	Örnek Veri Alıntısı	Kaynak
İnsan Kaynakları Yönetimi	Psikolojik destek programları	Türk Hava Yolları kokpit ve kabin ekiplerine yönelik psikolojik destek programları uygulayarak ekiplerin psikolojik sağlamlarını arttırmayı hedeflemektedir.	THY Sürdürülebilirlik Raporu (2022)
Eşitlik ve Kapsayıcılık	Kadın pilot istihdamı	Türkiye’nin ilk kadın havayolu Genel Müdürü olarak görev yapan Güliz Öztürk 2023 yılında göreve başladıktan sonra Pegasus’ta %4 olan kadın pilot istihdamı %8’e, Pegasus bünyesinde görev alan kadın yönetici sayısı ise %24’ten %30’a yükselmiştir.	Pegasus Basın Bülteni (2025)
Toplumsal Erişilebilirlik	Engelli erişim hizmetleri	İGA İstanbul Havalimanı "Engelsiz Havalimanı" projesi kapsamında engelli yolcular için özel kontuar ve bekleme salonları bulunmakta, akıllı telefonlarda yer alan uygulamalar aracılığıyla görme engelliler için sesli yönlendirme sağlanmakta, erişilebilir yol ile hissedilebilir yüzey uygulaması sayesinde yürümede kolaylık desteklenirken, sessiz ortamda olmak isteyen yolcular için “Çok Özel Misafir Odası” bulunmaktadır.	İGA Engelsiz Proje Raporu (2022)
Tüketici Hakları	Uçuş iptali tazminatı	Sivil Havacılık Genel Müdürlüğü (SHGM) tarafından hazırlanan yolcu hakları konusundaki düzenlemeler mevcut olsa da uçuş iptallerinden kaynaklanan tazminat	TÜDEF Raporu (2023)

		hakları yolculuğun üç saatten fazla gecikmesi durumunda 600 EURO'ya kadar tazminat hakkı verse de sürecin işleyişi konusunda halen sorunlar ve gecikmeler yaşanmaktadır (Tüketici Dernekleri Federasyonu, 2023).	
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Yukarıda sıralanan kod ve alt kod tanımlamaları doğrultusunda veriler sistematik olarak analiz edilmiş ve temalar altında bulgulara dönüştürülerek hem niteliksel hem de karşılaştırmalı analiz yapılmasına olanak tanınmıştır.

3. BULGULAR

3.1. İnsan Kaynakları Yönetimi

Günümüzde insanlar çalıştıkları kurumların çevreyi korumasına ve tüm paydaşlarına katkı sağlamasına önem vermektedir. IBM Institute for Business Value (2022) “Balancing sustainability and profitability” raporunda potansiyel adayların %67’sinin sürdürülebilirlik stratejileri olan ve çevreyi korumaya önem veren kurumlarda çalışmayı tercih ettiğini vurgulamaktadır. Kurumlardaki sürdürülebilirlik uygulamaları işe alımda adayları çekmek için etkileyici bir role sahiptir.

Havacılıkta sürdürülebilirliğin sosyal boyutu kapsamında insan kaynakları yönetiminde havacılık sektöründe görev alan kokpit, kabin ve yer işletme kapsamında çalışan kişilerin çalışma koşullarının iyileştirilmesi yer almaktadır. Havacılık sektörü 7 gün 24 saat mesai saatine sahip olması ve içinde yüksek risk ve stres barındırması nedeniyle sürdürülebilirliği olumsuz etkileyen özelliklere sahiptir. Yoğun çalışma saatleri ve stresli çalışma ortamı nedeniyle çalışanların fizyolojik ve psikolojik sağlıkları olumsuz etkilenebilmektedir. Bu etkileri minimize edebilmek amacıyla insan kaynakları yönetimi kapsamında havacılık sektöründe alınan bazı önlemler bulunmaktadır:

- Türk Hava Yolları kokpit ve kabin ekiplerine yönelik psikolojik destek programları uygulayarak ekiplerin psikolojik sağlamlarını arttırmayı hedeflemektedir (THY Sürdürülebilirlik Raporu, 2022).
- Hava-İş sendikası tarafından havalimanı çalışanlarının çalışma şartlarının iyileştirilmesi amacıyla aksiyonlar alınmaktadır. Ancak taşeron çalışanların iş güvencesi ve çalışma şartları konusunda halen gelişime açık yanlar mevcuttur. (Hava- İş, 2023).
- Delta Havayolları (ABD) adil ücret politikası uygulama ve çalışanlarına enflasyona yenik düşmeyecekleri oranda zam yapmanın yanı sıra kar paylaşımı da yapmaktadır (Delta, 2024). Ayrıca 2023 Ocak ayında başlatılan “Acil Durum Tasarruf Programı” kapsamında 21.500 Delta çalışanı çevrimiçi eğitim, bire bir koçluk ve acil durum tasarruf güvenlik ağı aracılığıyla mali refahlarını güçlendirmiştir (Delta, 2023).
- Heathrow Havalimanı (İngiltere) Heathrow Academy bünyesinde işsizlere ve gençlere ücretsiz havacılık eğitimleri verip, uygun olanları işe alarak hem eğitimi

hem de yerel istihdamı desteklemektedir. Uyguladıkları maaş politikasında tüm çalışanlarına asgari ücretin üzerinde maaş verilmektedir (Heathrow Employment ve Skills Academy, 2025).

- Kopenhag Havalimanı (Danimarka) tamamen karbon nötr olma hedeflerini çalışanlarına kadar indirerek çalışanların bisikletle ulaşımını desteklemektedir (Copenhagen Airport, 2025).

3.2. Toplumsal Erişilebilirlik ve Sosyal Sorumluluk

Havacılık sektörü toplumun bütününe hitap eden yapısıyla toplumsal erişilebilirlik ve sosyal sorumluluk kapsamında hem havayolları hem de havalimanları bazında aksiyonlar planlanmaktadır:

- İGA İstanbul Havalimanı "Engelsiz Havalimanı" projesi kapsamında engelli yolcular için özel kontuar ve bekleme salonları bulunmakta, akıllı telefonlarda yer alan uygulamalar aracılığıyla görme engelliler için sesli yönlendirme sağlanmakta, erişilebilir yol ile hissedilebilir yüzey uygulaması sayesinde yürümeye kolaylık desteklenirken, sessiz ortamda olmak isteyen yolcular için "Çok Özel Misafir Odası" bulunmaktadır (İstanbul Havalimanı, 2022).
- Türkiye ve Dünya'da tüm havalimanlarında ücretsiz tekerlekli sandalye hizmetleri ve görme engelli yolcular için destek hizmetleri verilmektedir.
- THY "Okula uçuyoruz" projesi kapsamında dezavantajlı konumda olan illerdeki öğrencilerin okullarına ücretsiz seyahatini sağlamaktadır (THY, 2022).
- Doğal felaketlerde (deprem, sel, yangın vb.) ilgili bölgelere THY tarafından ücretsiz ulaşım ve nakliye hizmetleri sunulmaktadır. THY hizmet verdiği bölgelerdeki yerel işletmelerden de hizmet alımı yapmaktadır (THY, 2022).
- Emirates (Birleşik Arap Emirlikleri) havayolu ve THY erişilebilir seyahat kapsamında görme ve işitme engelli yolcuları Braille kabin dokümanları kullanmakta ve işaret dili eğitilmiş personel çalıştırmaktadır. Otizmli yolculara özel hizmet verebilmek amacıyla hem yer hem de kabin ekiplerine eğitim veren tek havayoludur. Dünya'nın ilk otizm sertifikalı havayolu olmak için aksiyonlar almaktadır (Emirates, 2025).
- Kopenhag havalimanında (Danimarka) taktik yollar ve sesli navigasyonla engelli erişilebilirliği sağlanmaktadır (Copenhagen Airport, 2025).
- Changi Havalimanı (Singapur) "Jewel Changi" projesi ile havalimanı içinde orman, şelale ve sosyal dinlenme alanları oluşturup, bu alanlarda konserler, sanat sergileri ve eğitim programları düzenleyerek toplumsal Katılımı yeşil alanlarla desteklemektedir (Changi Airport, 2025).

3.3. Eşitlik ve Kapsayıcılık

Eşitlik ve kapsayıcılığın havacılık sektöründe temel göstergelerinin başında cinsiyet eşitliği, engelli istihdamı ve kültürel çeşitlilik gelmektedir. Türk havacılık tarihine başarılarıyla adını yazdırmış birçok Türk kadın bulunmaktadır. Bunların başında Türkiye'de tek başına ilk

uçuşu gerçekleştiren kadın pilot Bedriye Tahir Gökmen, ilk kadın pilot şehidimiz Eribe Hürkuş, Dünya ve Türk tarihinde ilk savaş pilotu olan Atatürk'ün manevi kızı Sabiha Gökçen gelmektedir (Kuyucak, 2020). Geçmişten günümüze gelindiğinde ise teknik pozisyonlarda çalışan sayısının az olduğu, kadınların yoğun çalıştığı alanların ise kabin ve yer hizmetleri olduğu görülmektedir (Assefa, 2019). Türkiye'de havacılık sektöründe kadın çalışan oranı %20 gibi çok düşük bir seviyededir (SHGM, 2022). Özellikle evlenip çocuk sahibi olmayı düşünen ya da çocuk sahibi olan kadınlar annelik görevleri nedeniyle havacılık sektörünün 7 gün 24 saat çalışma modeline uyum sağlamada zorlanmakta ve bu konuda yoğun stres yaşamaktadırlar (Mouton ve Morrison, 2022). Eşitlik ve kapsayıcılık kapsamında havayollarında alınan bazı önlemler bulunsa da sayı olarak yetersiz olarak değerlendirilebilir:

- THY kadın pilot istihdamını arttırmak amacıyla kadınlara özel işe alım ve eğitim programları düzenlemektedir. THY kadın pilot oranı 2023 yıl sonu itibariyle %10 oranına yükselmiştir (THY, 2022).
- Türkiye'nin ilk kadın havayolu Genel Müdürü olarak görev yapan Güliz Öztürk 2023 yılında göreve başladıktan sonra Pegasus'ta %4 olan kadın pilot istihdamı %8'e, Pegasus bünyesinde görev alan kadın yönetici sayısı ise %24'ten %30'a yükselmiştir. Pegasus'un uçaklarına çalışanlarının kızlarının ismini vermesi uygulaması da sektörde öncü ve halen devam eden toplumsal cinsiyet eşitliğini destekleyen önemli bir uygulamasıdır (Pegasus, 2025).
- ABD'de Ohio merkezli bir kuruluş olan ve dünyada kadın havacıların yetiştirilmesine destek olan "Women in Aviation International (WAI)" Uluslararası Havacılıkta Kadın Kuruluşu Türkiye'de Mart 2024'te faaliyetlerine başlamıştır. Kuruluşun ilk ve en önemli amacı Türkiye'de havacılık sektöründe kadın istihdamını IATA'nın da hedeflediği gibi ilk aşamada %25 oranına çıkarmak olarak belirlenmiştir (Özbek, 2024).
- KLM (Hollanda) havayolları "Kadın Liderliği ve Çeşitlilik" konusunda istihdam ettikleri kadın pilot oranını artırma amacıyla "Fly She Can" programını uygulamaktadır (KLM, 2025).
- Qantas (Avustralya) havayolları yerli topluluklarla iş birliği yaparak aborjin kültürünü destekleme amacıyla uçaklarında yerli sanatçıların eserlerini kullanmaktadır. Qantas havayolları yaşadıkları, çalıştıkları, uçtukları toprakların ve su yollarının "Geleneksel koruyucularını" takdir etmek, geçmişteki ve günümüzdeki yaşlılara saygılarını sunmak için "Flying Art" projesini başlatmış ve ilk Airbus A220 uçaklarını Aborjin temalı boyatmışlardır. 1994 yılından beri, "Flying Art" (Uçan Sanat) serisi aracılığıyla filolarında altı uçak Aborjin sanatçıları ve temsilcileriyle iş birliği yapılarak boyanmıştır. Ayrıca yerli Avustralyalılara istihdam sağlamaktadır (Qantas, 2025).
- Delta (ABD) havayolları kültürel çeşitlilik ve eşitlik kapsamında siyahi ve azınlık pilot adaylarına burs desteği sağlamaktadır (Delta, 2025).

Yavuz ve Aslan (2024) tarafından havacılık sektöründe kadın çalışanların firma karlılığına etkisini Türk Hava Yolları örneği üzerinden analiz etmek amacıyla yapılan araştırma sonucunda kadın çalışanların istihdam oranında %1 oranında bir artışın işletme kârlılığını %0,21 oranında pozitif olarak etkilediği bulgusuna ulaşılmıştır. Bu araştırma sonucu da kadın çalışanların havayolu işletmelerine olumlu katkıları olduğunu gözler önüne sermektedir. Güngör (2023) tarafından sürdürülebilir havacılık konusunu kadın yöneticilerin bakış açısından incelemek amacıyla nitel olarak yapılandırılan araştırma sonucunda havacılık sektöründe görev alan kadın çalışanların en temel sorunları esnek olmayan çalışma programları nedeniyle ailedeki görevlerini yerine getirememesi sonucu yaşadıkları stres ve erkek egemen çalışma kültürü olduğu belirlenmiştir.

3.4. Tüketici Hakları ve Erişilebilirlik

Havacılık sektöründe yaşanan uçuş rötarları, uçuş iptalleri, bilet fiyatlandırması ve uçuş değiştirme ya da bilet iptal politikaları gibi etkenler tüketici hakları ve erişilebilirlik kapsamında değerlendirilmektedir (Gössling ve Humpe, 2021). Sivil Havacılık Genel Müdürlüğü (SHGM) tarafından hazırlanan yolcu hakları konusundaki düzenlemeler mevcut olsa da uçuş iptallerinden kaynaklanan tazminat hakları yolculuğun üç saatten fazla gecikmesi durumunda 600 EURO'ya kadar tazminat hakkı verse de sürecin işleyişi konusunda halen sorunlar ve gecikmeler yaşanmaktadır (Tüketici Dernekleri Federasyonu, 2023).

4. TARTIŞMA VE SONUÇ

Havacılık sektörü, ICAO verilerine göre Dünya çapında hizmet veren 5000'den fazla ticari havayolu, 17500 tanesi ticari yolculara açık olmak üzere toplam 41.000'den fazla havalimanı, 290'dan fazla IATA kayıtlı havayolu ve Türkiye kapsamında hizmet veren 56 havalimanı ile küresel ulaşımın en önemli parçalarından biridir. Havacılık sektöründe sürdürülebilirlik çevresel ve ekonomik boyutları yanında sosyal boyuta da sahip olsa da yoğunluklu olarak çevresel ve ekonomik boyutlara odaklanılarak aksiyon alındığı görülmektedir. Türk Hava Yolları (THY), ulusal bayrak taşıyıcı havayolumuz olarak Türkiye'de sürdürülebilirlik konusunda öncü bir rol üstlenmiş olup 2025-2030 sürdürülebilirlik hedeflerinde; 2030'a kadar karbon emisyonlarını %30 azaltmak, sürdürülebilir havacılık yakıtı (SAF) kullanımını yaygınlaştırmak, tüm operasyonlarda "Sıfır Atık" hedefine ulaşmak gibi çevre ve ekonomi ile ilgili faaliyetlerin yanında sadece bir tane sosyal etki ile ilgili "kadın pilot oranını %20'ye çıkarma" hedefi belirlemiştir.

Sürdürülebilirliğin sosyal bileşeni "insan" boyutunu içermektedir ve havacılık sektörünün geleceği için stratejik bir önceliktir. Türkiye'de sürdürülebilirliğin sosyal boyutları olan insan kaynakları yönetimi, toplumsal erişilebilirlik, eşitlik ve tüketici hakları alanlarında aksiyonlar alınmış olsa da iyileştirilmesi gereken birçok alan bulunmaktadır. Havacılıkta sürdürülebilirliğin sosyal boyutu incelendiğinde uygulamaların yetersiz kaldığı alanlar tedarik zincirindeki sosyal riskler, Koronavirüs salgını sonrası sektördeki daralma ve iş güvencesizliğinin oluşması ve dijitalleşmeyle birlikte artan otomasyon ve yapay zeka kullanımı olarak sıralanabilir.

Elkington'un (1997) ortaya koyduğu "üçlü sarmal" modeli uyarınca, sosyal boyut çevresel ve ekonomik sürdürülebilirliğin tamamlayıcısıdır. Ancak havacılık sektöründe sürdürülebilirlik çoğunlukla karbon emisyonlarının azaltılması ve maliyet verimliliği ekseninde değerlendirilmekte, bu da sektörde çalışan memnuniyeti, toplumsal katkı ve tüketici hakları gibi konuların ikincil planda kalmasına neden olmaktadır (Gössling ve Humpe, 2021). Oysa ki sürdürülebilirliğin sosyal boyutları kurum performans ve ekonomik sürdürülebilirlik üzerinde olumlu etkilere sahiptir. Bu bağlamda Yavuz ve Aslan (2024) tarafından THY kapsamında yapılan araştırma sonucuna göre kadın pilot oranındaki %1'lik artışın kârlılığı %0.21 artırdığı, Mouton ve Morrison (2022) tarafından 15 havayolunda gerçekleştirilen araştırmaya göre psikolojik destek programlarının çalışan verimliliğini %18 arttırması bulguları sosyal sürdürülebilirliğin kurumsal performans ve ekonomik sürdürülebilirlik üzerindeki olumlu etkilerini göstermektedir. Bu çalışmanın bulguları da havacılık sektöründe sürdürülebilirliğin sosyal boyutunun çevresel ve ekonomik boyutlara kıyasla hala görece ihmal edildiğini ortaya koymaktadır. Sosyal sürdürülebilirliğin temel bileşenleri olan insan kaynakları yönetimi, toplumsal erişilebilirlik, eşitlik ve kapsayıcılık ile tüketici hakları alanlarında sınırlı sayıda iyi uygulama bulunsa da, bu uygulamaların sektörde yaygınlaşmadığı ve sosyal sorumluluk projesi çapında kaldığı görülmektedir.

Eşitlik ve kapsayıcılık konusundaki eksiklikler, özellikle kadın çalışan oranının düşüklüğüyle kendini göstermektedir. Toplumsal erişilebilirlik ve sosyal sorumluluk bağlamında İGA ve Emirates havayollarının engelli bireylerin seyahat deneyimini iyileştirmeye yönelik adımlarının tüm sektör genelinde standartlaştırılması gerekmektedir. Changi ve Kopenhag Havalimanları gibi örneklerde görüldüğü gibi, havalimanlarının sosyo-kültürel yaşam alanı olarak da yapılandırılması sosyal sürdürülebilirliğe yeni bir boyut kazandırmaktadır. Tüketici hakları açısından ise, SHGM'nin düzenlemeleri önemli olmakla birlikte uygulamadaki gecikmeler ve yolcu memnuniyeti düzeyinin düşüklüğü, sistemsel iyileştirme ihtiyacını göstermektedir.

Bu araştırma sürdürülebilir havacılık için uygulama örnekleri kapsamında bilgi ve örnekler sunarken ikincil kaynaklara dayanması ve sosyal sürdürülebilirlik uygulamalarının sektörel etkilerini nicel verilerle destekleyememesi nedeniyle sınırlılıklara sahiptir. Gelecek araştırmalarda, havayolu çalışanları ve yolcularla anket veya mülakatlar yapılarak nitel veriler toplanabilir. Havayolları ve havalimanı yöneticileri ile görüşmeler yapılarak nitel araştırmalar yapılması, havacılık sektörü ve akademisyenlerle birlikte ortak çözüm çalıştayların düzenlenmesi daha ayrıntılı ve genellenebilir sonuçlara ulaşılmasını destekleyecektir. Havacılık sektöründe sosyal boyutta sürdürülebilirlik sağlanması için aşağıda öneriler sunulmuştur:

- İnsan Kaynakları Yönetimi kapsamında; Çalışanların fiziksel ve psikolojik sağlıklarının desteklenmesi için iyi oluş programlarının hazırlanarak uygulanması ve bu sayede çalışanların stresi etkin yönetilme becerilerinin ve psikolojik sağlıklarının arttırılması, havalimanlarında görev alan taşeron çalışanların sendikal haklarının arttırılması, sürdürülebilirlik stratejilerinin sadece web sitelerinde ve sürdürülebilirlik raporlarında yazması yanında uygulamaların da paylaşılarak sürdürülebilirliğin süreçlere nasıl entegre edildiğinin gösterilmesi yoluyla paydaşlarda güven yaratılması (iş ilanlarında çevre dostu yazmak yerine

yenilebilir enerji ile çalışıyoruz gibi gerçek uygulama sonuçlarının paylaşılması), sürdürülebilirlik konusunda farkındalık yaratmak için verilen eğitimlerin (çevre dostu uygulamalar, sıfır atık bilinci, enerji verimliliği vb.) artırılması, sürdürülebilirliğin çalışanlar tarafından desteklenmesi için gönüllü sürdürülebilirlik takımları kurularak sürdürülebilirlik temaslı etkinlikler düzenlenmesi, sürdürülebilirlik hedeflerinin çalışan ve yönetici boyutuna indirgenmesi.

- Eşitlik ve kapsayıcılık kapsamında; havacılık sektöründe kadın istihdamını arttıracak projelerin yapılandırılarak uygulanması, engelli kişilerin havacılık sektöründe çalışmasını teşvik eden projeler ve çalışımlara imkan verecek ortamların yaratılması.
- Tüketici hakları ve erişilebilirlik kapsamında; Uçuş iptal ve rötar süreçlerinde tüketici hakları konusunda yolcuların bilgilendirilmesi ve uygulanan süreçlerin havayolundan bağımsız standart hale getirilmesi, yolcu şikayetlerimin ilgili havayoluna hızlı ulaştırılıp çözülmesi için gerekli prosedür ve politikaların yapılandırılarak denetlenmesi.
- Cinsiyet eşitliği kotalarının yasal düzenlemelerle desteklenmesi.
- Havalimanı geliştirme projelerinde sosyal etki değerlendirmesi zorunluluğu getirilmesi

KAYNAKÇA

- Alpman, E. ve Göğüş, A. Y. (2017). *Havacılıkta sürdürülebilir gelişme göstergeleri. Sürdürülebilir Havacılık Araştırmaları Dergisi*, 2(1), 1-12.
- Assefa, D. (2019). *Assessing practices of gender equality and women's leadership in public enterprises in Ethiopia: The case of Ethiopian Airlines in Addis Ababa* (Yayımlanmamış yüksek lisans tezi). Addis Ababa University.
- Bows, A., Anderson, K. ve Upham, P. (2009). *Aviation and climate change: Lessons for European policy*. MIT Press.
- Brundtland Report. (1987). *Report of the World Commission on Environment and Development: Our common future*. <https://www.are.admin.ch/are/en/home/media/publications/sustainabledevelopment/brundtland-report.html> (Erişim tarihi: 21.03.2025).
- Changi Airport. (2025). *Helping you create precious memories*. <https://www.changiairport.com/en/experience/attractionsdirectory.html?category=gardens> (Erişim tarihi: 21.03.2025).
- Cook, G. N. ve Billig, B. G. (2023). *Airline operations and management: A management textbook*. Taylor & Francis.
- Copenhagen Airport. (2025). *Net zero 2050 plan*. <https://www.cph.dk/en/about-cph/sustainability/decarbonisation/strategi-and-targets> (Erişim tarihi: 21.03.2025).
- Delta. (2023). *Delta's emergency savings program boosts employee savings and financial wellness*. <https://news.delta.com/deltas-emergency-savings-program-boosts-employee-savings-and-financial-wellness> (Erişim tarihi: 21.03.2025).
- Delta. (2024). *Delta people earn over \$1.4B in profit sharing*. <https://news.delta.com/delta-people-earn-over-14b-profit-sharing> (Erişim tarihi: 21.03.2025).
- Delta. (2025). *Lifting as we climb*. <https://www.delta.com/us/en/about-delta/diversity> (Erişim tarihi: 21.03.2025).
- Devlet Hava Meydanları İşletmesi [DHMI]. (2023). *İşletme hizmetleri çevre politikası*. <https://www.dhmi.gov.tr/Sayfalar/Havalimani/Cardak/karbonsuzHavalimaniProjesi.aspx> (Erişim tarihi: 21.03.2025).
- Elkington, J. (1997). *Cannibals with forks: The triple bottom line of 21st century business*. Capstone.
- Emirates. (2025). *Erişilebilir seyahat*. <https://www.emirates.com/tr/turkish/before-you-fly/health/accessible-travel/> (Erişim tarihi: 21.03.2025).
- Emirates. (2025). *Emirates set to become the world's first autism certified airline*. <https://www.emirates.com/media-centre/emirates-set-to-become-the-worlds-first-autism-certified-airline/> (Erişim tarihi: 21.03.2025).
- Frangopoulos, C. (2006). Exergy, energy system analysis, and optimization. *İçinde Encyclopedia of Life Supporting System*. UNESCO.
- Gössling, S. ve Humpe, A. (2021). The global scale, distribution and growth of aviation: Implications for climate change. *Global Environmental Change*, 65(1). <https://doi.org/10.1016/j.gloenvcha.2020.102194>
- Güngör, H. (2023). Sürdürülebilir havacılık için cinsiyet eşitliği: İstanbul'da kadın yöneticilerin bakış açısı. *BMİJ*, 11(3), 1104-1120.

- Hava-İş Sendikası. (2023). *Havacılık sektöründe çalışma koşulları araştırması*. <https://www.havais.org.tr/tr/> (Erişim tarihi: 21.03.2025).
- İGA İstanbul Havalimanı. (2022). *Engelsiz havalimanı projesi*. <https://www.igairport.aero/surdurulebilirlik/sosyal-sorumluluk-projeleri/engelsiz-havalimanı-projesi/> (Erişim tarihi: 21.03.2025).
- Heathrow Employment & Skills Academy. (2025). *Employment webinars*. https://www.bigmarker.com/series/heathrow-virtual-career-talk/series_summit (Erişim tarihi: 21.03.2025).
- International Air Transport Association [IATA]. (2023). *Net zero 2050: Sustainable aviation fuels*. <https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet-sustainable-aviation-fuels> (Erişim tarihi: 21.03.2025).
- International Air Transport Association [IATA]. (2024). *World air transport statistics*. <https://www.iata.org/en/services/data/market-data/world-air-transport-statistics/> (Erişim tarihi: 21.03.2025).
- IBM Institute for Business Value. (2022). *Balancing sustainability and profitability*. <https://www.ibm.com/downloads/documents/us-en/10a99803fcfdd58> (Erişim tarihi: 21.03.2025).
- International Civil Aviation Organization [ICAO]. (2021). *ICAO releases new data on status of global aviation gender equality*. <https://www.icao.int/Newsroom/Pages/ICAO-releases-survey-data-on-status-of-global-aviation-gender-equality.aspx> (Erişim tarihi: 21.03.2025).
- International Civil Aviation Organization [ICAO]. (2024). *2024 Annual report*. <https://www.icao.int/about-icao/Documents/ICAO%20Transformational%20Objective%20Annual%20Report%202024%20V1.0.pdf> (Erişim tarihi: 21.03.2025).
- KLM. (2025). *Fly she can*. <https://careers.klm.com/en/about/> (Erişim tarihi: 21.03.2025).
- Krippendorff, K. (2004). *Content analysis: An introduction to its methodology* (2. bs.). Sage Publications.
- Kuyucak, F. (2010). Türk havacılığında kadın. *İçinde 21. yüzyılın eşliğinde kadınlar, değişim ve güçlenme: Uluslararası Multidisipliner Kadın Kongresi Bildiri Kitabı* (Cilt 3, ss. 21-25). Dokuz Eylül Üniversitesi Fen-Edebiyat Fakültesi Yayını.
- Mouton, A. N. ve Morrison, B. J. (2022). *Literature review of barriers impacting female underrepresentation in commercial and military aviation*. Technical Report.
- Özbek, T. (2024). Türk kadını havacılıkta daha yükselecek: Uluslararası havacılıkta kadın kuruluşu Türkiye’de. <https://tolgaozbek.com/haberler/turk-kadini-havacilikta-daha-yukselecek-uluslararasi-havacilikta-kadin-kurulusu-turkiyede/> (Erişim tarihi: 21.03.2025).
- Pegasus. (2025). *Cinsiyet ve kapsayıcılık girişimlerimiz*. <https://www.flypgs.com/surdurulebilirlik/cesitlilik-ve-kapsayicilik-girisimlerimiz> (Erişim tarihi: 21.03.2025).
- Sivil Havacılık Genel Müdürlüğü [SHGM]. (2024). *Sivil Havacılık Genel Müdürlüğü istatistikler 2023*. <https://web.shgm.gov.tr/documents/sivilhavacilik/files/kurumsal/2023istatistikler.pdf> (Erişim tarihi: 21.03.2025).

- Türk Hava Yolları [THY]. (2022). *Türk Hava Yolları sürdürülebilirlik raporu*. <https://investor.turkishairlines.com/tr/kurumsal-yonetim/surdurulebilirlik> (Erişim tarihi: 21.03.2025).
- Türk Hava Yolları [THY]. (2025). *Engelli ve hasta yolcularımıza özel hizmetler*. <https://www.turkishairlines.com/tr-tr/bilgi-edin/hasta-ve-engelli-yolcular/> (Erişim tarihi: 21.03.2025).
- Türk Hava Yolları [THY]. (2025). *Sürdürülebilirlik hedefleri 2025-2030*. <https://www.turkishairlines.com/tr-tr/turk-hava-yollarinda-surdurulebilirlik/> (Erişim tarihi: 21.03.2025).
- Torum, O. ve Küçük Yılmaz, A. (2009). Havacılıkta sürdürülebilirlik yönetimi: Türkiye’deki havalimanları için sürdürülebilirlik uygulamaları araştırması. *Havacılık ve Uzay Teknolojileri Dergisi*, 4(2), 47-58.
- Tüketici Dernekleri Federasyonu. (2024). *Uçan tüketici hakkını arıyor*. <https://www.tuketici.org.tr/tr/h/tuketici-tv/ucan-tuketici-hakkini-ariyor/> (Erişim tarihi: 21.03.2025).
- Qantas. (2025). *Flying art series*. <https://www.qantas.com/au/en/about-us/our-company/fleet/flying-art.html> (Erişim tarihi: 21.03.2025).
- Yavuz, S. ve Aslan, A. (2024). Havacılık sektöründe kadın çalışanların firma karlılığına etkisi: Türk Hava Yolları örneği. *Türk Dünyası Kadın Araştırmaları Dergisi*, 3(4), 50–64. <https://doi.org/10.5281/zenodo.10850689>
- Yıldırım, A. ve Şimşek, H. (2021). *Sosyal bilimlerde nitel araştırma yöntemleri* (12. bs.). Seçkin Yayıncılık.



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A Multiple Correspondence Analysis Study on Career Orientations of Aviation Management Students ¹

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Abstract

This study aims to understand the motivations of Aviation Management students in Turkey and their career trends after graduation. The study examines how the growth of the aviation industry and the demand for qualified labor force in this field affect students' major preferences and career planning. In the study, data were collected through a questionnaire developed for Aviation Management students and the data obtained were evaluated using Multiple Correspondence Analysis (MCA). This method offers the opportunity to analyze the relationships between categorical variables in depth. The findings will reveal the basic dynamics behind the demographic, socio-economic and individual factors affecting students' major preferences, as well as their sectoral tendencies. The results of the research are expected to contribute to the development of educational policies for the aviation sector and to the achievement of students' career goals.

Key Words: Career, Aviation Management, Multiple Correspondence Analysis (MCA), Education.

JEL Classification: I21, I26.

Havacılık Yönetimi Bölümü Öğrencilerinin Meslek Yönelimlerine İlişkin Çoklu Uyum Analizi Çalışması

Öz

Bu çalışma, Türkiye'deki Havacılık Yönetimi bölümü öğrencilerinin bölüm tercih nedenlerini ve mezuniyet sonrası kariyer eğilimlerini anlamayı amaçlamaktadır. Araştırma, havacılık sektörünün büyümesi ve bu alandaki nitelikli iş gücüne olan talebin öğrencilerin bölüm tercihlerini ve kariyer planlamalarını nasıl etkilediğini incelemektedir. Çalışmada, Havacılık Yönetimi bölümü öğrencilerine yönelik geliştirilen bir anket aracılığıyla veri toplanmış ve elde edilen veriler Çoklu Uyum Analizi (Multiple Correspondence Analysis-MCA) yöntemiyle değerlendirilmiştir. Bu yöntem, kategorik değişkenler arasındaki ilişkileri derinlemesine analiz etme imkânı sunmaktadır. Bulgular, öğrencilerin bölüm tercihlerini etkileyen demografik, sosyo-ekonomik ve bireysel faktörlerin yanı sıra, sektörel yönelimlerinin arkasındaki temel dinamikleri ortaya koyacaktır. Araştırma sonuçlarının, havacılık sektörüne yönelik eğitim politikalarının geliştirilmesine ve öğrencilerin kariyer hedeflerine ulaşmasına katkı sağlaması beklenmektedir.

Anahtar Kelimeler: Kariyer, Havacılık Yönetimi, Çoklu Uyum Analizi, Eğitim.

JEL Sınıflandırma: I21, I26.

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INTRODUCTION

Career can be defined as a series of positions achieved by employees throughout their lives, especially advancing in the same profession, receiving more and more monetary rewards and responsibilities. In other words, it can be seen as progressing in the same field of work over a large period of time (Bakioğlu, 1996: 10). From a developmental perspective, a career is the sum total of every event in an individual's professional journey throughout his/her life (Vondracek, 1998). Career is the field in which an individual will progress in public or private working life, pursued and worked to achieve success (Aytaç 1997: 17). The concept of career has organizational and individual dimensions. Career development of individuals in terms of the organization enables them to work in the organization as experts in their field and to produce solutions to problems, and this is important for the effectiveness of the organization. Career development for the individual will ensure the creation of a happy working environment in the organization and thus increase job satisfaction (Bakioğlu & İnandı, 2001: 514).

Career planning can be defined as a set of events, professional preferences and personal development processes that an individual encounters throughout life (Vondracek, 1998). This process is influenced by individuals' educational experiences, social environment and economic status. Sevinç (2010) states that career choices are shaped not only by individual characteristics but also by environmental factors such as family, friends and social pressures.

The aviation sector stands out as a strategic area that is growing rapidly on a global scale and contributes significantly to the economic development of countries. In countries like Türkiye, where the development of the aviation industry continues at a rapid pace, the need for qualified human resources is increasing (Kakşa & Soyca, 2022: 123; Ulufer Kansoy, 2023: 25). In this context, the role of higher education institutions providing education in the field of aviation has become quite critical. Aviation Management departments contribute to the development of the sector and enable individuals to realize their career goals by training individuals equipped with knowledge and skills in line with sectoral expectations (Bilkay, 2021). As of 2024, more than 35 universities in Türkiye offer undergraduate programs in Aviation Management, indicating the growing academic and sectoral interest in this field (YÖKATLAS, 2024). However, studies to understand the motivations of students studying in this field and their career intentions after graduation are quite limited (Şen, 2019; Kiracı & Bayrak, 2014; Durmuş & Tokyay, 2021).

In recent years, Türkiye has become an increasingly important country in the international arena by making significant progress in the field of aviation with the advantages of its geographical location. The long-term advancement of the civil aviation industry in Türkiye, characterized by rapid population growth and urbanization, significant tourism potential, and its emergence as a regional trade center, is of paramount importance (Bakır et al., 2017). A number of legal regulations and standards have been introduced for the development of the Turkish Civil Aviation Sector in the national and international arena and for the sector to be carried out in a safe, reliable, high quality, open and transparent manner. By introducing policies based on competition and safety in the airline transportation service, national

competitiveness has been increased and the country's economic and social development process has been accelerated (Battal et al., 2006).

Located at the intersection of Asia, Europe and Africa, Türkiye has managed to become an important hub between these continents and is taking important steps to sustain this with major investments such as Istanbul Airport and SMARTIST (Turkish Airlines Cargo Hub Project) (Aksoy & Dursun, 2018: 1061). In such a growing sector, companies want to close the personnel gap with educational institutions that provide qualified education in this field. This has led to an increase in the demand for aviation schools and especially the aviation management department, which is the most common department in this field. Students turn to this field with the desire to contribute to the rapid expansion of the sector (Durali & Özdamar, 2021).

This study investigates the reasons affecting the departmental preferences of Aviation Management students in Türkiye and their career goals after graduation. The study aims to analyze the socio-economic and demographic characteristics of the students and the effects of these characteristics on their preferences and orientations. The questionnaire used as a data collection tool includes questions to understand students' educational motivations, perceptions about the sector and career expectations. The collected data were analyzed using Multiple Correspondence Analysis (MCA). This method provides in-depth information about students' preferences and tendencies by analyzing the relationships between categorical variables in detail (Johnson & Wichern, 2007).

When the literature is examined, it is seen that there are many studies examining the career tendencies of students in different fields such as tourism, engineering and health, but research focusing on aviation management students is quite limited (Ilgaz & Güzel, 2019; Ateş, 2016; Daku, 2021; Ternavska et al., 2023; Costa et al., 2025; Ying, 2025). This study aims to fill this gap in the literature by providing a unique perspective on the educational and career preferences of students in the field of Aviation Management. It is anticipated that the findings of the study will contribute to the development of educational policies for the aviation sector and help students to direct their career goals more consciously.

In this context, the research is looking for answers to the following questions:

- RQ1: What are the factors that influence Aviation Management students to choose this department?
- RQ2: What are the factors that influence the sectoral tendencies of Aviation Management students?
- RQ3: What is the effect of external factors on aviation management students to continue to work in the aviation industry?

This study is one of the first comprehensive analyses to understand the educational and career preferences of Aviation Management students. In particular, a detailed examination of the factors affecting the preferences of students studying in a dynamic field such as Aviation Management will contribute to a better understanding of both individual and sectoral needs. The results of the research will not only shape the individual career planning

of the students, but also shed light on the development of strategies to create qualified human resources for the aviation sector. This research, which aims to fill the gap in the literature, is a valuable reference for reviewing aviation education policies and adopting student-centered approaches. The findings are expected to contribute to a sustainable understanding of education and career planning in the aviation sector.

1. THEORETICAL BACKGROUND

Education is recognized as one of the most fundamental tools for individuals to reach their career goals by improving their knowledge, skills and competencies. Especially higher education is a process in which individuals shape their professional preferences and prepare for the world of work. In this process, individuals' educational experiences, social environment and economic conditions have a direct impact on their career choices (İstanbullu Dinçer et al., 2013). Career planning involves individuals setting lifelong goals by evaluating their strengths and weaknesses and plays an important role in meeting sectoral needs as well as personal development. Walker and Gutteridge (1990) define career planning as the process of creating action plans in line with short, medium and long-term goals by analyzing individuals' competencies.

The selection of a career is a significant matter in the developmental journey of young individuals, as it is linked to both beneficial and adverse psychological, physical, and socio-economic disparities that extend beyond adolescence into adulthood (Robertson, 2014; Bubić & Ivanišević, 2016). When an individual is planning their career and determining the field they want to work in, it is important to assess in which sector or job position they can perform best based on their current skill set, educational background and experiences. To assess this, it may be useful to use a multiple correspondence analysis (MCA). Such an analysis can offer a data-driven approach to determining one's career path. MCA is associated with the development of statistical science and the evolution of regression analysis. In particular, statistics and regression analysis have been shaped over time by the work and contributions of statisticians such as Francis Galton, Karl Pearson, Ronald Fisher, Jerzy Neyman, Egon Pearson (Clausen, 1998; Suner & Çelikoğlu, 2008). While career planning helps an individual to determine a career path that is compatible with his/her goals, values and abilities, MCA allows him/her to evaluate the most suitable sectors or job positions to achieve these goals. In this way, one's career planning can be more knowledge-based and goal-oriented (Aytaç, 2005).

In the literature, the factors affecting career choices are generally considered in two main groups: individual and environmental. Individual factors include interests, personal competencies and the professional values that the individual assigns to himself/herself, while environmental factors include family, social environment, educational policies and economic conditions (Kaynak, 1996). Sevinç (2010) states that social norms, economic expectations and social environment have a strong influence on individuals' career choices. In a fast-growing field such as the aviation sector, understanding the factors affecting students' career planning is of great importance for sectoral sustainability.

Aviation Management is a discipline that aims to train qualified individuals to meet the various operational and managerial needs of aviation, a complex and dynamic sector.

Students studying in this department aim to specialize in areas that require technical knowledge such as air transportation, logistics management, safety and security. However, the high standards and sectoral expectations required by this education cause students to face various factors that affect their education process and career planning (Kozak, 2009). Factors such as limited internship opportunities, foreign language proficiency and financial difficulties can make it difficult for students to achieve their career goals after graduation (Richardson, 2008).

To further conceptualize the motivations behind such preferences, this study is grounded in Holland's Theory of Vocational Personalities and Work Environments. According to Holland (1997), individuals tend to select career paths that match their personality traits. The theory defines six personality types: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (RIASEC). Aviation Management students often demonstrate "Enterprising" and "Realistic" characteristics due to the operational and decision-making nature of the industry. Those with an interest in administrative or support services may also reflect "Conventional" traits. Framing the analysis within this theoretical model enhances the understanding of students' department choices and career intentions.

In addition, Donald Super's (1990) Life-Span, Life-Space Theory views career development as a lifelong process shaped by evolving self-concepts and life stages. University students are typically in the "exploration stage," during which they begin to define their career goals and assess educational paths. Variables such as age, class level, and academic progression—used in this study—align with Super's model.

Lastly, Krumboltz et al. (1976) Social Learning Theory of Career Decision Making emphasizes that career choices are influenced by environmental factors, observational learning, and chance events. In the context of this research, elements such as family background in aviation, internship experience, and exposure to the industry can be seen as learned influences shaping students' career orientations. Integrating these three perspectives enables a deeper understanding of how personality, developmental stage, and experiential learning jointly impact career-related decisions

2. PREVIOUS STUDIES

There are studies on students' career orientations in different contexts. Some of these studies, including but not limited to these, are listed as follows:

Akış Roney and Öztin (2007) conducted research involving a sample of 450 Turkish university students in the field of tourism to examine their perceptions of careers in tourism. The results indicated that, overall, participants' perceptions were neutral. The findings indicated that the aspiration to pursue studies in tourism, the intention to engage in a tourism career post-graduation, and relevant work experience are significant elements influencing their perception of a career in tourism. Ünal and Baran (2012) conducted a study on pre-service teachers and found that the relationship between the satisfaction of pre-service teachers with their choice of profession and their desire to develop themselves professionally is regulated entirely by the efforts they plan to make professionally.

Akoğlan Kozak and Dalkıranoglu (2013) examined the career orientations of Anadolu University graduate students. The research data were analyzed with t-test and chi-square test. As a result of the research, it was revealed that the students were not adequately guided in their career preferences and made their preferences according to traditional patterns. In addition, another finding of the study was that financial concerns override career opportunities. Kiracı and Bayrak (2014) conducted their research on the employment and career status of civil aviation undergraduates with a survey model. In the study, it was concluded that ensuring the job satisfaction of employees in terms of wages will make significant contributions to aviation safety. In addition, the finding that a significant number of civil aviation graduates are employed in a job related to aviation is one of the other findings of the study.

Ateş (2016) examined the factors affecting the career start preferences of students studying in the field of aviation with the scale developed by Adıgüzel (2008). The effects of family members, relatives, legal factors, individual characteristics, economic and social expectations, occupational characteristics, economic and political environment on career plans were analyzed on average basis. As a result of the research, it was concluded that the mother has the most influence among the family members of higher education students studying in the field of civil aviation in Türkiye. Another result of the research is that teachers are the most important factor in the initial stage of career planning.

Ilgaz and Güzel (2019) conducted a study on the career continuity of tourist guidance students. In the study, findings were obtained by MCA method about the desire of tourism guidance students who study tourism at undergraduate level to continue their careers. Küçüköğlü et al. (2020) conducted their research on the career and entrepreneurship orientations of vocational school students with a mixed method system in which qualitative and quantitative research methods were used together in order to determine the career preferences of Vocational School students taking entrepreneurship courses and the share of entrepreneurship career in these tendencies. As a result of the research, the highest rate of career preference among the students was determined as the private sector with 39.80% and it was concluded that Vocational School students consider factors such as working conditions, job security and regular income while choosing between the public sector and entrepreneurship. Durmuş and Tokyay (2021), in their research on the occupational preference tendencies of Aviation Management undergraduate students, included the measurement of preference tendencies and the analysis of the professions that students are interested in outside the department.

Daku (2021) conducted a study to examine the relationship between aviation students' happiness towards career guidance courses and its impact on career decision-making self-efficacy. The study found that academic satisfaction, future time perspective and clarity of career success criteria increased students' career decision-making self-efficacy, which in turn had a positive effect on happiness. In a similar vein, Ternavska et al. (2023) have highlighted the pivotal role of educational and professional motivations in shaping the career choices and academic preferences of future aviation professionals. Costa et al. (2025) examined the personal, cognitive and contextual factors that shape young people's interest in the aviation industry, using the Social Cognitive Career Theory (SCCT) to reveal how the interaction of

self-efficacy beliefs, outcome expectations and personal goals play a role in career choice. In her 2025 analysis of the factors affecting student happiness towards career guidance courses, Ying (2025) states that academic satisfaction and proactive personality are important factors that positively affect students' career decisions and happiness. The extant literature indicates that the factors influencing the career interests of young people in a specific field, such as the aviation sector, are shaped by a multidimensional interaction. Furthermore, educational and psychological factors supported from an early age appear to strengthen career choices.

The fact that there is not enough research on the vocational orientations of Aviation Management Department Students in the literature constitutes the motivation of the current study. On the other hand, it is seen that few studies in the field of aviation management have been evaluated through YÖK Atlas data. As a result of the detailed literature review, no MCA research study on vocational orientations of aviation management students was found. In addition to the foreseen scientific contributions, it is thought that the research will provide academic and sectoral contributions due to the methodology used and the characteristics of the targeted research audience. In addition to these, the fact that no research has been conducted on behalf of this department before will fill the gap in the literature. In order to provide a clearer overview of previous studies, a summary table is presented below. Table 1 outlines the methods, findings, and thematic focus areas of related research that support the context of this study.

Table 1. Summary of Previous Studies

Author(s) and Year	Scope	Method	Key Findings	Thematic Focus
Greenacre (2007)	Correspondence analysis in practice	MCA	MCA is effective for analyzing multi-dimensional categorical data	Method Justification
Pendergrass (2008)	Career choice factors and academic success	Mixed Methods	Interest, family influence, and academic performance affect choices	Career Planning
Wen & Chen (2011)	Mapping airline competition via MCA	MCA	MCA helps visualize competition between airlines using categorical data	Methodological Contribution
Steckel et al. (2018)	Career choice motivations in aviation science	Survey	Reputation and program quality influence student decisions	Institutional Motivation
Ilgaz and Güzel (2019)	Career tendencies of tourism undergraduate students	MCA	Demographic and socio-economic factors affect student preference	Career Planning
Küçükoğlu et al. (2020)	Career and entrepreneurship orientations of vocational school students	Mixed qualitative and quantitative methods	Working conditions, job security and regular income is important while choosing between the public sector and entrepreneurship	Career orientation
Durmuş & Tokyay (2021)	Career Preferences of Aviation	Survey	Socio-demographic variables affect program choices	Demographics, Preferences

	Management Students			
Yavaş et al. (2021)	Evaluation of Internship Experiences in Aviation Education	Survey& Observation	Internship satisfaction impacts career orientation	Practical Education
Daku (2021)	Career Aspirations of Collegiate Aviation Students	Survey and Interview	Students determine their career goals by prioritising the values of staying close to family and friends	To understand the factors that shape the career aspirations of university aviation students
Ternavska et al. (2023)	Educational and professional motivations of future aviation specialists	Literature review	Motivational factors play a decisive role in the educational and professional preferences of individuals in career choices	Theoretical study
Costa et al. (2025)	Analyse the career development processes	Literature review	Career interest is formed by the interaction of self-efficacy, expectations and goals	Conceptual Analysis
Ying (2025)	Modelling and analysing psychological and educational factors affecting student happiness towards career guidance courses	Survey	Academic satisfaction, future perspective and career success clarity increase self-efficacy	Career Guidance Course Happiness

3. METHODOLOGY

This study aims to explore the factors influencing Aviation Management students' selection of their department and their career aspirations post-graduation. The study aimed to identify the demographic characteristics of the students, their educational preferences, and the factors influencing their career aspirations. The study employs a quantitative research method, utilizing a questionnaire technique for data collection.

The study group of the research consists of students studying in the department of Aviation Management at different universities across Türkiye. The study group was determined by convenience sampling method. It can be said that accessibility to the research group and time constraints were effective in the selection of this method. Within the scope of the study, 1050 students enrolled in the 2024-2025 academic year were reached and 990 valid responses were obtained from these students.

The data collection tool to be used in the Multiple Correspondence Analysis of Aviation Management Department Students' Occupational Orientations is the questionnaire used in Ilgaz and Güzel's (2019) study on tourism students. The questionnaire form used in the study was adapted to the aviation management department and finalized by taking expert opinions.

The questions in the survey are; gender, age, family income level, city where the family

lives, place of residence, foreign language level, internship status, reason for choosing the department, grade, grade point average, preference status of this department if the exam is taken again, department preference order, traveling by plane before starting school, tendency to work in the field of aviation after graduation, whether there is an airport in the city where the family lives, evaluation of whether the courses taken are sufficient to work in the sector, whether the effects of epidemics such as covid-19 affect the perspective on the profession, whether there are enough businesses to work in the field of aviation.

The survey form consisted of multiple-choice questions. The data were analyzed using Multiple Correspondence Analysis (MCA). MCA extends Correspondence Analysis (CA) and facilitates the analysis of relationship patterns among multiple categorical dependent variables. This can be viewed as a generalization of principal components analysis for categorical variables instead of quantitative ones. MCA has been (re)discovered multiple times, leading to the identification of equivalent methods under various names, including optimal scaling, optimal or appropriate scoring, binary scaling, homogeneity analysis, scalogram analysis, and quantification method (Abdi & Valentin, 2007: 1).

MCA is employed to analyze a collection of observations characterized by nominal variables. Each nominal variable comprises multiple levels, with each level represented as a binary variable. Gender, categorized as male and female, represents a nominal variable with two distinct levels. For a male participant, the model would be represented as 0 1, while for a female participant, it would be represented as 1 0. The data table comprises binary columns, with each nominal variable represented by a single column assigned the value "1". MCA can accommodate quantitative variables by recoding them into categories. A score ranging from -5 to +5 can be categorized as a nominal variable with three levels: below 0, equal to 0, or above 0. In this scheme, the value 3 is represented by the pattern 0 0 1. The coding scheme for MCA indicates that each row maintains an identical sum, whereas for CA, each row possesses the same weight (Abdi & Valentin, 2007: 2).

CA and MCA are multivariate exploratory methods for exploring and visualizing categorical data. Dimensionality reduction techniques can be viewed as a generalization of principal component analysis for categorical variables. CA and MCA offer graphical depictions of the rows and columns in a contingency table (CA for two categorical variables) or a cross-table (MCA for multiple categorical variables) (Hsu, Wu & Chen, 2022: 4). Consequently, examining the typology of variables, categories, or individuals allows for the identification of relationships among variables or categories and similarities among individuals. MCA represents a particular application of CA to multivariate categorical data, which is encoded as an indicator matrix or Burt matrix (Nenadic & Greenacre, 2005).

The MCA used in this study is a method that allows a deeper understanding of individuals' preferences and orientations by analyzing the relationships between categorical variables. MCA visualizes the relationship between different variables, allowing for a clearer interpretation of the results. This method, which is frequently used in educational research, is an effective tool for understanding students' major preferences and career goals (Johnson & Wichern, 2007). The MCA method, which has been successfully applied in studies examining student trends in the tourism and health sectors, plays a critical role in

understanding the effects of demographic and socio-economic factors (İlgaz & Güzel, 2019; Ateş, 2016).

The use of Multiple Correspondence Analysis (MCA) in this study is justified by the nature of the variables, which are primarily categorical. MCA enables the simultaneous analysis and visual representation of the relationships between several categorical variables, making it a suitable method for uncovering patterns in educational and social science data (Greenacre, 2007).

While other methods such as chi-square tests or factor analysis could also be applied, they are limited in their capacity to provide a multidimensional view of associations among multiple categorical variables. For instance, chi-square tests focus only on pairwise relationships, and factor analysis is typically designed for continuous variables. In contrast, MCA offers both a statistical and graphical interpretation of the data, which is essential for understanding complex interactions such as those present in students' career preferences (van der Heijden et al., 1997). This methodological choice aligns with previous research that applied MCA in educational and career-related contexts.

The data collection process consisted of providing face-to-face questionnaires and online forms to students who consented to participate in the study. The study's purpose and scope have been disclosed to the students, and participant confidentiality was guaranteed. The data collection process lasted approximately four weeks. The data collected were analyzed utilizing the SPSS software. The analysis involved calculating frequency and percentage distributions of the participants' demographic characteristics using descriptive statistics. This method facilitated the visualization of the relationships among the reasons for selecting a major, demographic factors, and career objectives. The analysis results were interpreted to address the research questions and identify the factors influencing students' preferences. The findings are organized to facilitate both theoretical and practical implications.

4. FINDINGS

4.1.Descriptive Statistics

Within the scope of the study, 20 questions were asked to the students of aviation management department. A total of 990 questionnaires, including first class (247), second class (237), third class (279) and fourth class (227) students, were returned and the data were included. Within the scope of the study, firstly, frequency analysis of the survey data was performed. Then, multiple correspondence analysis was performed to determine the relationships between variables. Frequency analysis was conducted on the answers given by the participants to the survey questions. Percentage and frequency distributions of the data related to frequencies are given in Table 2.

Table 2. Descriptive Statistics

Variables	Items	Frequency	Percent
Gender	Male	392	39,6
	Female	598	60,4
Age	18-20	219	22,1
	21-22	491	49,6
	23-24	252	25,5
	+25	28	2,8
University	Dicle University	64	6,5
	Alanya Alaaddin Keykubat University	23	2,3
	Amasya University	43	4,3
	Balıkesir University	53	5,4
	Muğla Sıtkı Koçman University	27	2,7
	Erciyes University	57	5,8
	Erzincan Binali Yıldırım University	50	5,1
	Eskişehir Teknik University	19	1,9
	Gümüşhane University	46	4,6
	Iğdır University	24	2,4
	İskenderun Teknik University	115	11,6
	Kastamonu University	158	16,0
	Kocaeli University	90	9,1
	Malatya Turgut Özal University	20	2,0
	Necmettin Erbakan University	50	5,1
	Samsun University	13	1,3
	Selçuk University	106	10,7
	Isparta Süleyman Demirel University	32	3,2
Income (USD)	Below 350	202	20,4
	350-500	289	29,2
	351-650	182	18,4
	651-850	123	12,4
Airport Existence at Family City	Airport Exist	770	77,8
	No Airport	220	22,2
Current place of residence	City Center	546	55,2
	Suburb	31	3,1
	County	311	31,4
	Small town	23	2,3
	Village	79	8,0
Foreign Language Level	Poor	408	41,2
	Medium	484	48,9
	Good	91	9,2
	Very Good	7	0,7
Internship Status	Intern Done	280	28,3
	No Intern	710	71,7
Family working status in the aviation industry	Aviator Exist	103	10,4
	No Aviator	887	89,6
Selection Cause	Family	50	5,1
	Teacher	92	9,3
	Love Aviation	466	47,1
	Job Opportunity	247	24,9
	Randomly	135	13,6
Preference Order	First Choice	379	38,3
	2 - 5	343	34,6
	6 - 10	149	15,1
	11 - 23	91	9,2
	Last Choice	28	2,8
Travelling by plane	Travel Air Before	462	46,7

	Any Travel by Air	528	53,3
Repeated Choice	Choice Again	725	73,2
	Never Choice	265	26,8
Working in the aviation sector after graduation	Continue Aviation Career	838	84,6
	Undecided	126	12,7
	No Career	26	2,6
GPA (Grade Point Average)	Low	55	5,6
	Medium	580	58,6
	High	355	35,9
Class	1	247	24,9
	2	237	23,9
	3	279	28,2
	4	227	22,9
Sufficiency of courses	Courses Enough	412	41,6
	Undecided	258	26,1
	Courses Not Enough	320	32,3
Covid-19 etc. Effect	Covid19 etc effective	220	22,2
	Undecided	158	16,0
	Covid19 etc not effective	612	61,8
Firm Number Knowledge	Firms Enough	390	39,4
	No idea	212	21,4
	Not Enough Firms	388	39,2

Table 2 presents the frequency values of the survey conducted on the demographic characteristics, department preferences and career orientations of Aviation Management students in Türkiye. These data include information on various socio-economic factors such as age, gender, income level, and whether the students have a family member working in the aviation industry. In addition, information on students' reasons for choosing their program, whether they have done an internship or not, their foreign language proficiency level and their career goals after graduation are also presented.

Of the survey participants, 39.6% were male and 60.4% were female. This rate indicates that women are more interested in Aviation Management than men and that the gender balance in the industry may be changing. This finding may serve as a preliminary indicator for future studies on female representation in the sector. When we look at the age groups, 49.6% of the students are between the ages of 21-22. This shows that the Aviation Management department appeals to a young age group and career plans are largely shaped in this age range. In addition, since this age group is still in the early stages of their education process, it can be said that their expectations about the sector and their career goals can be shaped more.

Looking at the university distribution, 16.0% of the participants were from Kastamonu University, and there were participants from other universities with different rates. This shows that the Aviation Management department has become widespread throughout Türkiye and the interest in the sector has increased, while the fact that the participants come from various universities reveals that the demand for this department is spread over a wide geography. When we look at the distribution by income level, 29.2% of the students earn between 350-500 USD. This finding suggests that students' living expenses and education costs may be associated with their preferences. The distribution in other income groups reveals that the interest in aviation management is widespread in different socio-economic groups. The rate of individuals working in the aviation sector in the family is 10.4%. This

rate shows that students' ties with aviation are largely based on personal preferences and that their interest in the sector is shaped by individual preferences and passions rather than familial factors.

When the reasons for choosing the department are analyzed, 47.1% of the students chose this department because they like aviation. This reveals that personal interest and passion play a decisive role in their choice of department. The rate of internship remained at 28.3%, indicating that there is a lack of practical experience in the sector and that students need more practical experience. It was observed that most of the foreign language proficiency level (48.9%) was at intermediate level. This finding indicates that language knowledge plays an important role in the aviation industry, but students need to improve their language skills. In terms of career goals after graduation, 84.6% of the students stated that they plan to pursue a career in the aviation sector. This rate indicates a high interest in career opportunities in the aviation sector.

Finally, the fact that 22.2% of the students stated that their career perspectives were negatively affected by the effects of pandemic diseases such as Covid-19 on the sector reveals that the negative effects of the pandemic on the aviation sector have significantly shaped students' career plans and their perspectives on the sector. The data in Table 2 provides an important overview of the demographic structure of Aviation Management students, their reasons for choosing the department and their career orientations. This data will constitute an important resource in shaping educational policies related to the sector, making strategic decisions regarding the educational processes of students and developing strategies for the labor force needs in the sector.

4.2. Multiple Correspondence Analysis

Variables were grouped and MCA was performed in five groups. The variable of desire to continue a career after graduation, which constitutes the purpose of the study, was included in all five analyses. Information on the first analysis, the multiple fit analysis of the variables of desire to continue career, gender, age and income level, is given below.

Table 3. Discriminant Measures for Gender, Age, Income, Aviation Career and Current Place of Residence

Variables	Dimensions	
	1	2
Working in the aviation sector after graduation	,293	,040
Gender	,152	,011
Age	,315	,147
Income	,351	,525
Current place of residence	,209	,483
% of Variance	26,400	24,143

Table 3 presents the discriminant measures for the variables. The results obtained from the table show the effects of variables such as gender, age, income and career continuity on students' career choices. Income level has the highest variance explanation rates in both dimensions (35.1% and 52.5%). Residence status is the variable with the highest explanatory power in the second dimension. This indicates that socio-economic conditions are a determining factor, especially for students studying in a costly sector such as aviation. The

age variable has a strong effect on the first dimension (31.5%), but its effect on the second dimension is relatively lower (14.7%). This suggests that students' age plays an important role in understanding their career orientation, but may have a more limited effect than other factors. While the gender variable made a low contribution in the first dimension (15.2%), it was almost ineffective in the second dimension (1.1%). This suggests that gender is less determinant in career choices compared to other demographic factors. Career continuity has a significant contribution in the first dimension (29.3%), while its effect in the second dimension is quite low (4.0%). This finding indicates that students' career goals are strongly related to the variables represented in the first dimension (income and age). Following the presentation of the dimensions, Figure 1 shows the MCA analysis of the related variables.

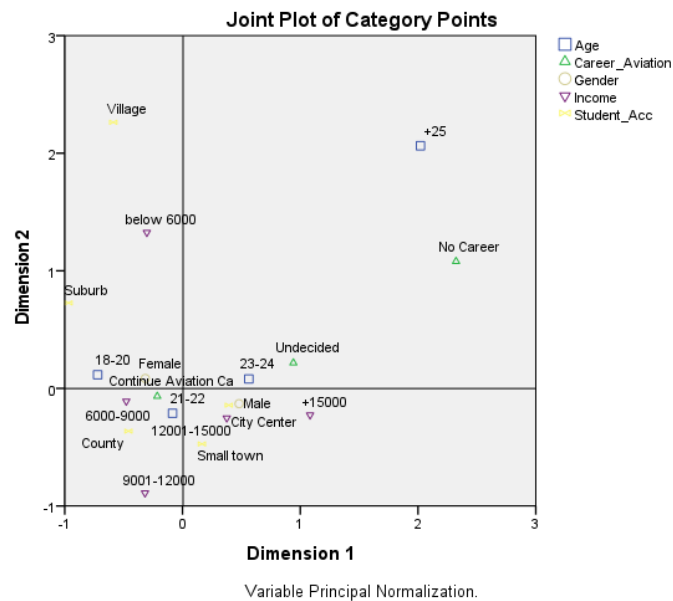


Figure 1. Cloud Map of First Group of Variables (Authors Evaluation)

According to the data obtained from the graph in Figure 1, the relationship between age, income level, gender and career tendencies of students is clearly demonstrated. In terms of age groups, it is seen that students in the 18-20 age group generally prefer to continue their careers, whereas individuals aged 25 and above mostly do not have career plans. In terms of income level, low-income individuals (below 350 USD) prefer to live in rural areas, while high-income individuals (+850 USD) generally prefer to live in urban centers. Regarding the gender variable, male students show a more pronounced tendency to pursue a career, while female students are more likely to be undecided or not favorable to career plans. Finally, when the type of residence is examined, it is found that individuals living in small cities and urban centers have higher income levels, whereas individuals living in rural areas are generally in the low-income group. These findings indicate that individual and environmental factors significantly affect students' career tendencies and preferences. Following this information, Table 4 presents the findings of the discrimination criteria related to the family status of the students.

Table 4. Discriminant Measures for Aviation Career, Family Residence, Existence of Airport, Family Working Status and Travelling by Plane

Variables	Dimensions	
	1	2
Working in the aviation sector after graduation	,030	,506
Existence of airport in the family place	,600	,001
Family Place of Residence	,506	,002
Family working status in the aviation industry	,002	,544
Travelling by plane	,181	,021
% of Variance	26,380	21,479

As a result of the analysis, it is seen that the variables are divided into two main dimensions. The first factor explains 26.38% of the total variance and shows the relationship between the environment where the individual lives and career continuity. The variables with the highest values in this dimension are “Existence of airport in the family place” and “Family Place of Residence”. This can be considered as a factor showing the connection between the geographical location of the individual and aviation. The second factor explains 21.479% of the total variance and stands out as a dimension related to the individual's family's relationship with aviation and future career plans. The variables with the highest values in this factor are “Working in aviation after graduation” and “Family working status in the aviation industry”. This shows how an individual's family background and career goals can affect his/her tendencies in the field of aviation. In addition, the variable “I traveled by plane before starting school” has a low relationship with both factors. This shows that the variable cannot be placed under a distinct dimension and can be considered as an independent variable within the scope of the research. Following the presentation of the discriminant measures, Figure 2 shows the results of the MCA between family status and career continuity.

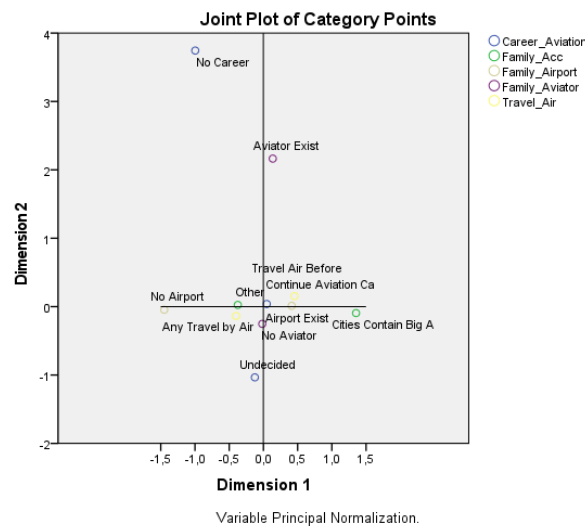


Figure 2. Cloud Map of Second Group of Variables (Authors Evaluation)

Figure 2 shows the distributions between students’ career continuation status in aviation management and their family background and travel experiences. The variable “Career Aviation” is associated with the other variables at an intermediate point. In particular, there

is a significant dissociation between “Family working status” (aviator in the family) and “Career Aviation”. This shows that the family history of aviation profession is poorly reflected in the career plans of the students. The variables “Family Airport” (having an airport in the area where the family lives) and “Travel Air Before” (having traveled by air before) show a stronger relationship with the option to continue an aviation career. This suggests that air travel experience or being close to an airport may affect students’ career choices. On the other hand, the fact that the “Undecided” category is far away from the other variables indicates that individuals in this group may have more independent preferences. In conclusion, the data in the graph and the table show the impact of different variables on students’ career planning in detail. Although career choices are influenced by family and environmental factors, it is understood that these interactions are weak in some cases. Table 5 presents the discrimination criteria of the analysis conducted to define the relationship between career continuity and the reason for, order of, and re-preference status of the department.

Table 5. Discriminant Measures for Aviation Career, Selection Cause, Preference Order and Repeated Choice

Variables	Dimensions	
	1	2
Working in the aviation sector after graduation	,514	,286
Selection Cause	,516	,477
Preference Order	,219	,380
Repeated Choice	,600	,009
% of Variance	46,249	28,790

According to the findings presented in Table 5, it is seen that the variables are grouped into two main dimensions. The first dimension explains 46.249% of the total variance and has a strong relationship with the variables related to individuals’ reasons for choosing the department and career plans after graduation. In this context, it is seen that the variable “If I were to take the exam again, I would choose this department again (Repeated Choice)” has the highest loading value of .600. This shows that individuals’ commitment to and satisfaction with their preferred department is strongly related to this factor. Similarly, the variable “Career Aviation” has a high value of ,514. This shows that individuals’ post-graduation career expectations and department preferences are significantly grouped under the same dimension. The second dimension explains 28.790% of the total variance and is related to individuals’ preference rankings and reasons for choosing the department. For example, the variable “Selection Cause” (What is your reason for choosing this department?) shows a strong connection with this factor with a load value of .477. This shows that the motivation of individuals in choosing a department can be considered as an independent factor. In addition, the variable “Preference Order” (Indicate your preference ranking) has a moderate relationship with the second factor with a value of .380. This indicates that individuals’ preference ranking is related to their reasons for choice but has a relatively low relationship with their direct career goals. Figure 3 shows the MCA conducted to define the relationship between career continuity and the reason, order and re-preference status.

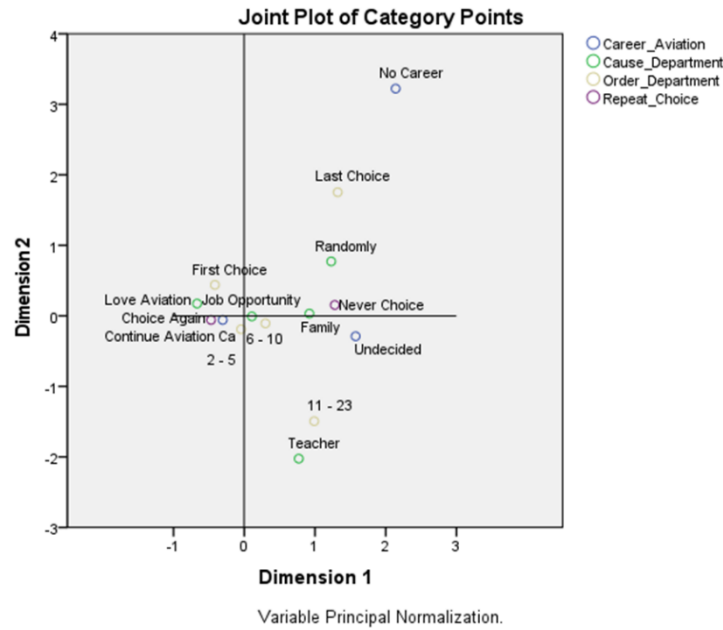


Figure 3. Cloud Map of Third Group of Variables (Authors Evaluation)

The graph shows the distribution of students' decision to pursue an aviation career and other categorical variables. The category "No Career" (not considering an aviation career) is located in a distant and independent position from the other variables. This shows that students who do not intend to pursue an aviation career exhibit a different profile. The "First Choice" and "Love Aviation" categories are located very close to the "Career Aviation" variable. This shows that the interest in aviation and the fact that the department is among the first choices have a strong influence on the decision to continue an aviation career. The fact that the variable "Repeat Choice" is close to the same region as "Career Aviation" supports the tendency of students with clear career plans to choose this department again. The categories "Randomly" and "Last Choice" are in the same area as "No Career", indicating that these students have unclear career goals or limited interest in aviation. In conclusion, the findings show that decisions towards an aviation career are clearly related to interest, order of preference and propensity to choose again, whereas other factors such as family influence are less determinant. Table 6 presents the discrimination criteria of the analysis that presents the relationship between career persistence and variables indicating the academic status of the student in university life such as internship, foreign language level, grade point average.

Table 6. Discriminant Measures for Aviation Career, Class, Grade, Intern and Language

Variables	Dimensions	
	1	2
Working in the aviation sector after graduation	,085	,118
Internship	,687	,023
Grade	,310	,275
Class	,749	,388
Language	,027	,434
% of Variance	37,188	24,742

As a result of the analysis, it is seen that the variables are grouped in two main dimensions. The first dimension explains 37.188% of the total variance and has a strong relationship with internship, grade level and academic achievement. In particular, the “Grade” variable has the highest value in the first dimension with a factor load of .749. This shows that the grade level of the student has the strongest relationship with this factor compared to other variables. Similarly, the variable “Internship” has a very strong relationship with the first factor with a loading value of .687. This shows that the student’s grade level and internship status are significantly grouped under the same factor and that progress in the educational process is a determining factor. The variable “Grade Point Average (Grade)”, which represents academic achievement, shows a moderate relationship with the first factor with a loading value of .310, while it is also related to the second factor with a loading value of .275. This shows that academic achievement is related to both the educational process and other individual variables. The second dimension explains 24.742% of the total variance and shows a stronger relationship with students’ foreign language knowledge and academic goals. In particular, it is seen that the variable “Foreign Language Level (Language)” has a higher connection with the second factor with a loading value of .434. This shows that the foreign language level of the student can be considered as an independent factor from other academic and vocational variables. Figure 4 shows the MCA results of the relevant variables.

Figure 4. Cloud Map of Fourth Group of Variables (Authors Evaluation)

achievement level (Grade) has a moderate loading in both dimensions, indicating that students' overall academic performance is in a balanced relationship with different variables. Looking at the positions of the category dots, it is seen that students who have done an internship are generally in a similar position with students who have high academic achievement and are considering continuing their career in the aviation sector. The positioning of the "Intern Done" category in the positive first dimension suggests that students who have completed an internship are generally career-oriented individuals. However, the positive position of "No Career" in the first dimension indicates that students who do not consider a career are differentiated from other variables. The high position of the category "Very Good" in the second dimension, which includes students with high language proficiency, suggests that it may be directly related to academic achievement or professional competencies. On the other hand, students with low academic achievement and those with low grade level show a similar distribution with individuals who have not done an internship. The categories "Poor" and "Low" are positioned in the negative first dimension and low second dimension, suggesting that these students have limited academic achievement and sectoral experience. In conclusion, the results of the multiple correspondence analysis indicate that students who are considering a career in aviation are generally individuals who have high grade level, are academically successful and have internship experience. On the contrary, it is observed that students with low academic achievement, those who have not completed an internship and those who do not intend to pursue a career in the sector are in a different position. These findings reveal that students' academic and professional development processes have a strong relationship with each other. Table 7 presents the discrimination criteria for the relationship between career continuity and some external factors.

Table 7. Discriminant Measures for Aviation Career, Courses, Covid and Firm Number Knowledge

Variables	Dimensions	
	1	2
Working in the aviation sector after graduation	,346	,351
Sufficiency of courses	,445	,062
Covid-19 etc. Effect	,343	,400
Firm Number Knowledge	,407	,263
% of Variance	38,532	26,894

According to the results of the analysis, students' perceptions of the aviation sector and various factors related to the sector are addressed in two main dimensions. The first dimension explains 38.53% of the total variance, while the second dimension explains 26.89%. This shows that the first dimension is more determinative on issues such as students' future expectations and educational competence in the aviation sector. When the loadings of the variables to the dimensions are analyzed, it is seen that the statement "I plan to work in aviation after graduation" has moderate loadings in both dimensions (0.346 and 0.351). This shows that students' career plans can be associated with both general professional perception and sectoral opportunities. Students' views on whether the courses they have taken are sufficient for working in the sector (I think the courses I have taken are sufficient for working in the sector) has a high loading in the first dimension (0.445). This

situation reveals that students think that their education programs are a critical factor in terms of preparation for the sector. However, in the second dimension, the effect of this variable is quite low (0.062), meaning that this opinion is less related to other dimensions of professional perception.

The variable on whether infectious diseases such as Covid-19 negatively affect the perception towards the aviation profession (loadings of 0.343 and 0.400) has a significant effect on both the first and second dimensions. This finding suggests that the pandemic is an important factor shaping the perception towards the aviation sector and may affect students' career plans. Finally, the perception of whether there are enough businesses to work in aviation after graduation ("There are enough businesses to work in aviation") has a high loading especially in the first dimension (0.407). This shows that employment opportunities in the sector have a direct impact on students' professional expectations. In general, the analyzed variables reveal that external factors such as education quality, employment opportunities and pandemic play an important role in shaping students' professional perceptions towards the aviation sector. The fact that students find the courses they take sufficient and think that there are sufficient job opportunities in the sector stands out as an important source of motivation for their career plans. However, the negative impact of global crises such as Covid-19 on the perception of the profession brings along uncertainties about the future of the sector. Figure 5 shows the results of the MCA for these variables.

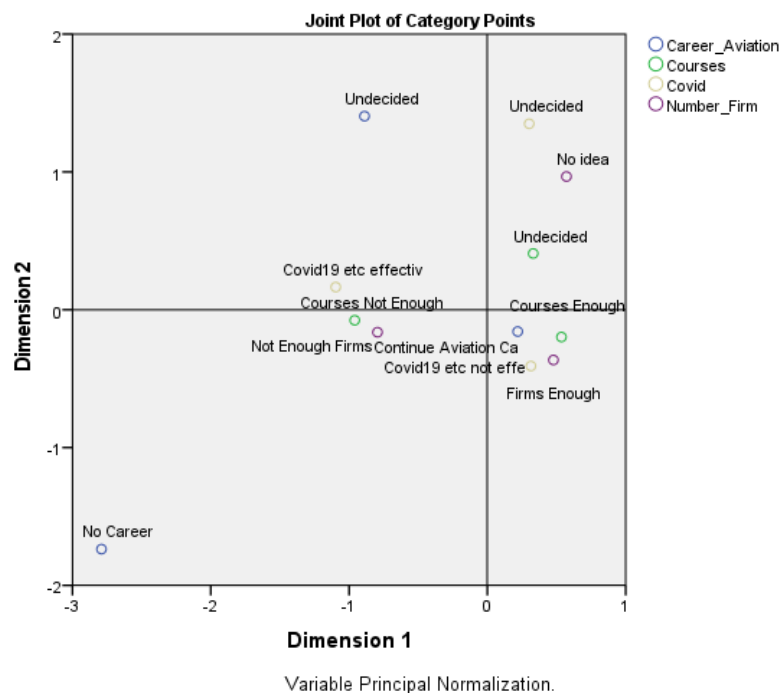


Figure 5. Cloud Map of Fifth Group of Variables (Authors Evaluation)

In the graph, students' views on career plans for the aviation sector, the adequacy of the courses they take, the impact of Covid-19 on professional perception and job opportunities in the sector are analyzed in two main dimensions. While the first dimension reflects the clarity and orientation of students' views, the second dimension reveals their approaches to uncertainty and variable factors. The graph shows that the category "No Career" has the

lowest position in the first dimension. This shows that students who do not intend to pursue a career in aviation are clearly differentiated from other variables and have a different perspective towards the profession. It is observed that the “Undecided” category is clustered at different points in both the first and second dimensions. This shows that students experience uncertainty about the sector and that different factors may be effective in their decision-making processes. In particular, it is seen that there are differentiations as “Courses Enough” and “Courses Not Enough” regarding the adequacy of the courses.

It is understood that students who find the courses sufficient have a clearer stance on finding a job in the sector and continuing their profession, while those who find them insufficient are more indecisive. It is noteworthy that students are divided into two regarding the impact of Covid-19. While the category “Covid19 effective” represents the students who think that the pandemic has negatively affected their perception of their profession, the category “Covid19 etc. not effective” shows the students who think that these effects are not important. The fact that students who find Covid-19 effective are more closely positioned with the “Courses Not Enough” and “Not Enough Firms” categories suggests that the pandemic may have increased concerns about the quality of education and employment opportunities. Students who think that there are enough businesses in the sector are clustered in the lower right region with the category “Firms Enough”, while those who think that there are not enough job opportunities are located further to the left. This reveals that the perception of job opportunities is directly related to students’ career expectations. In general, the graph shows that there are significant differences in students’ views on the aviation sector and that factors such as educational qualification, the effects of Covid-19 and job opportunities shape these perceptions. Undecided students are mostly located in the middle and upper regions, while those with clear views are generally located at the extremes of the graph. These findings reveal that sector-related uncertainties and individual experiences significantly affect the perception of the profession.

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This study aims to examine the attitudes of Aviation Management students towards their profession and the factors affecting these attitudes. The aviation sector has a growing and changing structure both worldwide and in Türkiye (Gursoy & Chi, 2020). However, despite this growth, career opportunities in the sector carry various uncertainties, especially for new graduates. Analyses have shown that the main factors affecting students’ professional preferences and willingness to stay in the sector are related to academic experiences, internship opportunities, language proficiency and employment opportunities in the sector. It was found that students expressed different opinions on the adequacy of the courses taken. Students who found the courses insufficient generally expressed concerns about the industry and emphasized that academic programs should be more aligned with industry expectations. Similarly, a study conducted by Richardson (2008) revealed that students studying in the fields of tourism and aviation have difficulties in the sector due to the lack of practical training. Therefore, it is important for aviation education institutions to increase the opportunities for practical training. In addition, it has been observed that internship experience plays a critical role in the decision to stay in the sector. While students who did

not do an internship were more ambivalent about pursuing a career in the sector, students who had an internship experience had a clearer attitude about continuing in the sector. This finding is also observed in the research on the tourism sector conducted by Kozak (2009) and reveals that practical experiences in the sector are decisive on career choice. Similar results were reported by Yavaş et al. (2021), who emphasized the effect of internship on students' career orientation.

One of the main reasons for students not considering a career in the aviation sector is their perception that there are not enough employment opportunities in the sector. Previous studies have also shown that graduates' uncertainty about finding a job, especially in fields with volatile market conditions such as aviation and tourism, can negatively affect their professional motivation (İlgaz & Güzel, 2019). Therefore, the ties between industry representatives and educational institutions need to be strengthened and students need to be more aware of the industry. Finally, it was observed that the uncertainties created by global crises such as Covid-19 had an impact on students' career planning. The stoppages in the aviation and tourism sectors during the pandemic caused individuals planning to pursue a career in these fields to reconsider their decisions (Gursoy & Chi, 2020). Therefore, the impact of the crises experienced in the sector on long-term professional plans should be examined in more depth.

The findings of this study align with the theoretical framework discussed earlier. For example, the relationship between program preferences and variables such as gender, age, and internship experience support Holland's (1997) vocational personality theory, in which individuals choose environments that fit their personality types. Students drawn to aviation due to its operational and leadership characteristics may reflect "Enterprising" and "Realistic" types. Similarly, age and class level are variables closely related to Super's career development theory Super (1990), which views students in this age group as being in the "exploration" stage—assessing possibilities and shaping their professional identities. The observation that older students and those with more experience are more career-oriented reflects this model. Furthermore, Krumboltz's social learning theory helps interpret the impact of environmental and experiential factors Krumboltz et al. (1976) such as having a family member in the aviation sector, prior exposure to air travel, and internships. These experiences likely contribute to the formation of students' career decisions through observational learning and perceived reinforcement. Thus, the study's results are consistent with the multi-dimensional nature of career development as described in these theoretical approaches. All these findings suggest that the content of Aviation Management education should be more aligned with sectoral expectations. Educational institutions should develop closer relationships with industry stakeholders to facilitate students' adaptation to business life. In addition, students need to be better informed about job opportunities in the sector in order to reduce their perception of occupational uncertainty. Future studies should focus on strengthening the link between industry and education and identifying measures to help students make more informed career planning.

The limited information in the literature on the educational and career preferences of Aviation Management students increases the importance of this study. The rapidly increasing demand for qualified labor force in the aviation industry requires a more

conscious shaping of educational policies in this field. In this context, the findings of this study will provide a valuable resource to better understand the needs in the sector and support students in achieving their career goals. More effective planning of education processes and the development of student-oriented approaches can make significant contributions to sectoral sustainability. Since the data was collected solely from Turkish universities, generalization of the results to other cultural or institutional contexts should be approached with caution.

Significant findings were obtained in the context of the variables determined in the study. However, these findings need to be examined in detail with different methods. In particular, mixed studies using both qualitative and quantitative research methods can contribute to a deeper understanding of students' attitudes towards the sector. For example, the factors affecting students' decisions to pursue a career in the aviation industry can be elaborated in the context of gender. In previous studies, it has been revealed that the reasons why female students move away from some professions are related to factors such as the stress level of the profession, its social status and its impact on family life (Aloudat, 2017). Similarly, the factors affecting the career expectations of female students in the aviation sector can be examined. In addition, due to the impact of the Covid-19 pandemic on the aviation sector, students' perceptions of occupational uncertainty should be investigated in detail. For example, Gursoy and Chi (2020) stated in their study that the pandemic had negative effects on the career planning of individuals working in the tourism and aviation sectors. Similarly, long-term longitudinal studies can be conducted to understand students' attitudes towards the sector after Covid-19. Finally, the research can be repeated in the future with larger samples and the career expectations and perspectives of aviation management students from different universities can be examined comparatively.

The results of this study can inform several policy and educational practices. First, universities offering Aviation Management programs should consider strengthening career guidance services to support students in the exploration stage of their development. Personalized counseling may help students better understand their career profiles and match them with relevant industry roles. Second, the integration of practical training and mandatory internships into the curriculum can significantly enhance students' readiness for aviation careers. Institutions should collaborate with airlines and ground handling companies to offer structured, supervised internship experiences. Third, considering the importance of foreign language proficiency in the global aviation industry, universities should reinforce language training, especially English, within aviation programs. Lastly, sectoral stakeholders and civil aviation authorities may use these findings to better understand the future workforce and design initiatives (e.g., scholarship programs, mentorship opportunities, early talent recruitment) that align with students' expectations and motivations.

As with any research, this study also has some limitations. Due to time and resource constraints, the data of the study is limited to a specific sample group of aviation management students. Therefore, it should be cautious about the generalizability of the findings. Future studies can increase the comparability of the findings by including a larger sample of students from different universities. Similar limitations were also mentioned in

the study conducted by Alkan and Kahraman (2021). The researchers emphasize that studies conducted with students from a specific university may be insufficient to make generalizable inferences about the sector. Therefore, it is recommended that mixed-method studies that include the views of professionals working in the sector should be conducted in future research. In addition, the variables used in the study were limited to certain factors. Cultural, economic and personal factors that may affect students' professional attitudes can be addressed in a broader framework and contribute to future studies.

REFERENCES

- Abdi, H., & Valentin, D. (2007). Multiple correspondence analysis. *Encyclopedia of measurement and statistics*, 2(4), 651-657.
- Adıgüzel, O. (2008). *Türkiye'de Gençlerin Kariyer Planlamasını Etkileyen Faktörler ve Üniversite Hazırlık Öğrencileri Üzerine Bir Araştırma*. Kütahya: Dumlupınar Üniversitesi, Sosyal Bilimler Enstitüsü, İşletme Anabilim Dalı, Doctoral Dissertation.
- Akış Roney, S., & Öztin, P. (2007). Career perceptions of undergraduate tourism students: A case study in Turkey. *Journal of Hospitality, Leisure, Sport and Tourism Education*, 6(1), 4-17.
- Akoğlu Kozak, M. & Dalkıranoglu, T. (2013). Mezun öğrencilerin kariyer algılamaları: Anadolu Üniversitesi örneği. *Anadolu Üniversitesi Sosyal Bilimler Dergisi*, 13(1), 41,52.
- Aksoy, C., & Dursun, Ö. O. (2018). A general overview of the development of the civil aviation sector in Turkey. *Electronic Journal of Social Sciences*, 17(67), 1060-1076.
- Alkan, G., & Kahraman, A. (2021). Üniversite öğrencilerinin mesleki yönelimleri üzerine bir araştırma: Havacılık sektörü örneği. *Journal of Aviation Studies*, 8(2), 45-60.
- Aloudat, A. (2017). Tourism students' career perceptions: A study on career uncertainty and expectations. *International Journal of Tourism Research*, 19(3), 78-92.
- Ateş, S. S. (2016). Yükseköğretim Kurumlarında Öğrenim Gören Öğrencilerin Kariyer Başlangıç Tercihlerini Etkileyen Faktörler: Havacılık Alanında Uygulama. *Cataloging-In-Publication Data*, 153.
- Aytaç, S. (1997). *Çalışma Yaşamında Kariyer Yönetimi Planlaması Geliştirilmesi Sorunları*. Epsilon Yayıncılık. İstanbul.
- Aytaç, S. (2005). *Çalışma yaşamında kariyer yönetimi planlaması ve sorunları*. Bursa: Ezgi Kitabevi.
- Bakır, M., Bal, H. T., & Akan, Ş. (2017). Türk sivil havacılık sektörünün değerlendirilmesinde bütünleşik SWOT-AHS yaklaşımı. *Journal of Aviation*, 1(2), 154-169.
- Bakıoğlu, A. (1996) *Profesyonel Gelişme, Hektograf çoğaltma*, İstanbul.
- Bakıoğlu, A. & İnandı, A. G. Y. (2001). Öğretmenin kariyer gelişiminde müdürün görevleri. *Kuram ve Uygulamada Eğitim Yönetimi*, 28(28), 513-529.
- Battal, Ü., Yılmaz, H., & Ateş, S. S. (2006). *Türkiye'de iç hatlarda serbestleşme ve geleceği*. In Conference Paper Presented on Kayseri VI. Havacılık Sempozyumu.
- Bilkay, S. (2021). Havacılıkta nitelikli insan kaynağı yetiştirme sorununun üniversitelerdeki sivil hava ulaştırma işletmeciliği ve havacılık yönetimi bölümlerinde görev alan akademik kadroların niteliği-niceliği bağlamında değerlendirilmesi. *Beykoz Akademi Dergisi*, 9(1), 1-18.
- Bubić, A. and Ivanišević, K. (2016). The role of emotional stability and competence in young adolescents' career judgments. *J. Career Dev.* 43, 498–511. doi: 10.1177/0894845316633779

- Clausen, S. E. (1998). *Applied Correspondence Analysis: An Introduction*, Sage Publications Inc., USA.
- Costa, A., Pinho, C., & Denis Malta, M. (2025). High-Flying Future: Attracting Young Talents to Aeronautics. In *Accelerating Sustainable Aviation Initiatives: Technology, Markets and Social Issues* (pp. 267-290). Cham: Springer Nature Switzerland.
- Daku, S. A. (2021). *Career Aspirations of Collegiate Aviation Students*. Doctoral Dissertation, The University of North Dakota.
- Durali, M. and Özdamar, N. (2021). Havacılık yönetimi lisans programı öğrenenlerinin genel profil analizi ile açıköğretim sistemine ilişkin memnuniyetlerinin ve bağlılıklarının incelenmesi. *Açıköğretim Uygulamaları Ve Araştırmaları Dergisi*, 7(2), 64-86. <https://doi.org/10.51948/auad.854625>
- Durmuş, S. & Tokyay, E. O. (2021). Havacılık Yönetimi Lisans Öğrencilerinin Meslek Tercih Eğilimlerinin İncelenmesi. *Journal of Aviation Research*, 3(2), 227-242. DOI: 10.51785/jar.945831
- Greenacre, M. (2007). *Correspondence Analysis in Practice* (2nd ed.). Chapman and Hall/CRC. <https://doi.org/10.1201/9781420011234>
- Gursoy, D., & Chi, C. G. (2020). Effects of COVID-19 pandemic on hospitality industry: Review and recommendations for future research. *Journal of Hospitality Marketing & Management*, 29(5), 527-534.
- Holland, J. L. (1997). Making vocational choices: A theory of vocational personalities and work environments (3rd ed.). *Psychological Assessment Resources*.
- Hsu, T. P., Wu, Y. W., & Chen, A. Y. (2022). Temporal stability of associations between crash characteristics: A multiple correspondence analysis. *Accident Analysis & Prevention*, 168, 106590.
- İlgaz, B. & Güzel, Ö. (2019). Turist Rehberliği Bölümü Öğrencilerinin Kariyer Devamlılığı: Çoklu Uyum Analizi Çalışması. *Turizm Akademik Dergisi*, 6(2), 61-74.
- İstanbullu Dinçer, F., Akova, O., & Kaya, F. (2013). *Mesleki eğitim ve kariyer planlamasında bireysel farkındalıkların rolü*. İstanbul: Beta Yayınları.
- Johnson, R. A., & Wichern, D. W. (2007). *Applied Multivariate Statistical Analysis*. New Jersey: Prentice Hall.
- Kakşa, G. N. and Soyca, S. Y. (2022). Havacılık öğrencilerinin istihdam umudu düzeylerinin incelenmesi. *Asrel*, 1(2), 113-124. <https://doi.org/10.56753/asrel.2022.2.4>
- Ulufer Kansoy, S. (2023). Havacılık sektöründe insan kaynaklarını inceleyen çalışmalara bir bakış: bir içerik analizi çalışması. *Kırklareli Üniversitesi Sosyal Bilimler Meslek Yüksekokulu Dergisi*, 4(1), 24-54. <https://doi.org/10.51969/klusbmyo.1269978>
- Kaynak, T. (1996). *İnsan kaynakları planlaması*. İstanbul: Alfa Yayınları.
- Kıracı, K., & Bayrak, Ü. (2014). Sivil havacılık lisans mezunlarının istihdam ve kariyer durumları üzerine bir araştırma. *E-International Journal of Educational Research*, 5(2), 67-88.
- Kozak, M. (2009). Akademik turizm eğitimi üzerine bir durum analizi. *Muğla Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 22(1), 1-20.

- Krumboltz, J. D., Mitchell, A. M., & Jones, G. B. (1976). A Social Learning Theory of Career Selection. *The Counseling Psychologist*, 6(1), 71-81. <https://doi.org/10.1177/001100007600600117> (Original work published 1976)
- Küçüköğlu, M. T., Baynazoğlu, M. E., & Berber, Ş. (2020). Meslek Yüksekokulu Öğrencilerinin Kariyer ve Girişimcilik Yönelimleri. *Yönetim ve Ekonomi Dergisi*, 27(1), 91-108.
- Nenadić, O., Greenacre, M. (2005). *Computation of Multiple Correspondence Analysis, with code in R*. UFP Working Paper No. 887, Available at SSRN: <https://ssrn.com/abstract=847698>.
- Pendergrass, D. C. (2008). Career choice factors of high school students (Doctoral dissertation, University of Phoenix). ProQuest Dissertations Publishing.
- Richardson, S. (2008). Undergraduate tourism and hospitality student's attitudes toward a career in the industry: A preliminary investigation. *Journal of Teaching in Travel and Tourism*, 8(1), 23-46.
- Robertson, P. J. (2014). Health inequality and careers. *Br. J. Guid. Counc.* 42, 338-351. doi: 10.1080/03069885.2014.900660
- Sevinç, E. (2010). *Kariyer planlama ve yönetimi*. İstanbul: Etap Yayınları.
- Steckel, J., Kraus, R., & Hensley, J. (2018). What motivates students to choose a career in aviation? *Journal of Aviation/Aerospace Education & Research*, 27(1), 23-35.
- Suner, A., & Çelikoğlu, C. C. (2008). Uygunluk analizinin benzer çok değişkenli analiz yöntemleri ile karşılaştırılması. *İstatistikçiler Dergisi: İstatistik ve Aktüerya*, 1(1), 9-15.
- Super, D. E. (1990). A life-span, life-space approach to career development. In D. Brown & L. Brooks, *Career choice and development: Applying contemporary theories to practice* (2nd ed., pp. 197-261). Jossey-Bass.
- Şen, G. (2019). Üniversitede Havacılık Bölümlerinde Okuyan Öğrencilerin Meslek Seçiminde Etkili Olan Faktörlerin İncelenmesi. *Journal of Aviation*, 1(2), 122-131.
- Ternavska, T., Danylko, O., & Radul, S. (2023). Theoretical Analysis of Educational and Professional Motivation of Future Aviation Specialists, *Bulletin of Oleksandr Dovzhenko Hlukhiv National Pedagogical University*, 51(1), 141-150.
- Ünal, N. & Baran, G. (2012). Öğretmen Adaylarının Mesleki Yönelimi, Kariyer Geliştirme Arzuları Ve Kariyer Seçim Memnuniyeti. *Kastamonu Eğitim Dergisi*, 20(3), 807-826. Retrieved from <https://dergipark.org.tr/en/pub/kefdergi/issue/48698/619565>
- van der Heijden, P. G. M., Teunissen, J., & van Orlé, C. (1997). Multiple Correspondence Analysis as a Tool for Quantification or Classification of Career Data. *Journal of Educational and Behavioral Statistics*, 22(4), 447-477. <https://doi.org/10.3102/10769986022004447> (Original work published 1997)
- Vondracek, F. W. (1998). Career development: A lifespan perspective (Introduction to the special section). *International Journal of Behavioral Development*, 22(1), 1-6.
- Walker, J. W., & Gutteridge, T. G. (1990). *Career planning and development*. Boston: Houghton Mifflin.

- Wen, C. H., & Chen, Y. C. (2011). Using multiple correspondence analysis to map airline market structure. *Transportation Research Part A: Policy and Practice*, 45(9), 904–912.
- Yavaş, H., Gümüş, S., & Eryiğit, S. (2021). Havacılık eğitiminde staj uygulamalarının değerlendirilmesi. *Meslek Yüksekokulları Dergisi*, 55–68.
- Ying, C. (2025). Factors Influencing Aviation Services Students' Happiness Toward Career Guidance Course in Hainan, China. *AU-GSB e-JOURNAL*, 18(1), 45-54.
- YÖK Atlas (2024). *Yükseköğretim Program Atlası*. <https://yokatlas.yok.gov.tr/> adresinden erişildi.



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Artificial Intelligence-Based Stress Prediction for Rotor Blisk in Gas Turbine Engines

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Abstract

Gas turbine engines are critical components in aerospace, power generation, and industrial applications, consisting of complex rotating and stationary parts subject to extreme mechanical, thermal, and aerodynamic loads. A key component in modern gas turbines is the rotor blisk, which combines the blades and disk into a single unit. Due to its complex geometry and harsh operating conditions, the rotor blisk experiences significant mechanical stresses that must be accurately calculated to ensure reliability, safety, and optimal performance. Traditional methods, such as finite element analysis (FEA), are widely used to calculate stress distributions under various loading conditions. However, FEA is computationally expensive, especially when analyzing multiple scenarios for different operating conditions. This computational cost can become a bottleneck in iterative design studies and real-time decision making. To address this challenge, this study proposes a novel approach that uses deep learning to predict stresses in rotor blisks under varying loads. A deep neural network (DNN) was trained on FEA-generated stress data to learn the relationships between input parameters and resulting stress distributions. The AI-based model was validated using unseen load scenarios for radial, axial, and tangential stress distributions and maximum-minimum stress results, with a maximum deviation of 6% to 15% from FEA results. In addition, the Artificial Intelligence (AI) approach reduced the computational cost by 13,000 times faster than FEA by predicting results instead of solving complex equations. The AI approach enables rapid stress predictions and facilitates real-time design iteration and optimization. These results highlight the transformative potential of AI in engineering simulation, enabling faster, more efficient structural assessments and advancing the optimization of gas turbine components in the aerospace and energy industries.

Key Words: Artificial Intelligence (AI), Finite Element Analysis (FEA), Gas Turbine Engine, Rotor Blisk, Deep Learning

JEL Classification: C45, C63.

Gaz Türbinli Motorlarda Rotor Blisk için Yapay Zeka Tabanlı Gerilme Tahmini

Öz

Gaz türbinli motorlar; havacılık, enerji üretimi ve endüstriyel uygulamalarda kritik bileşenler olup, aşırı mekanik, termal ve aerodinamik yüklere maruz kalan karmaşık döner ve sabit parçalardan oluşmaktadır. Modern gaz türbinlerinin temel bileşenlerinden biri, kanatları ve diski tek bir bütün halinde birleştiren rotor bliskdir. Karmaşık geometrisi ve zorlu çalışma koşulları nedeniyle rotor blisk, güvenilirliğin, emniyetin ve optimal performansın sağlanabilmesi için doğru bir şekilde hesaplanması gereken önemli mekanik gerilmelere maruz kalmaktadır. Sonlu elemanlar analizi (SEA) gibi geleneksel yöntemler, farklı yükleme koşullarında gerilme dağılımlarını hesaplamak için yaygın şekilde kullanılmaktadır. Ancak, SEA özellikle farklı çalışma koşulları için çoklu senaryoların analizinde hesaplama açısından maliyetli olup, bu hesaplama yükü tekrarlamalı tasarım çalışmalarında ve gerçek zamanlı karar vermede bir darboğaz hâline gelebilmektedir. Bu zorluğun üstesinden gelmek amacıyla, bu çalışma rotor blisklerde farklı yükler altında gerilmeleri tahmin

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etmek için derin öğrenme kullanan yeni bir yaklaşım önermektedir. Bir derin sinir ağı (DSA), giriş parametreleri ile ortaya çıkan gerilme dağılımları arasındaki ilişkileri öğrenebilmek için SEA tarafından üretilmiş gerilme verileri üzerinde eğitilmiştir. Yapay zeka tabanlı model, radyal, eksenel ve teğetsel gerilme dağılımları ile maksimum-minimum gerilme sonuçları için görülmemiş yük senaryoları kullanılarak doğrulanmış ve SEA sonuçlarına kıyasla %6 ila %15 arasında maksimum sapma göstermiştir. Ayrıca, yapay zeka yaklaşımı karmaşık denklemleri çözmek yerine sonuçları tahmin ederek SEA'ya kıyasla hesaplama maliyetini 13.000 kat azaltmıştır. Yapay zeka yaklaşımı, hızlı gerilme tahminleri yapılmasını mümkün kılmakta ve gerçek zamanlı tasarım yinelemelerini ve optimizasyonu kolaylaştırmaktadır. Bu sonuçlar, mühendislik simülasyonunda yapay zekânın dönüştürücü potansiyelini vurgulamakta, daha hızlı ve daha verimli yapısal değerlendirmeleri mümkün kılmakta ve havacılık ile enerji endüstrilerinde gaz türbini bileşenlerinin optimizasyonunu ilerletmektedir.

Anahtar Kelimeler: Yapay Zeka (YZ), Sonlu Elemanlar Analizi (SEA), Gaz Türbinli Motor, Rotor Blisk, Derin Öğrenme

JEL Sınıflandırma: M10, M19.

INTRODUCTION

Gas turbine engines are integral components in a wide range of industries, including aerospace, power generation, and industrial sectors. They are designed to operate under extreme mechanical, thermal, and aerodynamic loads, where high efficiency, reliability, and performance are of paramount importance (Mane et. al, 2023). These engines consist of complex rotating and stationary components that work in tandem to convert energy into mechanical power. Among these components, the rotor blisk which combines the disk and blades into a single structure plays a critical role. Rotor blisks are typically used in compressors, as they offer significant advantages such as weight reduction, enhanced aerodynamic performance, and improved thermal management (Kumar, 2013). The integration of the disk and blades into a single unit eliminates the need for traditional fastening methods, resulting in a more streamlined and efficient design, as shown in Fig. 1.



Figure 1. Compressor rotor blisk

Source: Bandini et. al, 2024

Due to their complex geometry and harsh operating conditions, rotor blisks are subjected to substantial mechanical stresses. These stresses are a result of various factors, including

rotational speed, aerodynamic forces, and thermal expansion effects, all of which vary depending on the engine's operating conditions. The accurate calculation of these stresses is essential for ensuring the component's reliability, preventing fatigue failures, and optimizing its lifespan (Elhefny & Megahed, 2018). Traditional methods such as finite element analysis (FEA) are widely used to perform stress analysis under different loading conditions. FEA is a powerful tool that provides high-fidelity results by breaking down complex geometries into smaller, manageable elements and solving the governing equations. However, while FEA is highly accurate, it is computationally expensive, particularly when multiple loading scenarios must be analyzed. As a result, this computational burden limits the feasibility of real-time analysis and optimization in many engineering applications, hindering timely design decisions and innovation (Zhang et. al, 2016).

In recent years, artificial intelligence (AI) has emerged as a promising solution to accelerate structural simulations and address the limitations of traditional methods like FEA. AI-driven models, particularly those based on machine learning (ML), have shown the potential to reduce the computational cost associated with structural analysis without compromising accuracy. These models, often referred to as surrogate models, are trained on large datasets generated through FEA or experimental testing. Once trained, they can predict stress distributions under various loading conditions much faster than traditional FEA, thus enabling real-time simulations (Shivaditya et. al, 2022). In particular, deep learning, a subset of AI, has demonstrated significant promise due to its ability to capture complex, non-linear relationships between input parameters and output results. Several studies have applied machine learning-based methods in fields such as structural health monitoring, material property prediction, and topology optimization, showcasing their ability to streamline design and analysis processes (Plevris & Papazafeiropoulos, 2024). However, despite the growing body of research on AI applications in engineering, the use of AI for stress prediction in structural components under varying operational conditions is still an emerging field.

The application of AI in gas turbine engineering has already shown considerable potential in improving performance and reducing maintenance costs. For instance, one study reviewed AI applications in condition assessment and fault detection, noting the success of machine learning models in enhancing the reliability of turbine systems (Zhao et. al, 2021). Similarly, another study introduced a hybrid temporal convolutional network–autoencoder model for real-time fault detection, improving diagnostic accuracy in gas turbine systems (Guo et. al, 2021). Other studies have proposed deep learning-based models for predicting low-cycle fatigue life in turbine blades (Zhu et. al, 2022), optimizing turbine blisk temperature distributions (Wang et. al, 2022), and enhancing fault detection under noisy conditions (Chen et. al, 2022). One study applied dynamic neural networks to diagnose engine failures at an early stage, while another leveraged AI-driven topology optimization to enhance the performance of compressor rotor blisks, improving their strength and efficiency [13,14]. A convolutional neural network (CNN) approach has been proposed for probabilistic low-cycle fatigue life prediction of turbine blisks, demonstrating significant accuracy improvements over conventional methods (Fei et. al, 2024). A comprehensive review of machine learning strategies in turbine cooling design optimization has also been conducted, emphasizing the role of surrogate models in reducing simulation time and design complexity (Li et. al, 2024).

Furthermore, a reduced-order modeling technique based on deep learning has been introduced to predict unsteady pressure fields on turbine blades, substantially decreasing computational effort while maintaining high fidelity (Joachim et. al, 2025). Another study investigated reinforced symbolic learning with logical constraints for predicting turbine blade fatigue life, integrating interpretability with predictive performance (Li et. al, 2024). In addition, recent reviews have focused on AI-driven frameworks for predictive maintenance and diagnostics in turbomachinery, addressing fault detection, anomaly prediction, and reliability enhancement (Bunyan et. al, 2025).

These studies underscore the growing recognition of AI's potential to optimize turbine systems and improve their performance across various stages of the life cycle, from design and operation to maintenance and failure prediction. Despite these advancements, the application of AI in predicting the stress distribution of complex components like rotor blisks under varying operational conditions remains an open challenge. Traditional FEA methods require detailed geometric models and significant computational resources, which makes it difficult to apply these methods in iterative design processes and real-time decision-making. Deep learning-based approaches, on the other hand, offer a potential solution by enabling faster and more efficient simulations.

This study introduces a novel deep neural network (DNN) approach for predicting stress in rotor blisks subjected to a variety of loading conditions, including rotational speed, gas pressure, and thermal loads. By training the DNN model using comprehensive FEA-generated stress data, the model effectively learns the complex, non-linear relationships between these input parameters and the resulting stress distributions. This research addresses the existing gap by demonstrating how AI can significantly accelerate stress prediction for critical aerospace components, thereby overcoming the computational limitations of traditional FEA for design optimization and real-time assessment. Once trained, the model can provide rapid predictions, with a maximum deviation of just 15% from traditional FEA results, while reducing computational costs by approximately 3300%. This dramatic reduction in computational load makes real-time design optimization feasible and opens up new possibilities for rapid prototyping and iterative design processes in gas turbine engineering. Moreover, the DNN-based approach provides an efficient way to perform sensitivity analysis, enabling engineers to explore the effects of different loading conditions on the component's performance without the need for extensive FEA simulations.

The main objectives of this study are:

- To develop a robust deep learning model for accurate stress prediction in rotor blisks under varying operational conditions.
- To demonstrate the significant computational efficiency gains of the AI-based approach compared to traditional FEA.
- To provide a framework for integrating AI into the design and analysis workflows of gas turbine components, facilitating faster design iterations and optimization.
- To analyze and compare the radial, tangential, and axial stress distributions predicted by the DNN with high-fidelity FEA results, identifying the model's strengths and

limitations in capturing complex stress patterns.

The subsequent sections of this paper are organized as follows: Section-2 details the material and methods, including the finite element analysis of the blisk model and the architecture of the deep learning model. Section-3 presents the results and a comprehensive discussion of the stress predictions. Finally, Section-4 provides the conclusions drawn from this study and outlines potential avenues for future research.

1. MATERIAL AND METHOD

1.1. Finite Element Analysis of the Blisk Model

The finite element method (FEM) is a numerical technique widely used for solving complex engineering problems involving structural, thermal, and dynamic analyses. It discretizes a continuum domain into smaller subdomains, known as finite elements, connected at nodes, thereby transforming partial differential equations into a system of algebraic equations that can be solved computationally. The general governing equation of motion in FEM for a dynamic system is expressed can be expressed as given in Equ. 1 (ANSYS, 2024).

$$[M]\{\ddot{u}\} + [C]\{\dot{u}\} + [K]\{u\} = \{F\} \quad (1)$$

Where M is the mass matrix, C is the damping matrix, K is the stiffness matrix, u is the displacement vector, and F represents the external force vector. Depending on the problem type, static or dynamic equilibrium conditions are enforced to obtain the solution. Since external forces does not vary with time in this study, inertial and damping effects are neglected and the general governing equation of motion becomes as given in Equ. 2.

$$[K]\{u\} = \{F\} \quad (2)$$

In this study, FEA was employed to simulate the behavior of a blisk model under operational conditions typically encountered in high-pressure compressor rotors. The geometry of the blisk was generated using SpaceClaim, and the numerical simulations were carried out using ANSYS Mechanical. To reduce computational costs while still capturing the key structural behaviors, a one-blade sector representation of a 70-bladed blisk was chosen for the finite element (FE) model. To replicate the behavior of the full blisk assembly without simulating all 70 blades, cyclic symmetry boundary conditions were applied to the boundary faces of the sector model as shown in Fig. 2. The model was meshed using 22,400 SOLID185 linear hexahedron elements, which were selected for their suitability in accurately capturing the complex geometries and stresses of the blisk while maintaining computational efficiency and constrained in both the axial and tangential directions from the forward side face of the disc bore and constrained only in tangential direction from aft side of the disc bore to simulate the physical boundary conditions of the actual component as shown in Fig. 3.

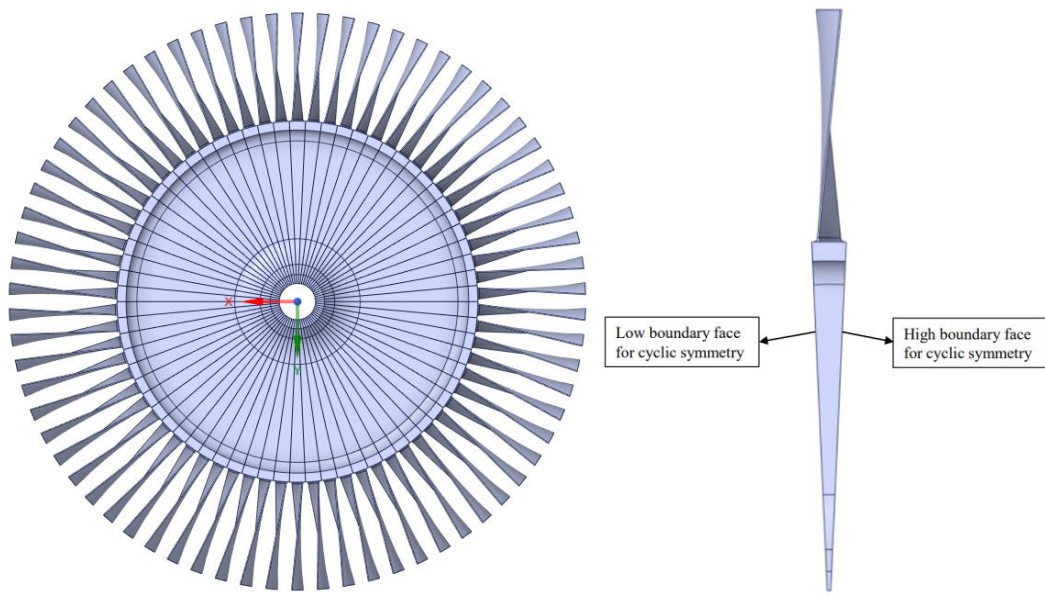


Figure 2. Compressor rotor blisk: 360° model (left), Cyclic sector model (right)

The material used in the simulations was assumed to be isotropic and temperature-dependent, reflecting the characteristics of high-performance titanium alloys commonly used in compressor rotor blisks. This choice allows for the incorporation of the temperature-induced variations in material properties, such as Young's modulus, Poisson's ratio, and thermal expansion, which are critical when assessing the blisk's performance under the extreme conditions encountered in turbine operation.

The loading conditions applied to the model were designed to simulate the real operational environment of high-pressure compressor rotors in gas turbine engines. These included centrifugal forces, represented by varying the rotational speed between 0 to 12,000 RPM, and aerodynamic loads, modeled by gas pressures ranging from 0 MPa to 0.5 MPa. To capture the effects of temperature that occur during engine operation, thermal loads were applied, with temperatures ranging from 0°C to 1,500°C, simulating both the thermal expansion of the material and the resulting stress redistribution within the structure as shown in Fig. 4. Geometric nonlinearity was taken into account in numerical simulations.

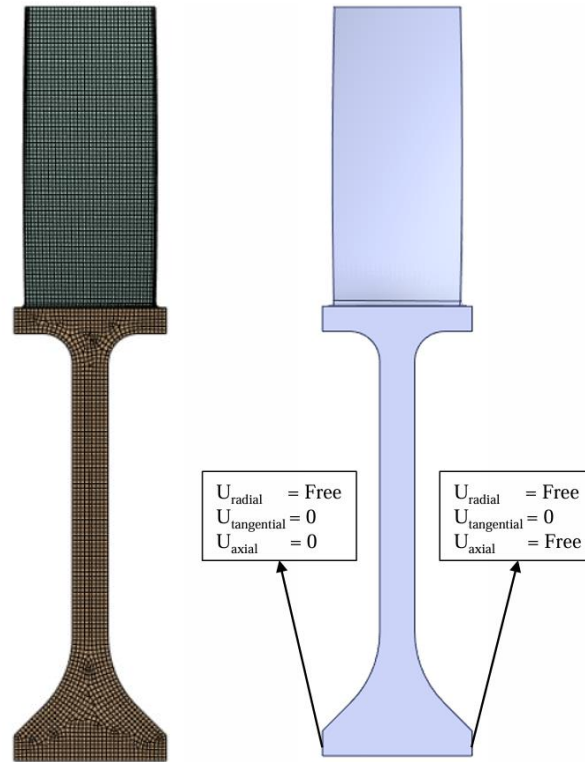


Figure 3. Compressor rotor blisk: FE model (left), Boundary conditions (right)

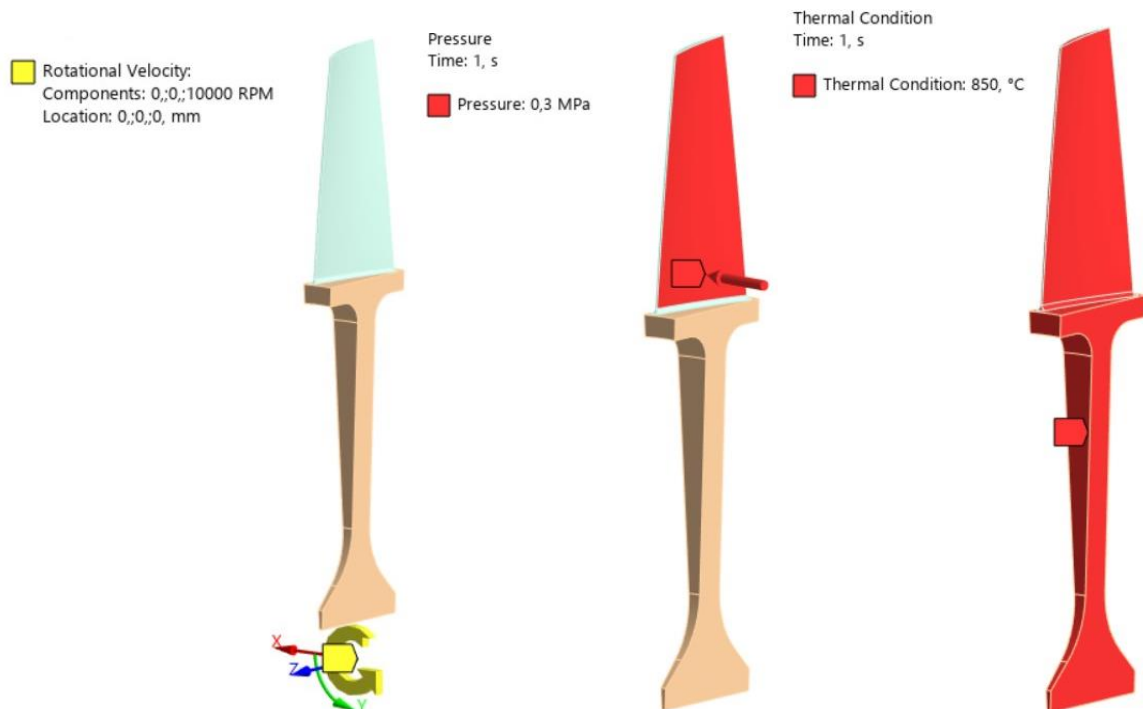


Figure 4. Applied loads for rotor blisk model: Rotational velocity (left), Gas pressure (middle), Temperature (right)

The solution phase involved performing static analyses to evaluate stress distributions at different load cases. A total of 10 distinct load cases were examined to obtain a comprehensive dataset, which could later be used for further validation and potential deep learning applications as shown in Table 1. The key performance indicators extracted from the results included radial, tangential, and axial stresses for the blisk sector under various

loading conditions. These findings provide valuable insights into the structural integrity and operational safety of the compressor rotor, contributing to the optimization of its design and performance.

Table 1. Applied loading conditions for the blisk model

Rotational Velocity (RPM)	Gas Pressure (MPa)	Temperature (°C)
0	0.25	0
0	0	1000
500	0.01	50
1000	0	0
2500	0.03	150
4000	0.2	250
5000	0.08	450
7000	0.12	600
10000	0.3	850
12000	0.5	1500

1.2. Deep Learning Model

Artificial neural networks (ANNs) are computational models inspired by the human brain, consisting of interconnected units called perceptron. A perceptron is the fundamental building block of an ANN, mimicking biological neurons by receiving weighted inputs, applying an activation function, and producing an output using Equ. 3 as shown in Fig. 5. When multiple perceptron is organized into layers, they form an ANN, which can learn patterns from data and make predictions. Deep learning refers to a subset of machine learning where ANNs contain multiple hidden layers, enabling them to model complex and highly nonlinear relationships in data. These deep networks are particularly effective in tasks such as image recognition, natural language processing, and engineering simulations (Al-Mahasneh et. Al, 2018).

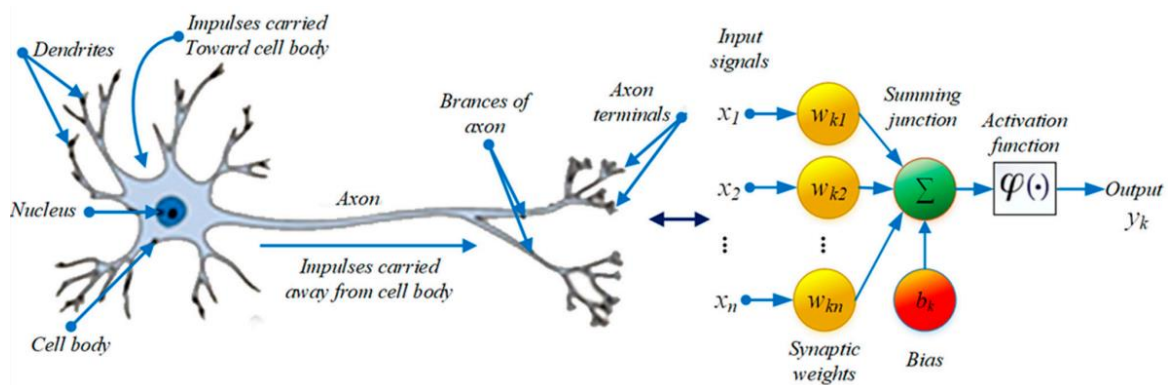


Figure 5. A biological neuron (left), a perceptron (right)

Source: Melina et. al, 2023

In this study, a deep neural network (DNN) was developed to predict the stress distribution in the rotor blisk, leveraging FEA-generated data under various operating conditions. The methodology and model architecture are comprehensively detailed as follows:

- Data Preprocessing:

The input features (RPM, aerodynamic pressure, temperature) and output stress components (radial, tangential, axial) were normalized to the range $[-1, 1]$ to enhance convergence and training stability. The dataset was divided into nine subsets for training and one subset for validation. Additionally, an unseen load case was reserved to rigorously assess the model's generalization capability.

- Neural Network Architecture:

The model comprises an input layer accepting normalized parameters, followed by four fully connected hidden layers, each containing 256 neurons. The activation function used in all hidden layers is the Rectified Linear Unit (ReLU), which transforms negative input values to zero while keeping positive values unchanged. This function is computationally efficient and helps mitigate the vanishing gradient problem, making it a preferred choice for deep networks. The output layer employs a linear activation function that preserves the continuous output values. These activation functions are defined in Equations 4 and 5.

- Training and Optimization:

Training minimizes the Mean Squared Error (MSE) loss function (Equation 6), which calculates the mean of the squared differences between predicted and actual values. MSE is widely used in regression problems involving continuous variables, as it penalizes larger errors more heavily. The optimization uses the RMSProp algorithm (Equation 7), which dynamically adjusts the learning rate for each parameter, improving stability and convergence on the validation dataset. The learning rate is set to 0.001, balancing gradual convergence and avoiding excessive fluctuations. The model is trained for 500 epochs to ensure sufficient learning of complex data patterns while monitoring validation loss. These hyperparameters, summarized in Table 2, were carefully selected to optimize the model's performance and enhance its generalization ability.

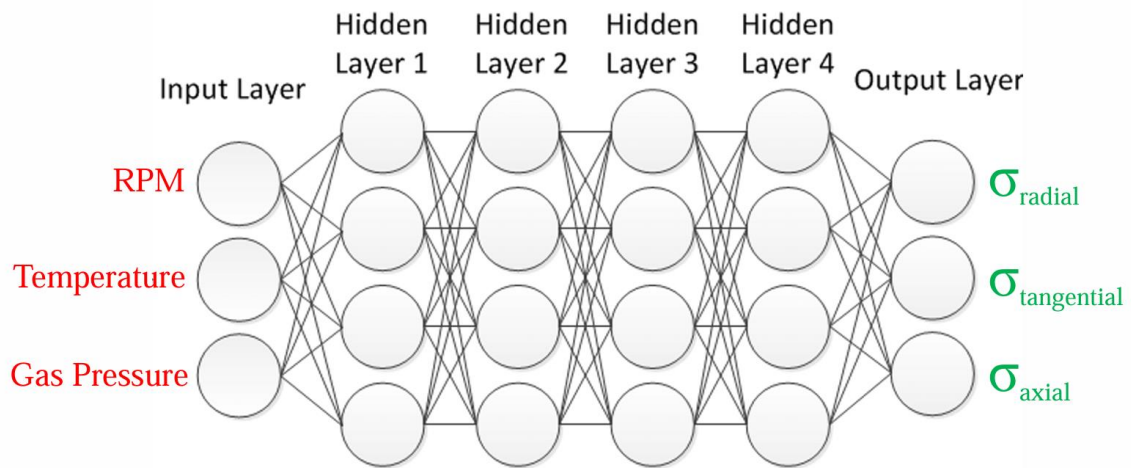


Figure 6. The deep neural network structure

$$y_i = \sum_j f(W_{ij}y_j + b_i) \quad (3)$$

$$f = f(x) = \begin{cases} x, & x > 0 \\ 0, & \text{otherwise} \end{cases} \quad (4)$$

$$f(x) = x \quad (5)$$

$$\mathcal{L}(\theta) = \frac{1}{n} \sum_{i=1}^n (y^{(i)} - \hat{y}^{(i)})^2 \quad (6)$$

$$u_t = \beta * u_t + (1 - \beta)(\nabla w_t)^2$$

$$w_{t+1} = w_t - \frac{\eta}{\sqrt{(u_t) + \epsilon}} \nabla w_t \quad (7)$$

Table 2. Hyperparameters for the deep learning model

Hyperparameter	Value
Number of Layers	4
Neurons per Layer	256
Activation Function	ReLU, Linear
Loss Function	MSE
Optimizer	RMSProp
Learning Rate	0.001
Epochs	500

For the validation, a single validation load set was utilized to assess the convergence of the model. The evaluation metric used to measure model accuracy is the Mean Squared Error (MSE). A lower MSE indicates improved model accuracy and better alignment with the actual data. Figure 8 presents the evaluation of loss and MSE on both the training and validation sets. The trends depicted in the graphs provide key insights into the network's learning behavior. At the beginning, with a limited number of epochs, MSE values are relatively high, showing that the network struggles to accurately capture the complex relationships between the input and target variables. As the number of epochs increases, a steady decrease in MSE is observed, which is in line with the expected behavior as the network continuously adjusts its weights and biases. This ongoing adaptation improves the network's ability to more accurately predict the free response of the test bench. To validate the DNN model, the predictions made by the trained model using the validation dataset were also checked as shown in Fig. 7.

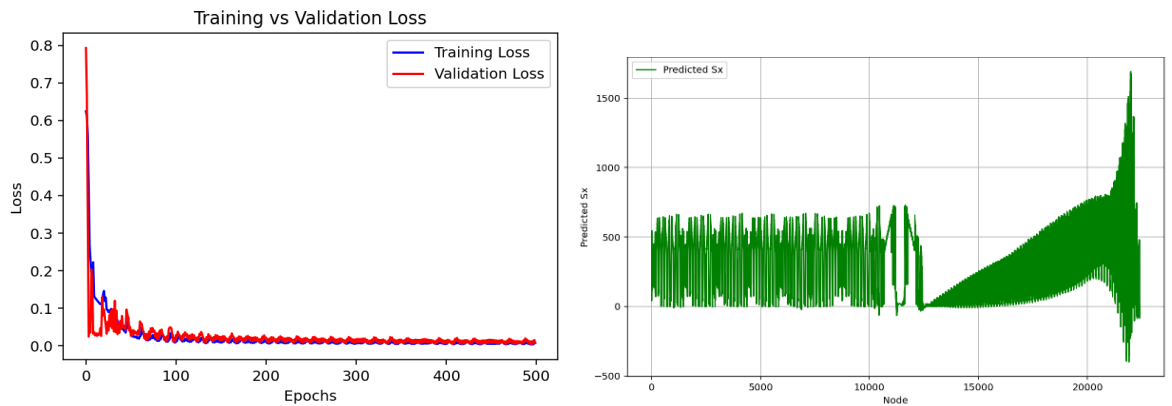


Figure 7. Training and validation loss through epochs (left), prediction of nodal radial stresses for validation load set (right)

The proposed framework follows a structured pipeline comprising several key steps as shown in Table 3: data generation via FEA simulations, data preprocessing and normalization, deep neural network training, and final stress prediction.

Table 3. Workflow Stages for AI-Based Stress Prediction

Step No	Stage	Description
1	Data Generation	Stress data were generated by finite element simulations
2	Preprocessing	Data were normalized and split for training and validation
3	Model Architecture	A deep neural network with four hidden layers was established
4	Training	The network was trained over 500 epochs
5	Prediction	The model predicts stresses quickly for given inputs
6	Evaluation	Accuracy was validated on unseen data

2. RESULTS AND DISCUSSION

This study investigates the stress distribution in a compressor rotor blisk subjected to centrifugal, gas pressure, and thermal loads using both finite element analysis (FEA) and deep neural networks (DNNs). Radial, tangential, and axial stress components were analyzed under ten different load cases, and the results were supplied to the DNN for training. The model was subsequently tested on an unseen load case, with its predictions compared to FEA results.

Radial stress distribution exhibited a characteristic gradient along the blisk, with maximum stress concentrations occurring near the root of the blade due to the transition in cross-sectional geometry as shown in Fig. 8. FEA results indicated a maximum radial stress of 1770.3 MPa, whereas the DNN-predicted value for the same location was 1789.5 MPa, demonstrating a relative error within an acceptable range. The minimum radial stress was observed at the root of the blade, where tensile and compressive stresses balanced out due to centrifugal loading effects, with FEA predicting -257.69 MPa and the DNN predicting -228.96 MPa. The overall radial stress distribution predicted by the DNN closely followed the FEA solution, with minor deviations attributed to the interpolation behavior of the neural network in regions with high stress gradients.

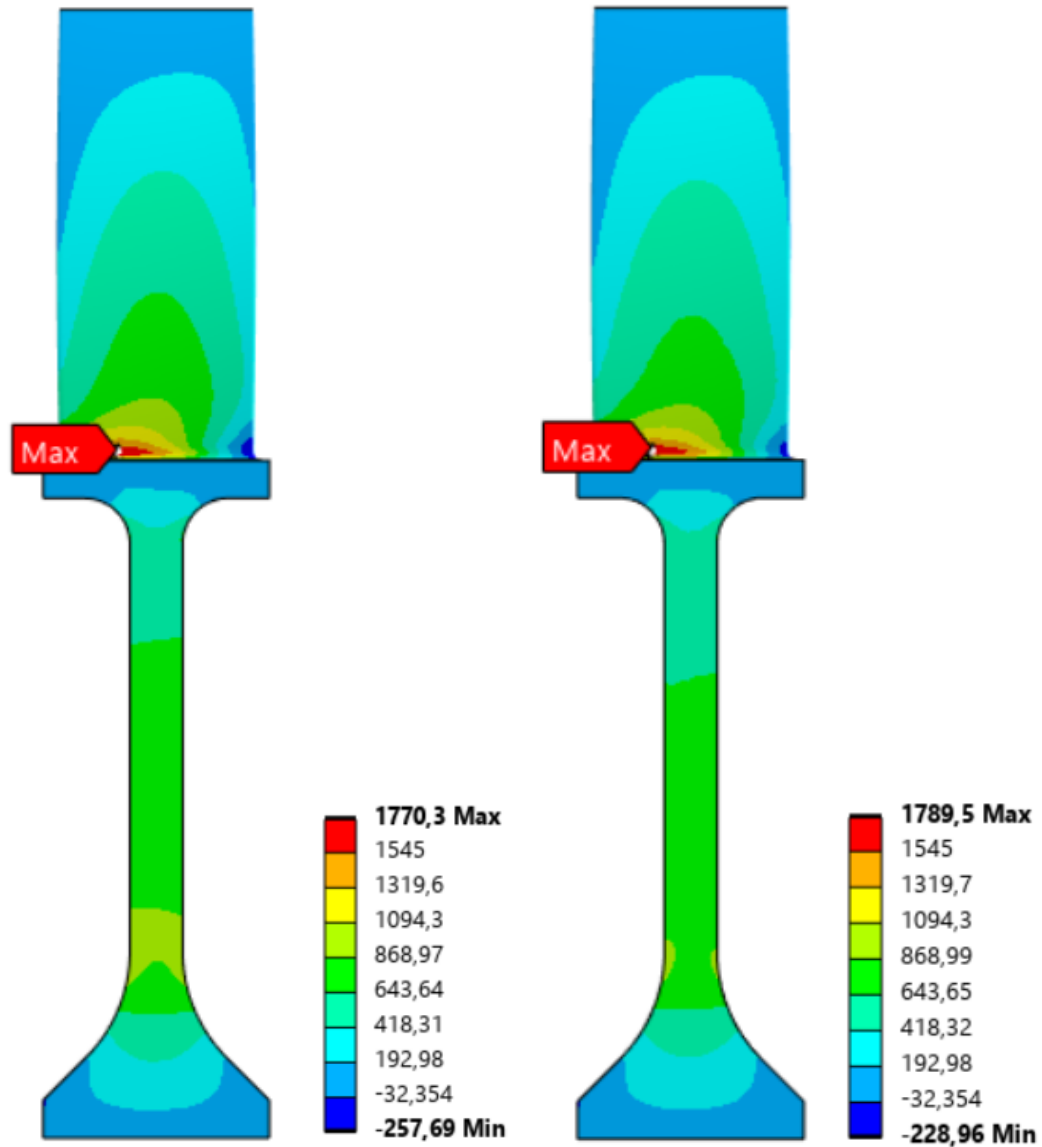


Figure 8. Compressor rotor blisk radial stress results: FEA (left), AI prediction (right)

Tangential (hoop) stresses, which primarily result from centrifugal forces acting on the rotating structure, showed peak values in the vicinity of disk upper bore region due to the accumulation of rotational inertia as shown in Fig. 9. FEA simulations revealed a maximum tangential stress of 790.13 MPa, while the DNN prediction yielded 661.68 MPa, showing a slight underestimation. The minimum tangential stress was located near the inner hub region, where compressive forces counterbalanced the tensile effects, with FEA predicting -257.32 MPa and DNN predicting -294.99 MPa. Despite the minor discrepancies, the overall stress distribution trends were accurately captured by the DNN, reinforcing its capability to generalize stress patterns under unseen conditions.

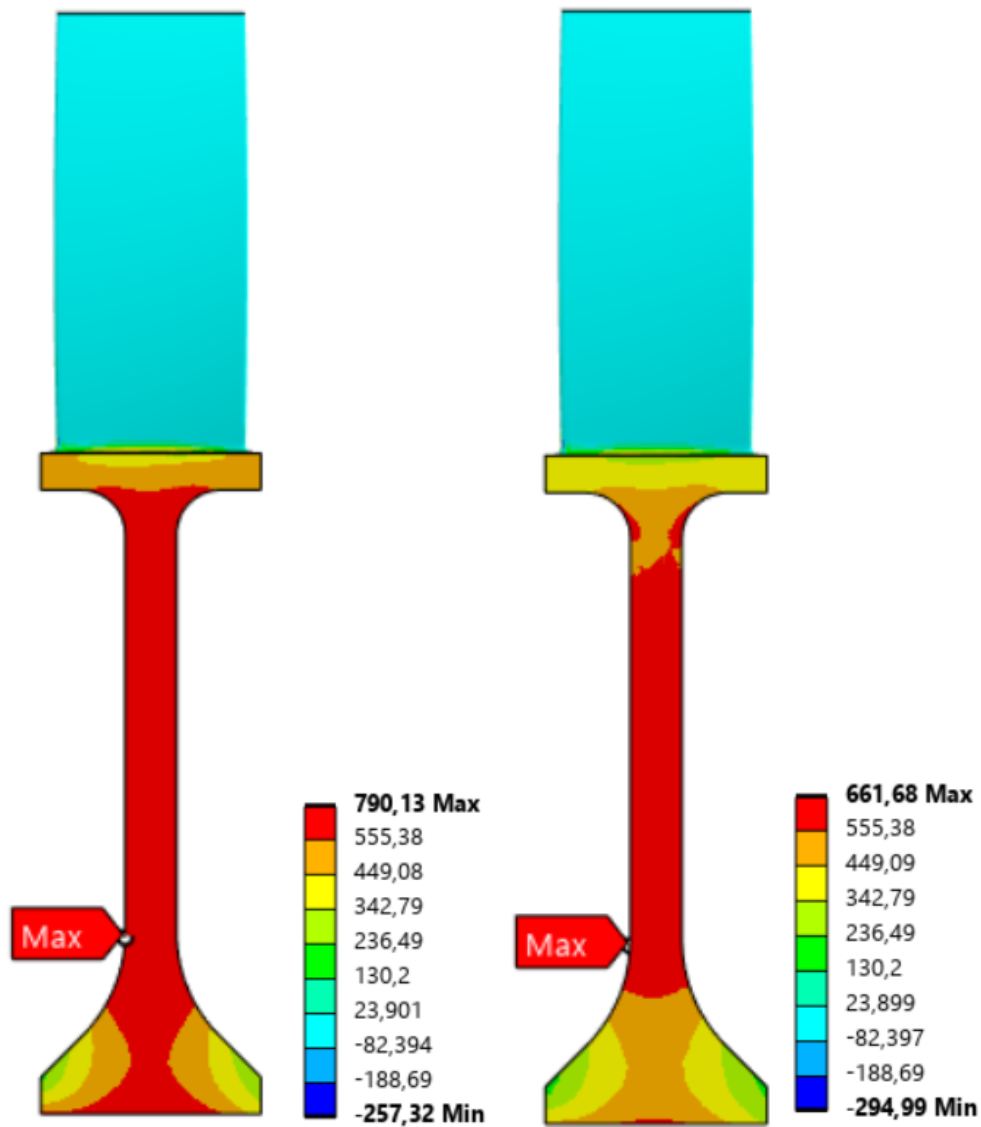


Figure 9. Compressor rotor blisk tangential stress results: FEA (left), AI prediction (right)

Axial stress, influenced by both thermal expansion and mechanical loads, exhibited its highest values near the disk-blade interface, where constraints on radial expansion induce tensile stress as shown in Fig. 10. FEA results showed a peak axial stress of 327.94 MPa, whereas the DNN-predicted value was 288.83 MPa, indicating a slight underestimation. The minimum axial stress was recorded at the lower disk section, with FEA predicting -418.86 MPa and the DNN predicting -422.89 MPa, demonstrating strong agreement in compressive stress regions. The stress distribution across the component followed a consistent trend, with the DNN capturing the overall pattern effectively, though minor deviations were observed in localized stress concentrations.

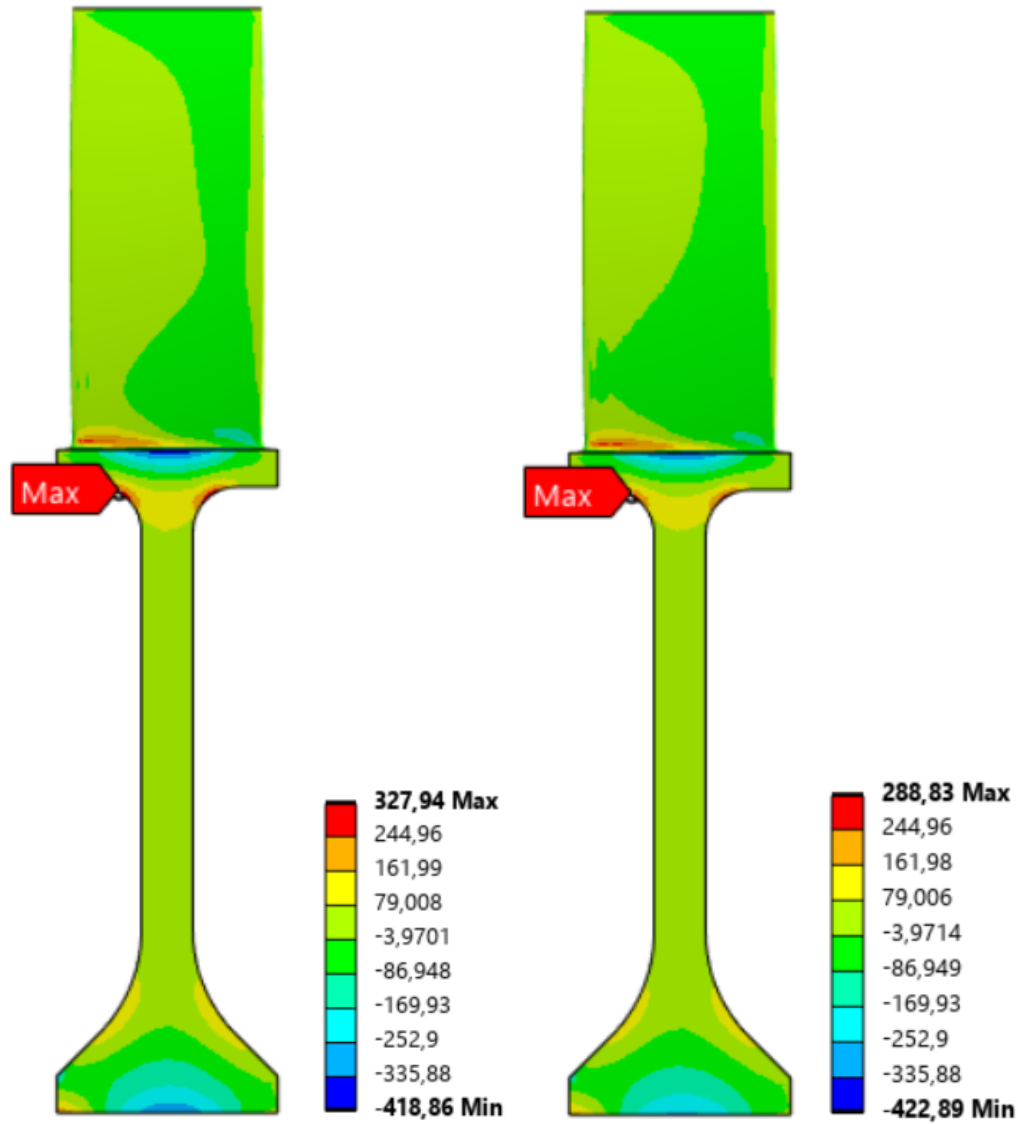


Figure 10. Compressor rotor blisk axial stress results: FEA (left), AI prediction (right)

A key advantage of the DNN approach was its significant reduction in computational time. The trained neural network predicted stress distributions in 0.005 second, compared to 50 seconds required for a single FEA run. This computational speed-up makes the DNN method highly suitable for real-time applications such as optimization, digital twins, and structural health monitoring. Future work will focus on improving prediction accuracy through refined training strategies, expanding the dataset with additional load cases, and incorporating physics-informed machine learning techniques to enhance generalization. Additionally, integrating uncertainty quantification methods will provide confidence intervals for the DNN predictions, further increasing its reliability in engineering applications.

The findings from this study confirm the promising potential of deep learning as a powerful tool for accelerating stress analysis in complex engineering components. While minor discrepancies exist between DNN predictions and FEA results, particularly in highly localized stress concentration regions, the overall accuracy and the substantial reduction in computational time underscore the practical applicability of this approach.

Additionally, the main findings and their comparison with existing literature are summarized as follows and presented in Table 4:

- The deep neural network (DNN) model accurately predicted radial, tangential, and axial stresses within a maximum deviation of 15% compared to finite element analysis (FEA), confirming its capability to generalize under unseen loading conditions.
- The DNN approach achieved a computational speed-up exceeding 13,000 times compared to conventional FEA, highlighting its potential for real-time structural analysis and optimization.
- The significant reduction in computational storage requirements (from approximately 34 MB for FEA results to 0.36 MB for the DNN model) supports the feasibility of deploying this model in resource-constrained environments.
- Minor discrepancies in stress concentration regions indicate opportunities for further refinement, possibly through enhanced training datasets or physics-informed machine learning techniques.
- Compared to previous studies focused on fatigue life prediction [10], temperature distribution [11], and topology optimization [14], this study uniquely presents full-field stress prediction with a considerably higher speed-up, thereby extending the application of AI in gas turbine blisk analysis.
- The proposed framework lays the foundation for integration with digital twin technologies and structural health monitoring systems, which require rapid and reliable stress predictions.

Table 4. Summary of key findings and comparison with literature

Finding	Description	Comparison with Literature
Stress prediction accuracy	Maximum deviation of 15% for radial, tangential, and axial stresses	Comparable accuracy to [10], [11], [14]
Computational speed	Prediction time of 5 ms compared to 66 s for FEA (~13,200× speed-up)	Significantly higher speed-up than prior studies
Storage efficiency	Model size 0.36 MB vs. 34.25 MB for FEA results	Enables lightweight deployment
Applicability to unseen load cases	Successful generalization to previously unseen load conditions	Demonstrates robustness beyond training data
Potential for real-time application	Suitable for design iteration, optimization, digital twins, and structural health monitoring	Extends AI utility in gas turbine component analysis

3. CONCLUSION

This study demonstrates the potential of combining finite element analysis with deep learning for efficient stress prediction in the complex geometry of rotor blisks used in gas turbine engines. By leveraging FEA to model the blisk’s structural behavior under realistic loading conditions, a high-fidelity dataset was created that includes various combinations of centrifugal forces, aerodynamic loads, and thermal effects. The application of cyclic symmetry allowed for computational efficiency, reducing the need to simulate the full blisk geometry while maintaining accuracy. The obtained FEA results served as the foundation for training a deep learning model capable of predicting stress distributions in rotor blisks under different operational conditions. The deep learning model, trained on the FEA dataset,

exhibited strong predictive capabilities, providing a rapid alternative to traditional FEA simulations. In comparison, to survey stress results for each node with the traditional FEA approach requires 66 seconds for only one loading condition, whereas DNN predicts stress results for each node within only 5 milliseconds. Moreover, traditional FEA requires 34250 kilobytes disk storage whereas DNN only requires 363 kilobytes. By reducing the time required to perform complex simulations, this approach holds great promise for improving design optimization and life prediction of gas turbine components, which are critical in aerospace and energy industries. The deep learning model's ability to predict stress with high accuracy offers a powerful tool for structural engineers, reducing reliance on computationally expensive and time-consuming FEA simulations. Through this research, we have also shown the potential of AI-enhanced numerical simulations, where the integration of deep learning can significantly reduce analysis time without sacrificing accuracy.

Future studies can focus on enhancing the deep learning model by exploring more advanced neural network architectures, such as convolutional or recurrent networks, to better capture spatial and temporal dependencies. Expanding the dataset to include a wider range of operational conditions and failure modes will also improve model accuracy. Further validation through experimental testing and the use of transfer learning for different geometries and conditions could make the model more adaptable.

This study successfully addresses the computational bottleneck associated with traditional FEA methods by proposing an accurate and efficient AI-based stress prediction framework for rotor blisks. The demonstrated speed-up and reduced storage requirements underscore the practical utility of this approach for real-time engineering applications and iterative design processes. The insights gained pave the way for more efficient and robust design of critical gas turbine components, contributing to advancements in aerospace and energy sectors.

REFERENCES

- Al-Mahasneh, A. J., Anavatti, S. G., & Garratt, M. A. (2018). The development of neural networks applications from perceptron to deep learning. *International Journal of Computer Theory and Engineering*, 10(1), 23–28.
- ANSYS, Inc. (2024). ANSYS Mechanical 24.2 manual. ANSYS, Inc.
- Bandini, A., Cascino, A., Meli, E., Pinelli, L., & Marconcini, M. (2024). Improving aeromechanical performance of compressor rotor blisk with topology optimization. *Energies*, 17(8), 1883. <https://doi.org/10.3390/en17081883>
- Bunyan, S. T., Khan, Z. H., Al Haddad, L. A., Dhahad, H. A., Al Karkhi, M. I., Ogaili, A. A. F., & Al Sharify, Z. T. (2025). Intelligent thermal condition monitoring for predictive maintenance of gas turbines using machine learning. *Machines*, 13(5), 401. <https://doi.org/10.3390/machines13050401>
- Chen, T., Wang, Z., & Liu, S. (2022). Fault diagnosis using extreme learning machines with single hidden layer for gas turbines. *Journal of Vibration and Acoustics*, 144(2), 021004. <https://doi.org/10.1115/1.4051361>
- Elhefny, A., & Megahed, M. (2018). Design and life estimation of blisk in gas turbines. *International Research Journal of Engineering and Technology*, 5(2), 2312–2317. <https://www.irjet.net/archives/V5/i2/IRJET-V5I2231.pdf>
- Fei, C. W., Han, Y. J., Wen, J. R., Li, C., Han, L., & Choy, Y. S. (2024). Deep learning-based modeling method for probabilistic LCF life prediction of turbine blisk. *Propulsion and Power Research*, 13(1), 12–25. <https://doi.org/10.1016/j.jprr.2023.08.005>
- Guo, W., Li, J., & Zhao, Y. (2021). Hybrid temporal convolutional network–autoencoder for fault detection in gas turbines. *Mechanical Systems and Signal Processing*, 150, 107294. <https://doi.org/10.1016/j.ymssp.2021.107294>
- Joachim, A., Pérez, E., & Reitz, S. (2025). Reduced order modeling of unsteady pressure on turbine rotor blades using deep learning. arXiv Preprint, arXiv:2503.00013. <https://arxiv.org/abs/2503.00013>
- Kumar, B. V. R. R. (2013). A review on blisk technology. *International Journal of Innovative Research in Science, Engineering and Technology*, 2(5).
- Li, P., Xu, Y., & Zheng, W. (2024). Reinforced symbolic learning with logical constraints for predicting turbine blade fatigue life. arXiv Preprint, arXiv:2412.03580. <https://arxiv.org/abs/2412.03580>
- Li, X., Chen, Z., & Zhao, H. (2024). Review of machine learning methods in turbine cooling optimization. *Energies*, 17(13), 3177. <https://doi.org/10.3390/en17133177>
- Liu, Y., Zhang, M., & Guo, W. (2022). Early-stage fault diagnosis of gas turbines using dynamic neural networks. *Energy*, 240, 122652. <https://doi.org/10.1016/j.energy.2021.122652>
- Mane, S., Pawar, S., & Minde, S. (2023). Gas turbine and its applications. *International Journal of Advanced Engineering Research and Science*.
- Melina, M., Sukono, H., Napitupulu, H., & Mohamed, N. (2023). A conceptual model of investment-risk prediction in the stock market using extreme value theory with machine learning: A semisystematic literature review. *Risks*, 11(60). <https://doi.org/10.3390/risks11030060>

- Plevris, V., & Papazafeiropoulos, G. (2024). AI in structural health monitoring for infrastructure maintenance and safety. *Infrastructures*, 9(12), 225. <https://doi.org/10.3390/infrastructures9120225>
- Shivaditya, M. V., Alves, J., Bugiotti, F., & Magoules, F. (2022). Graph neural network-based surrogate models for finite element analysis. arXiv Preprint, arXiv:2211.09373. <https://arxiv.org/abs/2211.09373>
- Wang, H., Li, S., & Zhang, X. (2022). Ensemble learning for temperature distribution prediction of turbine blisk. *Computational Materials Science*, 202, 111040. <https://doi.org/10.1016/j.commatsci.2021.111040>
- Zhang, X., de Sturler, E., & Paulino, G. H. (2016). Stochastic sampling for structural topology optimization with many load cases: Density-based and ground structure approaches. arXiv Preprint, arXiv:1609.03099. <https://arxiv.org/abs/1609.03099>
- Zhao, Y., Guo, W., Li, J., & Wang, Z. (2021). Artificial intelligence in condition assessment and fault detection for gas turbines: A review. *Journal of Turbomachinery*, 143(10), 101001. <https://doi.org/10.1115/1.4053086>
- Zhou, L., Zhang, J., & Liu, Q. (2019). AI-driven topology optimization of compressor rotor blisk for improved aeromechanical performance. *Structural and Multidisciplinary Optimization*, 59(6), 2171–2185. <https://doi.org/10.1007/s00158-019-02348-3>
- Zhu, X., Zhang, W., Li, Y., & Li, L. (2022). Deep learning-based prediction of low cycle fatigue life for turbine blades in gas turbines. *Journal of Engineering for Gas Turbines and Power*, 144(3), 031001. <https://doi.org/10.1115/1.4051232>



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Investigating the Aviation English Needs of Ab-Initio Air Traffic Controllers

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Abstract

The aim of the study was to investigate the Aviation English needs of ab-initio air traffic controllers by applying a needs analysis model from the field of English for Specific Purposes, which emphasizes three key dimensions: lacks, wants, and necessities. The participant group comprised 86 ab-initio air traffic controllers who were enrolled in course-based and university-based undergraduate education programs in Türkiye. The data were collected using a structured questionnaire employing a 5-point Likert scale. The results revealed that the highest average score was in the want dimension (M= 3.9163), indicating a strong internal motivation to improve Aviation English skills. The necessity dimension followed (M= 3.6964), showing that participants recognized the importance of meeting professional language requirements. The lack dimension received the lowest score (M= 3.5388), suggesting a moderate level of perceived language deficiencies. These findings point to the need for training programs that balance personal motivation with regulatory and operational standards. A well-designed Aviation English program should integrate learners' goals with the communication demands of the profession to enhance both language development and aviation safety.

Key Words: Air Traffic Controller, Aviation, Aviation English, Aviation English Training, Needs Analysis.

JEL Classification: I20, M10, M19.

Öğrenci Hava Trafik Kontrolörlerinin Havacılık İngilizcesi İhtiyaçlarının İncelenmesi

Öz

Çalışmanın amacı, özel amaçlı İngilizce alanında geliştirilen ve eksiklikler, istekler ile gereklilikler olmak üzere üç temel boyutu vurgulayan ihtiyaç analizi modeli aracılığıyla öğrenci hava trafik kontrolörlerinin havacılık İngilizcesi ihtiyaçlarını incelemektir. Araştırmanın katılımcı grubu Türkiye’de kurs ve üniversitelerde lisans programlarına kayıtlı 86 öğrenci hava trafik kontrolöründen oluşmaktadır. Veriler 5 dereceli Likert ölçeği kullanan yapılandırılmış bir soru formu aracılığıyla toplanmıştır. Bulgular en yüksek ortalama puanın istek boyutunda olduğunu göstermektedir (M= 3.9163). Bu durum havacılık İngilizcesi becerilerini geliştirmeye yönelik güçlü bir içsel motivasyonu işaret etmektedir. Bunu katılımcıların mesleki dil yeterliliklerini karşılama gerekliliğini fark ettiklerini ortaya koyan gereklilik boyutu izlemektedir (M= 3.6964). En düşük puanı alan eksiklik boyutu ise (M= 3.5388), algılanan dil yetersizliklerinin orta düzeyde olduğunu göstermektedir. Bu bulgular kişisel motivasyon ile düzenleyici ve operasyonel standartlar arasında bir denge kuran eğitim programlarına duyulan ihtiyacı işaret etmektedir. Etkili bir havacılık İngilizcesi programı öğrenenlerin bireysel hedeflerini mesleğin iletişimsel gereklilikleriyle bütünleştirerek hem dil gelişimini hem de havacılık emniyetini artırmayı hedeflemelidir.

Anahtar Kelimeler: Hava Trafik Kontrolörleri, Havacılık, Havacılık İngilizcesi, Havacılık İngilizcesi Eğitimi, İhtiyaç Analizi.

JEL Sınıflandırma: I20, M10, M19

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INTRODUCTION

Aviation is a dynamic industry that supports economic growth and social development by connecting people, countries, and cultures. These global connections help facilitate trade, promote tourism, and encourage cooperation between developed and developing regions (Camelia & Mihai, 2010). The development of aviation began with the first successful flights in the early twentieth century and has continued to advance through constant innovation and a strong focus on safety (Lohmann & Pereira, 2020). Important achievements such as the Wright brothers' first flight played a key role in shaping the early stages of the industry. Over time, aviation has become a complex global system supported by modern engineering (Raju et al., 2019), international regulations (Abeyratne, 2016; Paschke & Lutter, 2018), and standardized operational practices (Singh, Sharma & Parti, 2024). Alongside these technical and structural improvements, the growing complexity of the aviation environment has also shown the importance of clear and effective communication among professionals from diverse cultural and linguistic backgrounds. Within this dynamic industry, air traffic controllers hold an important responsibility in maintaining the safety and systematic management of air traffic operations. These professionals come from diverse cultural and linguistic backgrounds, which makes effective communication and coordination essential in ensuring safe and efficient air traffic services.

Charged with managing the safe and orderly movement of aircraft, air traffic controllers are often required to make decisions under considerable time pressure, balancing the competing goals of selecting the best possible option and doing so within a limited time frame (Johnson, Payne & Bettman, 1993). This decision-making process demands not only technical competency but also the effective use of cognitive abilities and social integrative skills to guide aircraft and organize a safe and efficient flow of traffic (Sanne, 2001). In addition to these operational competencies, communication emerges as a fundamental determinant of performance. To optimize the effectiveness of pilot-controller interactions, standardized aviation phraseology, English language competency, and domain-specific knowledge are essential components (Hamzah, 2021). In this regard, the development of professional competencies such as the correct use of standardized phraseology, listening comprehension, sustained concentration, and the ability to deliver instructions that are accurate, clear, and concise is essential for reducing communication errors and strengthening aviation safety (Yang, Chang & Chou, 2023). Although technological innovations such as data link communication, sophisticated air traffic control displays, and other advanced systems have significantly enhanced the technical infrastructure of air traffic control, the human element remains central to the system's effectiveness (Rodgers, 2017).

The aim of the study is to fill that gap by examining the Aviation English needs of ab-initio air traffic controllers in Türkiye, drawing on a needs analysis framework that differentiates among necessities, lacks, and wants. Particular attention is given to the role of personal motivation and professional expectations in shaping these needs, as well as to how ICAO's global standards intersect with local training practices and cultural dynamics. The findings are expected to guide curriculum designers, support ESP practitioners in evaluating and enhancing pedagogical strategies, and contribute to the development of contextually relevant

course materials that promote motivated, effective, and standardized communication in air traffic control.

1. LITERATURE REVIEW

Effective communication between air traffic controllers and pilots continues to be a fundamental component of aviation safety, as even minor errors in verbal exchange can lead to serious consequences (Prinzo & Britton, 1993). A key part of controller-pilot communication is the readback-hearback loop as shown in Figure 1, where pilots repeat instructions and controllers confirm their accuracy (Prinzo, Hendrix & Hendrix, 2008). The effectiveness of the loop depends on communication competency, including the correct use of standard phraseology, clear speech, and mutual understanding. Deficiencies in these skills can lead to misunderstandings and compromise safety. Therefore, enhancing communication competency is essential for ensuring the effectiveness and integrity of this safety-critical exchange.

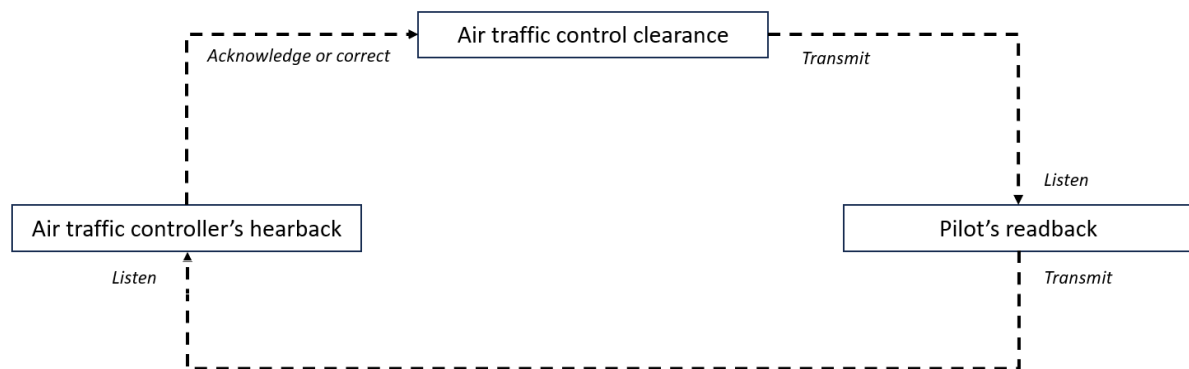


Figure 1. Readback-hearback Loop Between Air Traffic Controllers and Pilot

Considering the high stakes of air travel, the importance of standardized communication cannot be overstated. Graddol (2006) states that nearly 75% of flights occur between countries where English is not the main language, highlighting the significance of communication proficiency in Aviation English, especially for those participating in international aviation operations. Historical accidents, most notably the 1977 Tenerife disaster, clearly demonstrate how miscommunications can lead to catastrophic outcomes (Billings & Cheaney, 1981). In this particular incident, which remains the deadliest accident in aviation history, ambiguous phraseology and non-standard communication between the cockpit crew and air traffic control contributed to a fatal runway collision between two Boeing 747 aircraft. This tragedy highlighted the urgent need for globally harmonized aviation language protocols and strict adherence to standard phraseology. Subsequent accidents have further reinforced the critical role of effective communication in maintaining aviation safety. For example, the 1990 Avianca Flight 052 crash near New York was attributed in part to the flight crew's failure to communicate fuel emergency status in clear and assertive terms, which resulted in a misinterpretation by air traffic controllers and ultimately led to fuel exhaustion and a fatal crash (Helmreich, 1994). Similarly, the 1995

crash of American Airlines Flight 965 near Cali, Colombia, which caused the death of all 163 people on board, involved multiple contributing factors. Although the primary cause was identified as a navigation error by the American pilots, the Spanish-speaking air traffic controller failed to provide appropriate instructions. This failure was attributed to insufficient proficiency in English, and it was later acknowledged that more effective communication might have prevented the accident (Tajima, 2004). The 1996 Charkhi Dadri mid-air collision over India between Saudi Arabian Airlines Flight 763 and Kazakhstan Airlines Flight 1907 was caused by a breakdown in communication, compounded by limited English proficiency and non-compliance with air traffic control instructions. The 2006 collision at Brazil's upper airspace between Gol Transportes Aéreos Flight 1907 and a business jet, Embraer Legacy 600, also exposed the consequences of inadequate phraseology use and loss of situational awareness due to communication lapses (Mathews et al., 2023).

These tragic events prompted the aviation industry to increasingly adopt standardized phraseology and communication protocols aimed at minimizing ambiguity and enhancing clarity in operational contexts (Drayton & Coxhead, 2023). English has emerged as the *de facto* language of international aviation, a position shaped by significant historical developments in global air transport and reinforced by linguistic characteristics that promote precision and brevity in professional discourse (Alderson, 2011; Kraśnicka, 2016). As the designated *lingua franca* within the aviation sector, English serves a fundamental role in facilitating effective and reliable communication among pilots, air traffic controllers, and other aviation personnel operating in linguistically diverse environments (Campbell-Laird, 2004). Within this framework, Aviation English has developed as a specialized linguistic register designed to address the communicative and safety-related demands of aeronautical operations. In contrast to general English, Aviation English is defined by a controlled lexicon and formulaic structures that support unambiguous, concise, and context-specific exchanges during critical phases of flight (Tosqui-Lucks & de Carvalho, 2020). The codified nature of this communicative variety enables the mitigation of language-related misunderstandings and contributes to the standardization of communication across multicultural settings, thereby strengthening safety margins. Furthermore, effective proficiency in Aviation English extends beyond lexical knowledge to encompass phonological accuracy, prosodic features, and adherence to institutionalized communicative routines, all of which are integral to maintaining situational awareness and coordinated decision-making under time-constrained and high-stress conditions (Rankov, Jovanović, & Kapor, 2024). Accordingly, operational competency in both general and Aviation English is recognized as an essential professional qualification that directly influences the efficiency and safety of international aviation operations (Rashid & Teslenko, 2020).

Given its distinct communicative characteristics and critical operational role, Aviation English has been the subject of various scholarly definitions that reflect different disciplinary perspectives and practical considerations. While Aiguo (2008) defines Aviation English as a branch of English for Specific Purposes (ESP) with a clear focus on the aviation field, covering both standardized phraseology and plain language, Estival and Farris (2016) emphasize its functional nature, highlighting its use by both native and non-native English speakers in operational communication. In a similar context, Feak (2013) considers Aviation

English to be a spoken variety shaped by international guidelines, national policies, and instructional content. Moder (2012), on the other hand, conceptualizes Aviation English as the intersection of two forms: one that is simplified yet detailed for use in unexpected situations, and another that is limited and routine-based, both regulated through professional standards. Supporting this perspective, Cutting (2011) highlights that aviation professionals use standard features of English, including pronunciation, structure, and interaction, but these are adapted to meet the specific needs of aviation tasks and contexts. Aviation English cannot be considered a native language, as its use requires specific training and adherence to operational standards, regardless of the speaker's native proficiency in English (Seiler, 2009).

Recognizing the safety risks posed by miscommunication, international aviation authorities have emphasized the need for standardized language use. The International Civil Aviation Organization (ICAO) has played a central role in setting global Aviation English standards. Following several incidents in the late 1990s, ICAO identified inadequate English proficiency among pilots and air traffic controllers as a critical safety concern. This led to major regulatory amendments in 2003, a training and assessment manual in 2004, and the adoption of standardized testing systems in 2007 (ICAO, 2010). ICAO's Language Proficiency Requirements define minimum expectations based on the ICAO Rating Scale. Operational Level 4 is the baseline for certification and requires reassessment every three years, while Level 6 allows permanent qualification. The scale includes six components: pronunciation, grammar, vocabulary, fluency, comprehension, and interaction. At Level 4, speech may reflect accent but remains intelligible; grammar and vocabulary are adequate for standard operations; fluency may include some hesitation without disrupting flow; and comprehension is generally accurate in routine contexts. Interaction, in particular, involves timely and appropriate responses, as well as the ability to manage dialogue and resolve misunderstandings through effective communication strategies (Alderson, 2009).

In order to meet the ICAO-mandated proficiency standards, educational frameworks have increasingly relied on ESP methodologies tailored to aviation contexts. Training in ESP is designed to meet the specific academic or professional requirements of learners, emphasizing meaningful themes and real-world communicative tasks. Aviation English, as a specialized branch of ESP, focuses on the linguistic needs of aviation professionals by offering task-based and domain-specific content (Rochmawati, 2017). Due to the high-stakes nature of aviation communication, such training must extend beyond general language training to incorporate technical terminology, standardized phraseology, and intercultural competency (ICAO, 2010).

At the core of effective ESP training lies a thorough needs analysis (Rahman, 2015). This process is essential for identifying learners' existing proficiency, specific competencies required by their target context, and their personal goals and expectations (Basturkmen, 2010; Demirdöken, 2019). Needs analysis allows educators to tailor training content by determining learners' strengths, weaknesses, skills, and prior experiences with the English language (Sally & Pradana, 2019). Moreover, the process of needs analysis involves several stages, including problem definition, data collection planning, and the sequencing of relevant procedures (Brown, 2016). Contemporary approaches to ESP highlight the importance of

defining the target situation and studying the environment in which learners apply their language skills (Otilia & Brancusi, 2015). This ensures that the course content is both context-sensitive and learner-oriented. By grounding curriculum development in the principles of communicative competency, needs analysis helps to design a syllabus that reflects learners' needs (Astika, 1999). Additionally, needs analysis contributes directly to the construction of relevant learning tasks. Task design should stem from a clear understanding of learners' communicative needs within a particular professional domain or learner community (Malicka, Gilabert Guerrero & Norris, 2019). In this respect, needs analysis acts as a bridge between theoretical curriculum planning and practical language training, ensuring that learners acquire language skills that are immediately applicable to their future tasks. This learner-centered and systematic approach allows ESP training to become more effective, relevant, and aligned with the demands of specific professions such as aviation.

Considering the central role of needs analysis in ESP curriculum development, various theoretical models have been proposed to structure this process. Among them, one of the most influential was introduced by Hutchinson and Waters (1987), who categorized learners' needs into three main components: necessities, lacks, and wants. In this model, "necessities" refer to the essential skills and knowledge required for successful performance in a given target situation. "Lacks" point to the gaps between the learner's current abilities and these target requirements, whereas "wants" relate to the preferences and motivations expressed by learners themselves or identified by professionals involved in the educational process. This tripartite framework allows for a more comprehensive understanding of learner profiles and facilitates the design of tailored training programs. Beyond individual learner analysis, needs assessment also serves broader institutional goals. It enables educational stakeholders to examine the current state of curricula, programs, and teaching practices with a view to strategic improvement (Karababa & Karagül, 2013; Lambert, 2010). In this sense, needs analysis is not limited to language training but becomes a valuable tool for program evaluation and long-term planning. Moreover, the outcomes of a well-conducted needs analysis contribute to more effective course design by identifying learning barriers, defining course objectives, and selecting or adapting training materials (Ali & Salih, 2013; Macalister, 2012; Mahmoud, 2014; Wu, 2012). This process supports educators in aligning course content with both learners' actual needs and the communicative expectations of their target contexts. In domains such as aviation English, where communicative clarity and operational precision are vital for safety, the importance of a robust needs analysis becomes even more pronounced. However, the limited availability of domain-specific and contextually appropriate teaching materials continues to be a challenge. By incorporating multiple stakeholder perspectives, needs analysis provides a structured foundation for designing targeted courses. This approach helps address learning gaps by clarifying learner objectives and enabling instructors to prioritize training content accordingly (Dudley-Evans & St John, 1998; Lertchalermtipakoon, Wongsunbun, & Kawinkoonlasate, 2021).

Given the growing demands of the global aviation industry, the need for highly competent air traffic controllers who can communicate effectively in English has become increasingly evident. In Türkiye, as in many other countries, Aviation English is integrated into the ab-

initio training phase to prepare future controllers for the linguistic demands of operating in international airspace. However, the success of this training depends largely on how well it reflects the specific linguistic and contextual needs of learners. To ensure such alignment, conducting a comprehensive needs analysis is essential. Without a clear understanding of the learners' communicative requirements, there is a risk that training programs may fall short of preparing controllers for real-world operational scenarios. Although Aviation English curricula are commonly shaped by the ICAO language proficiency requirements, the extent to which these standards are met in local contexts remains underexplored.

Despite this, existing research in the field of aviation communication and language has primarily focused on identifying and analyzing deviations from standardized phraseology (Cardosi, 1994; Cardosi, Brett & Han, 1996; Hamzah & Fei, 2018; Howard, 2008; Molesworth & Estival, 2015; Morrow, Lee & Rodvold, 1993; Morrow, Rodvold & Lee, 1994; Prinzo, 1996), which are recognized as key contributors to communication breakdowns in aviation operations. Further attention has also been paid to the role of clarity and pronunciation in ensuring mutual intelligibility, particularly in international and multilingual flight operations (Hamzah, 2021; Jenkins, 2000). These findings highlight the importance of designing training content that not only prioritizes correct phraseology but also addresses pronunciation and other operational aspects of communication. Despite this, limited research has addressed these needs within the Turkish context, particularly from the perspective of ICAO language proficiency requirements. Although Demirdöken (2019) and Sirin and Inan (2024) conducted a study exploring the ICAO language proficiency requirements for ab-initio pilots, no comparable research appears to have been carried out for ab-initio air traffic controllers. Given that effective communication in aviation is a shared responsibility between pilots and controllers, examining the language needs of both parties is critical. Therefore, identifying the specific linguistic challenges faced by ab-initio air traffic controllers represents an important step toward improving communication competency and promoting compliance with ICAO standards within the cultural and institutional context of Türkiye.

2. METHODOLOGY

2.1. Population-Sample

The study population consists of 240 ab-initio air traffic controllers currently enrolled in training programs at institutions authorized by the Directorate General of Civil Aviation of Türkiye, namely the General Directorate of State Airports Authority, Eskişehir Technical University, and İstanbul Nişantaşı University. At the General Directorate of State Airports Authority, ab-initio air traffic controllers begin their course based-training after graduating from university and meeting certain entry requirements. On the other hand, those studying at Eskişehir Technical University and İstanbul Nişantaşı University receive undergraduate education in air traffic control, where both operational training and Aviation English are part of the curriculum.

A convenience sampling method was employed for data collection. The data were gathered through an online questionnaire, which was distributed to participants via social media platforms commonly used by ab-initio air traffic controllers. Data collection took place

between October 2024 and April 2025. A total of 86 respondents completed the survey in full, and no data loss was observed.

2.2. Research Purpose

The study focuses on ab-initio air traffic controllers, who are in the early stages of their professional training and are currently developing the communication skills needed for their future roles in aviation. As clear and effective communication is essential for aviation safety, it is important to understand the level of Aviation English proficiency these trainees possess and to identify the specific areas where they experience difficulties. By examining their needs, the study aims to provide insights that can support the development of more targeted and effective language training programs. Grounded in the needs analysis model proposed by Hutchinson and Waters (1987), the research distinguishes among three dimensions of need: necessities, lacks, and wants. The primary goal of the research is to analyze the Aviation English needs of ab-initio air traffic controllers by identifying the challenges they face, the language skills they consider most important, and the aspects of training that can be improved. The study also aims to explore how personal motivation and professional expectations shape learners' perceptions of their language needs. Ultimately, the study aims to help improve the overall communication competency of future controllers, supporting safer and more efficient air traffic operations. By aligning training design with both learner motivation and industry standards, the findings are expected to contribute to more effective and context-specific Aviation English education.

2.3. Research Instruments

Information Form: The demographic information form included items designed to gather information on participants' gender, age, and ab-initio training type.

Aviation English Needs Analysis Questionnaire: The Aviation English Needs Analysis Questionnaire, developed by Demirdöken (2019), was used in the study. The questionnaire consists of 29 items divided into three sections, based on the classification by Hutchinson and Waters (1987), who categorized target needs into three types: lacks, wants, and necessities. The first section, comprising six items, aimed to identify learners' lacks, meaning the language skills they currently do not possess but need for the target situation. The second section, consisting of five items, focused on learners' wants, referring to the specific language skills they wish to acquire based on their own interests and goals. The third section, which included eighteen items, was designed to explore the necessities, that is, the language skills that are considered essential for functioning effectively in the target situation. All items were rated on a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). The Cronbach's alpha value for the questionnaire was calculated as 0.893, indicating high reliability.

2.4. Ethical Approval

Ethical approval for the study was granted by the Ethics Committee of International Science and Technology University. The approval was issued during the committee meeting held on October 18, 2024, under the decision number 202410-01.

3. FINDINGS

The demographic characteristics of the participants are presented in Table 1. In terms of gender distribution, 59.3% of the participants were male ($n = 51$), while 40.7% were female ($n = 35$). Regarding the type of ab-initio training pursued, 53.5% of the participants ($n = 46$) were enrolled in undergraduate education programs, whereas 46.5% ($n = 40$) were receiving course-based training. It is important to note that at the time of data collection, the participants had not yet completed their training programs and were still actively engaged in their educational processes. With respect to familiarity with Aviation English, 86.0% of the participants ($n = 74$) reported being familiar with the concept, while 14.0% ($n = 12$) indicated unfamiliarity. Similarly, when asked about their knowledge of ICAO language standards in aviation, 81.4% ($n = 70$) stated that they were familiar, whereas 18.6% ($n = 16$) reported a lack of familiarity.

The participants' mean age was 23.07 years ($SD = 2.78$). The relatively low standard deviation indicates that the age distribution was concentrated around the mean, reflecting a high degree of homogeneity among the participants.

Table 1. Demographic Characteristics of the Participants

		Frequency	Percent
Gender	Female	35	40.7
	Male	51	59.3
Ab-initio training type	University-based undergraduate education	46	53.5
	Course-based training	40	46.5
Are you familiar with Aviation English?	Yes	74	86.0
	No	12	14.0
Are you familiar with ICAO language standards in aviation?	Yes	70	81.4
	No	16	18.6

The Kaiser-Meyer-Olkin (KMO) and Bartlett's Test are presented in Table 2. KMO measure of sampling adequacy was calculated as .761, indicating a moderate level of sampling adequacy for conducting factor analysis. According to Kaiser (1974), a KMO value above .70 is considered acceptable, suggesting that the sample size is sufficient to produce reliable factors. Bartlett's Test of Sphericity was found to be statistically significant ($\chi^2(406) = 1424.77$, $p < .001$), confirming that the correlation matrix was not an identity matrix. This result indicates that the variables are significantly correlated and therefore suitable for factor analysis (Bartlett, 1954). Additionally, the cumulative percentage of variance explained by the extracted factors was 50.322%. In exploratory factor analysis, a cumulative variance above 50% is generally considered acceptable in the social sciences, as it reflects a satisfactory level of explanation of the total variance by the identified factors (Streiner, 1994). Therefore, the data were considered appropriate for further factor analysis procedures.

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.761
Bartlett's Test of Sphericity	Approx. Chi-Square	1424.773
	df	406
	Sig.	.000

An exploratory factor analysis (EFA) was conducted to identify the fundamental structure of the Aviation English needs among ab-initio air traffic controllers. The factor loadings,

means (M), and standard deviations (SD) of each item are presented in Table 3. The exploratory factor analysis revealed a three-factor structure consistent with the theoretical framework of the original questionnaire. The first factor, labelled as Lacks, had factor loadings ranging from .460 to .793. The second factor, labelled as Wants, showed loadings between .552 and .674, while the third factor, labelled as Necessities, had loadings ranging from .388 to .786. All loadings exceeded the generally accepted minimum threshold of .30, which indicates that the items adequately represent their respective latent constructs (Büyüköztürk, 2020, Cassidy, 2016; Field, 2013).

Among all items, the highest mean score was observed for the item *"I can ask for clarification when I do not understand other people in terms of Aviation English"* (M = 4.13, SD = 0.682). This result suggests that participants feel confident in using communication strategies to resolve misunderstandings during interactions. This was followed by *"Oral communication is vital for me to be competent in Aviation English"* (M = 4.03, SD = 0.818) and *"I can ask for confirmation when a misunderstanding occurs"* (M = 4.02, SD = 0.735), indicating a strong perceived importance of effective oral interaction skills in aviation contexts. On the other hand, the lowest mean score was found for the item *"I need to improve my reading comprehension skill to meet the Aviation English language standards"* (M = 3.15, SD = 1.079). This may imply that participants perceive their reading abilities as relatively sufficient or consider them less critical compared to speaking and listening skills. This was followed by *"I need to improve my pronunciation more than the other skills in Aviation English"* (M = 3.20, SD = 1.038) and *"I can maintain fluent speech even in emergency/abnormal situations"* (M = 3.38, SD = 0.738), suggesting that fluency under pressure and pronunciation are seen as more challenging areas or lower priorities in their current learning needs.

Table 3. Means (M), Standard Deviations (SD), Factor Loadings, and Factor Distributions

		M	SD	F1	F2	F3
Lacks	1. I need to improve my pronunciation more than the other skills in Aviation English.	3.20	1.038	.663		
	2. I need to be a more fluent speaker of Aviation English.	3.83	.935	.694		
	3. I need to break through the difficulty of understanding different accents of aviators.	3.74	.785	.460		
	4. I need to improve my listening skill to meet the Aviation English language standards.	3.67	.900	.793		
	5. I need to improve my reading comprehension skill to meet the Aviation English language standards.	3.15	1.079	.597		
	6. I need to improve my oral communication skill to meet the Aviation English language standards.	3.64	.867	.792		
Wants	7. It is essential for me to comprehend what I read in order to meet the Aviation English language standards.	3.81	.819		.552	
	8. It is essential for me to comprehend oral messages in order to meet the Aviation English language standards.	3.92	.843		.669	

	9. It is vital for me to understand written aviation documents in order to meet the Aviation English language standards.	3.85	.976	.674
	10. It is vital for me to understand aviation-related speeches in order to meet the Aviation English language standards.	3.97	.774	.615
	11. Oral communication is vital for me to be competent in Aviation English.	4.03	.818	.603
Necessities	12. I can speak Aviation English fluently.	3.52	.808	.433
	13. I can pronounce Aviation English terms correctly.	3.85	.712	.603
	14. My Aviation English accent is intelligible for other aviators.	3.78	.693	.435
	15. I can have good control of sentence patterns in Aviation English.	3.57	.695	.514
	16. My knowledge of Aviation English terms is enough to understand audio files related to Aviation English.	3.42	.677	.388
	17. My knowledge of Aviation English terms is enough to express myself to other aviators.	3.76	.650	.658
	18. My knowledge of Aviation English terms is enough to explain an emergency/abnormal situation.	3.65	.763	.710
	19. I can communicate with other aviators effectively.	3.74	.706	.774
	20. I can maintain fluent speech even in emergency/abnormal situations.	3.38	.738	.786
	21. I am a fluent English speaker in terms of aviation.	3.48	.763	.783
	22. I can respond to the questions of other aviators appropriately.	3.73	.562	.631
	23. I can maintain effective communication when I speak Aviation English.	3.69	.619	.628
	24. I can easily understand a speech related to aviation.	3.73	.640	.430
	25. I can ask for clarification when I do not understand other people in terms of Aviation English.	4.13	.682	.559
	26. I can easily inform other aviators on a topic related to aviation.	3.73	.658	.678
	27. My knowledge of Aviation English terms is enough to explain a problem.	3.69	.690	.702
	28. I can ask for confirmation when a misunderstanding occurs.	4.02	.735	.574
	29. I can express myself in black and white easily.	3.66	.806	.712

The mean scores, standard errors, and normality test values for the three dimensions of the Aviation English Needs Analysis are shown in Table 4. According to the findings, the highest mean score was observed in the wants dimension ($M = 3.9163$), followed by necessities ($M = 3.6964$) and lacks ($M = 3.5388$). This pattern suggests that ab-initio air

traffic controllers placed more emphasis on what they personally desire to improve in Aviation English, rather than on what they objectively lack or what is required by the job. The normality of the data was evaluated based on skewness and kurtosis values. As suggested by Tabachnick and Fidell (2013), values between -1.5 and +1.5 for both skewness and kurtosis indicate an acceptable level of normality. In the study, all three dimensions met this criterion. Specifically, the skewness and kurtosis values for lacks were .111 and -.336; for wants, .070 and -.785; and for necessities, -.162 and .219. These results confirm that the data were approximately normally distributed and therefore suitable for further parametric statistical analyses.

Table 4. Mean, Std. Error and Normality test

	Mean	Std. Error	Skewness	Kurtosis
Aviation English Needs Analysis- Lacks	3.5388	.07528	.111	-.336
Aviation English Needs Analysis- Wants	3.9163	.07068	.070	-.785
Aviation English Needs Analysis- Necessities	3.6964	.04794	-.162	.219

The reliability analysis results, shown in Table 5, indicate high internal consistency for each dimension. The Cronbach's alpha coefficients were .838 for the lacks dimension, .831 for the wants dimension, and .912 for the necessities dimension. The overall reliability for the entire questionnaire was found to be .881. According to Nunnally and Bernstein (1994), a Cronbach's alpha value above .70 is considered acceptable, and values above .80 indicate good reliability. Therefore, it can be stated that the Aviation English Needs Analysis Questionnaire demonstrated strong internal consistency across all dimensions and overall.

Table 5. Reliability Statistics

	Cronbach's Alpha
Aviation English Needs Analysis Questionnaire- Lacks Dimension	.838
Aviation English Needs Analysis Questionnaire- Wants Dimension	.831
Aviation English Needs Analysis Questionnaire- Necessities Dimension	.912
Aviation English Needs Analysis Questionnaire	.881

The results of the independent samples t-test comparing Aviation English needs between two distinct training modalities are presented in Table 6. Analysis indicates that course-based trainees reported slightly elevated mean scores across all dimensions, with values of 3.5542 for lacks, 3.9350 for wants, and 3.7556 for necessities. In contrast, ab-initio undergraduate trainees demonstrated marginally lower means of 3.5254, 3.90, and 3.6449 for the respective categories. Despite these numerical differences, statistical testing confirmed the absence of significant between-group differences ($p > .05$) in any of the assessed need dimensions, suggesting equivalent perceived requirements for Aviation English proficiency regardless of training approach.

Table 6. t-test Air Traffic Control Training Based of Aviation English Needs Analysis

	Training Modalities	n	Mean	Std. Deviation	t	p
Lacks	University-based undergraduate education	46	3.5254	.77377	-.190	.859
	Course-based training	40	3.5542	.60903		
Wants	University-based undergraduate education	46	3.9000	.71274	-.246	.807
	Course-based training	40	3.9350	.59120		
Necessities	University-based undergraduate education	46	3.6449	.48524	-1.153	.252

Course-based training	40	3.7556	.39037
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4. DISCUSSION

The study offers important insights into the Aviation English needs of ab-initio air traffic controllers. The participants formed a demographically homogeneous group, which allowed the data to be interpreted consistently. Although they had not yet completed their formal training, many of these ab-initio air traffic controllers were already familiar with Aviation English and ICAO language standards. This early exposure may reflect a growing awareness of the importance of English communication in aviation, even at the initial stages of training. Language proficiency is a key factor in ensuring the safety and efficiency of air traffic operations (Barbieri, 2015).

Given the participants’ existing familiarity with standard phraseology and regulations, it was important to examine their language needs in a more systematic way. To achieve this, the study employed the needs analysis model developed by Hutchinson and Waters (1987), which categorizes language needs into three components: necessities (target situation), lacks (present situation), and wants (learning situation). The mean scores obtained for each component were 3.9163 for wants, 3.6964 for necessities, and 3.5388 for lacks.

The finding that ab-initio air traffic controllers scored highest in the “wants” category suggests a strong motivation to improve their English language skills, primarily driven by personal interest and career development goals. This result is consistent with previous studies emphasizing the importance of motivation in ESP learning. For instance, Alizadeh (2016) highlights that motivation plays a central role in successful language acquisition, particularly in professional contexts where language proficiency is closely linked to performance outcomes. Similarly, Tomak and Pavelić (2017) found that learners who rated their English proficiency higher were also more motivated to learn the language, highlighting the link between perceived competency and motivation. In the specific context of air traffic control, where clear and accurate communication is critical for safety, such motivation becomes even more valuable. Furthermore, learner motivation can be enhanced through well-structured training design. As shown by Kabdrgalinova et al. (2023), effective motivation strategies in ESP settings contribute to more active and goal-oriented learners. Conversely, demotivating factors such as outdated teaching methods and lack of relevance, as identified by Hotak et al. (2024), may hinder progress. Therefore, the high motivation levels observed in the study should be supported by modern, context-specific, and learner-centered training programs to ensure sustained engagement and improved communication performance in operational environments.

Following this, the relatively high score observed in the “necessities” category suggests that the participants are aware of the external expectations of their future profession. Among these expectations, English language proficiency stands out as a critical requirement for ensuring safe and effective communication in international aviation. Language-related communication failures between pilots and air traffic controllers have been identified as contributing factors in approximately 70% to 80% of aviation accidents (Yan, 2013). This finding highlights the need to prioritize English language training in air traffic control education. In addition to its role in safety, English proficiency is also essential for developing

the professional communication skills required for accurate and clear information exchange, both verbally and in writing (Satvinder Singh, Cheong & Rahman, 2021). Furthermore, the ICAO (2010) has emphasized that limited English proficiency among flight crew or controllers has played a contributing role in the chain of events leading to several aviation accidents. Therefore, the participants' awareness of such linguistic and operational necessities may be interpreted as a positive indication of their orientation toward meeting international safety standards.

In contrast to the others, the "lacks" category received the lowest score, pointing to how participants assess their current skills in relation to the expected performance level. As Hutchinson and Waters (1987) explain, this dimension identifies the gap between what learners can currently do and what they need to be able to do. This low score may not indicate a lack of needs, but instead shows that learners have difficulty recognizing their own deficiencies. Self-assessment in second language testing has shown mixed results and can serve as an alternative to formal assessment, but its accuracy largely depends on the learner's familiarity with the skill being assessed (Ross, 1998). Without adequate training or reflective practice, learners may not be able to identify their language gaps effectively (Sadler, 1989). In addition, social desirability bias may also play a role, especially in contexts like Türkiye, where learners may avoid admitting weaknesses in self-reports (Crowne & Marlowe, 1960). These factors suggest that low "lacks" scores might not only indicate limited awareness but also reflect socio-cultural and instructional variables, which should be considered when designing Aviation English training programs.

Even though the mean scores for wants ($M = 3.9163$) and lacks ($M = 3.5388$) were relatively close, the higher score for wants suggests that learners are more aware of what they want to learn than of the areas they actually need to improve. Ab-initio air traffic controllers often show strong interest and motivation to learn; however, they may not clearly understand which specific skills require development. This situation may result from learners focusing more on their personal interests or what they find relevant, instead of making an objective assessment of their current weaknesses. The difference between perceived needs and actual skill gaps is widely recognized in research on goal-based learning. While intrinsic motivation, especially when related to learning goals, helps learners stay committed over time (Rawsthorne & Elliot, 1999), it may not be enough to ensure accurate self-evaluation of skill levels. Even highly motivated learners may continue learning with enthusiasm while overlooking important weaknesses. For this reason, training programs should include structured feedback and assessment tools to help learners identify and improve their specific areas of need. This approach can ensure that learner motivation is aligned with real learning goals.

Lastly, the comparison between training environments revealed no statistically significant differences in the needs perceptions of ab-initio air traffic controllers from university-based and course-based programs. This consistency suggests that, regardless of educational setting, learners share similar views about their Aviation English needs. One possible explanation is the common exposure to ICAO phraseology and international communication standards (ICAO, 2010), which likely shapes a shared understanding of required language competencies across institutions.

5. CONCLUSION

The study aimed to investigate the Aviation English needs of ab-initio air traffic controllers in Türkiye by applying a needs analysis model that distinguishes between lack, want, and necessity. The results revealed that personal motivation (wants) was the most dominant factor, followed by awareness of professional obligations (necessities) and a moderate perception of existing deficiencies (lacks). These findings highlight the importance of designing training programs that not only fulfill external regulatory requirements but also align with learners' internal motivation. When training content reflects both professional standards and individual learning goals, it can promote more effective and sustainable language acquisition.

In addition, the findings are consistent with ICAO's (2010) emphasis on standardized language proficiency as a foundation for safety and operational efficiency in aviation. Although learner enthusiasm is high, the study reveals a need for objective language assessments to complement self-reported evaluations. A training model that combines learners' perceptions with performance-based data may enhance communication effectiveness, promote safety, and support long-term career development in the aviation field.

5.1. Theoretical and Practical Implications

Theoretically, the study reinforces the importance of distinguishing among lack, want, and necessity in needs analysis frameworks, as advocated by Hutchinson and Waters (1987). The findings emphasize that effective ESP course design must integrate both subjective learner perspectives and objective professional standards, particularly in contexts where safety and operational clarity are vital, such as air traffic control.

Practically, the study suggests that Aviation English training programs should:

- Leverage learners' motivation: Incorporate engaging and context-specific materials that build on learners' high internal drive to improve their English skills. This emphasis reflects the prominent role of the "want" dimension in the findings.
- Align with professional requirements: Emphasize the necessity of meeting ICAO (2010) and other aviation-specific language proficiency standards. Adhering to such standards supports both operational safety and international communication efficiency.
- Use objective assessments: Complement self-reported needs with initial diagnostic evaluations and performance-based tests. This combination helps address actual language deficiencies and reduces the risk of overestimating or underestimating competency based on self-perception.

A comprehensive and competency-based training approach that combines personal learning goals with professional communication demands is essential for optimizing language development among air traffic controllers. Such integration contributes to both individual career advancement and overall aviation safety.

5.2. Limitations and Future Research

Several limitations should be acknowledged. First, the study relied on self-reported data, which may be influenced by biases such as overconfidence or limited self-awareness. To strengthen future findings, researchers are encouraged to include objective language assessments, such as standardized proficiency tests or operational communication simulations.

Second, the sample of the study consisted of 86 ab-initio air traffic controllers in Türkiye. Although this provides valuable insights within a national context, the limited sample size restricts the generalizability of the results. Future research could expand the scope by conducting similar studies in different countries using comparable tools, which would allow for cross-cultural comparison and broader applicability.

Third, the study adopted a cross-sectional design, capturing a single point in time. Future research may benefit from a longitudinal approach to observe how English language needs change over time, particularly after formal training or on-the-job experience. Additionally, incorporating qualitative methods, such as interviews or focus group discussions, could provide a more nuanced understanding of learner motivation, perceived challenges, and training expectations beyond what quantitative data alone can reveal.

Fourth, the study did not account for contextual variables such as institutional training policies, instructor qualifications, or variations in local operational language environments across different training facilities. These contextual factors can significantly influence learners' perceptions of language needs and their actual communication performance. Future research could adopt a more ecological approach by integrating institutional data or conducting multi-site comparisons to examine how organizational settings mediate language learning outcomes.

REFERENCES

- Abeyratne, R. (2016). *Regulation of Air Transport*. Springer International Pu.
- Aiguo, W. (2008). Reassessing the position of Aviation English: From a special language to English for Specific Purposes. *Ibérica: Revista de la Asociación Europea de Lenguas para Fines Específicos (AELFE)*, 15, 151-164.
- Alderson, J. (2011). The Politics of Aviation English Testing. *Language Assessment Quarterly*, 8, 386 - 403.
- Alderson, J. C. (2009). Air safety, language assessment policy, and policy implementation: The case of aviation English. *Annual Review of Applied Linguistics*, 29, 168-187.
- Ali, H. I., & Salih, A. (2013). Perceived views of language teachers on the use of needs analysis in ESP materials writing. *English Language Teaching*, 6(3), 11-19.
- Alizadeh, M. (2016). The impact of motivation on English language learning. *International Journal of Research in English Education*, 1(1), 11-15.
- Astika, G. (1999). The role of needs analysis in English for specific purposes. *TEFLIN Journal*, 10(1), 31-47.
- Barbieri, B. (2015). Aviation English: History And Pedagogy. *Journal of Teaching English for Specific and Academic Purposes*, 2, 615-623.
- Bartlett, M. S. (1954). A note on the multiplying factors for various χ^2 approximations. *Journal of the Royal Statistical Society. Series B (Methodological)*, 296-298.
- Basturkmen, H. (2015). *Developing courses in English for specific purposes*. Springer.
- Billings, C. E., & Cheaney, E. S. (1981). *Information transfer problems in the aviation system* (No. A-8567).
- Brown, J. D. (2016). *Introducing needs analysis and English for specific purposes*. Routledge.
- Büyüköztürk, Ş. (2020). *Sosyal Bilimler İçin Veri Analizi El Kitabı: İstatistik, Araştırma Deseni, SPSS Uygulamaları ve Yorum* (27. Baskı). Ankara: Pegem Akademi.
- Camelia, G., & Mihai, S. (2010). The economic and social benefits of air transport. *Ovidius University Annals, Economic Sciences Series*, 10(1), 60-66.
- Campbell-Laird, K. (2004). Aviation English: a review of the language of International Civil Aviation. *International Professional Communication Conference, 2004. IPCC 2004. Proceedings.*, 253-261.
- Cardosi, K. M. (1994). *An analysis of tower (local) controller-pilot voice communications* (No. DOT-VNTSC-FAA-94-11). United States. Department of Transportation. Federal Aviation Administration.
- Cardosi, K. M., Brett, B., & Han, S. (1996). *An Analysis of TRACON (Terminal Radar Approach Control) Controller-Pilot Voice Communication* (No. DOT-VNTSC-FAA-96-7). United States. Department of Transportation. Federal Aviation Administration.
- Cassidy, S. (2016). The academic resilience scale (ARS-30): A new multidimensional construct measure. *Frontiers in Psychology*, 7(1787), 1-11.

- Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology*, 24(4), 349–354.
- Cutting, J. (2011). English for airport ground staff. *English for Specific Purposes*, 31(1), 3-13.
- Demirdöken, G. (2019). *Ready for Take-Off: An Aviation English Needs Analysis Study in Turkey* (Unpublished Master's Thesis). Bahçeşehir University, Graduate School of Educational Sciences, Istanbul, Türkiye.
- Drayton, J., & Coxhead, A. (2023). The development, evaluation and application of an aviation radiotelephony specialised technical vocabulary list. *English for Specific Purposes*, 69, 51-66.
- Dudley-Evans, T., & St John, M. J. (1998). *Developments in English for specific purposes*. Cambridge university press.
- Estival, D., & Farris, C. (2016). Aviation English as a lingua franca. In S. T. Masi, F. G. Amprimo, G. Ferrairs, & J. E. Priano (Eds.), *Aviation English: A Lingua Franca for Pilots and Air Traffic Controllers* (pp. 1-21).
- Feak, C. (2013). ESP and speaking. In B. Paltridge & S. Starfield (Eds.), *The handbook of English for specific purposes* (pp. 35–53). Wiley-Blackwell.
- Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics (Fourth Edition)*. London: Sage
- Graddol, D. (2006). *Why Global English may Mean the End of “English as a Foreign Language”*. United Kingdom: British Council.
- Hamzah, H. (2021). Clarity and pronunciation of ab-initio air traffic controller. *Aviation*, 25(4), 252-261.
- Hamzah, H., & Fei, W. F. (2018). Miscommunication in Pilot-controller Interaction. *3L: Southeast Asian Journal of English Language Studies*, 24(4).
- Helmreich, R. L. (1994). Anatomy of a system accident: The crash of Avianca Flight 052. *The international journal of aviation psychology*, 4(3), 265-284.
- Hotak, S., Hekmat, A. M., Kamal, M. M., & Rogmal, S. (2024). Investigating English for Specific Purpose (ESP) learners’ perspectives towards factors causing demotivation in ESP classes. *JETLEE: Journal of English Language Teaching, Linguistics, and Literature*, 4(1), 13–26.
- Howard, J. W. (2008). “Tower, am I cleared to land?”: Problematic communication in aviation discourse. *Human communication research*, 34(3), 370-391.
- Hutchinson, T., & Waters, A. (1987). *English for Specific Purposes: A Learning Centred Approach*. Cambridge: Cambridge University Press.
- International Civil Aviation Organization (ICAO). (2010). *Doc 9835- AN/453- Manual on the Implementation of ICAO Language Proficiency Requirements, Second Edition*.
- Jenkins, J. (2000). *The phonology of English as an international language*. Oxford University Press
- Johnson, E. J., Payne, J. W., & Bettman, J. R. (1993). Adapting to time constraints. In *Time pressure and stress in human judgment and decision making* (pp. 103-116). Boston, MA: Springer US.

- Kabdrgalinova, S., Kenzhebekova, A., Mirzoyeva, L., Manapbayeva, Z., & Daineko, Y. A. (2023). *Motivating students in learning English for specific purposes (ESP)*. In DTESI (workshops, short papers).
- Kaiser, H. F. (1974). An Index Of Factorial Simplicity. *Psychometrika*, 39(1), 31-36.
- Karababa, Z. C., & Karagül, S. (2013). A needs analysis for learners of Turkish as a foreign language. *Education and Science*, 38(170), 361-371.
- Krásnicka, I. (2016). English with Flying Colors: The Aviation English and the International Civil Aviation Organization. *Studies in Logic, Grammar and Rhetoric*, 45, 111 - 124.
- Lambert, C. (2010). A task-based needs analysis: Putting principles into practice. *Language Teaching Research*, 14(1), 99-112.
- Lertchalermtipakoon, P., Wongsunbun, U., & Kawinkoonlasate, P. (2021). Need analysis: English language use by students in the tourism and hospitality and industry. *English Language Teaching*, 14(3), 59-71.
- Lohmann, G., & Pereira, B. A. (2020). Air transport innovations: A perspective article. *Tourism Review*, 75(1), 95-101.
- Macalister, J. (2012). Narrative frames and needs analysis. *System*, 40, 120-128.
- Mahmoud, S. S. (2014). A framework for investigating foundation year students' needs in general English in KAU: Needs analysis extended to curriculum development. *Journal of Language Teaching and Research*, 5(2), 335-342.
- Malicka, A., Gilabert Guerrero, R., & Norris, J. M. (2019). From needs analysis to task design: Insights from an English for specific purposes context. *Language Teaching Research*, 23(1), 78-106.
- Mathews, E., Carson, J., Brickhouse, A., & Valdes, E. (2023). *Language as a Factor In Aviation Accidents and Serious Incidents: A Handbook for Accident Investigators* ed. 3. <https://commons.erau.edu/db-lhuft-book/3/> (Accessed on 19 Apr 2025).
- Moder, C. L. (2013). Aviation English. In B. Paltridge & S. Starfield (Eds.), *The handbook of English for specific purposes* (pp. 227–242). Wiley Blackwell.
- Molesworth, B. R., & Estival, D. (2015). Miscommunication in general aviation: The influence of external factors on communication errors. *Safety science*, 73, 73-79.
- Morrow, D., Lee, A., & Rodvold, M. (1993). Analysis of problems in routine controller-pilot communication. *The International Journal of Aviation Psychology*, 3(4), 285-302.
- Morrow, D., Rodvold, M., & Lee, A. (1994). Nonroutine transactions in controller-pilot communication. *Discourse processes*, 17(2), 235-258.
- Nunnally, J., & Bernstein, I. (1994). The Assessment of Reliability. *Psychometric Theory*, 3, 248–292.
- Otilia, S. M., & Brancusi, C. (2015). Needs analysis in English for specific purposes. *Annals of the Constantin Brâncuși University of Târgu Jiu, Economy Series*, 1(2), 54-55.
- Paschke, M., & Lutter, C. (2018). Regulatory Framework of Global Aviation. *Biokerosene: Status and Prospects*, 59-92.
- Prinzo, O. V. (1996). *An analysis of approach control/pilot voice communications* (No. DOT/FAA/AM-96/26). United States. Department of Transportation. Federal Aviation Administration.

- Prinzo, O. V., & Britton, T. W. (1993). *ATC/pilot voice communications: a survey of the literature*.
https://www.faa.gov/sites/faa.gov/files/data_research/research/med_humanfacs/oamtechreports/AM93-20.pdf (Accessed on 19 Apr 2025).
- Prinzo, O. V., Hendrix, A. M., & Hendrix, R. (2008). *Pilot English language proficiency and the prevalence of communication problems at five US air route traffic control centers* (No. DOT/FAA/AM-08/21). United States. Department of Transportation. Federal Aviation Administration. Office of Aviation. Civil Aerospace Medical Institute.
- Rahman, M. (2015). English for Specific Purposes (ESP): A Holistic Review. *Universal Journal of Educational Research*, 3(1), 24-31.
- Raju, D., Eleswarapu, L., Saiv, R., & Nath, V. (2019). Study and design of smart embedded system for aviation system: a review. *Nanoelectronics, Circuits and Communication Systems: Proceeding of NCCS 2017*, 573-590.
- Rankov, D., Jovanović, T., & Kapor, N. (2024). The challenges of aviation communication: Aspects of using aviation English. *Megatrend revija*, 21(1), 201-216.
- Rashid, Q. J., & Teslenko, N. (2020). Professionally oriented English teaching of future aviation industry professionals. *Universal Journal of Educational Research*, 8(11B), 5768-5778.
- Rawsthorne, L. J., & Elliot, A. J. (1999). Achievement goals and intrinsic motivation: A meta-analytic review. *Personality and Social Psychology Review*, 3(4), 326-344.
- Rochmawati, L. (2017, August). Adapting ICAO Language Aspects into Learning Activities In Esp Course Construction for Air Traffic Controller. In *International Conference on English Language Teaching (ICONELT 2017)* (pp. 97-102). Atlantis Press.
- Rodgers, M. (2017). *Human factors impacts in air traffic management*. Routledge.
- Ross, S. (1998). Self-assessment in second language testing: A meta-analysis and analysis of experiential factors. *Language Testing*, 15(1), 1–20.
- Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science*, 18(2), 119–144.
- Sally, S., & Pradana, S. A. (2019). A need analysis English for business course. *English Education: Jurnal Tadris Bahasa Inggris*, 12(2), 139-146.
- Sanne, J. (2001). Creating Safety in Air Traffic Control. *Administrative Science Quarterly*, 46, 345.
- Satvinder Singh, R. K., Cheong, C. Y. M., & Rahman, N. A. A. (2021). Spoken and Written Communication Needs of Aviation Management Trainees. *International Journal on Social and Education Sciences*, 3(3), 535-547.
- Seiler, W. (2009). English as a lingua franca in aviation. *English Today*, 25, 43-48
- Singh, S., Sharma, S. K., & Parti, R. (2024). Role of Aviation Infrastructure in Aviation Operation. In *New Innovations in AI, Aviation, and Air Traffic Technology* (pp. 212-245). IGI Global.
- Sirin, P. & Inan, T.T. (2024). Safety in focus: Analyzing aviation English competency among ab-initio pilots. *Collegiate Aviation Review International*, 42(2), 41-62.

- Streiner, D. L. (1994). Figuring out factors: the use and misuse of factor analysis. *The Canadian Journal of Psychiatry*, 39(3), 135-140.
- Tabachnick, B.G. & Fidell, L.S. (2013). *Using Multivariate Statistics (6th Ed.)*. Boston: Allyn & Bacon.
- Tajima, A. (2004). Fatal miscommunication: English in aviation safety. *World Englishes*, 23(3), 451-470.
- Tomak, T., & Pavelić, M. (2017). Motivation towards studying English for specific purposes among students of medical and healthcare studies. *Jahr – European Journal of Bioethics*, 8, 151–170.
- Tosqui-Lucks, P., & de Carvalho, A. L. B. (2020). Aeronautical English: Investigating the nature of this specific language in search of new heights. *The Specialist*, 41(3).
- Wu, Y. (2012). An empirical study on needs analysis of college business English course. *International Education Studies*, 5(2), 216-221.
- Yan, R. (2013). Assessing the English language proficiency of international aviation staff. *The Companion to Language Assessment*, 1, 484-496.
- Yang, H. H., Chang, Y. H., & Chou, Y. H. (2023). Subjective measures of communication errors between pilots and air traffic controllers. *Journal of Air Transport Management*, 112, 102461.



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