

UTJECAJ BIRD STRIKE DOGAĐAJA NA SIGURNOST ZRAČNOG PROMETA S OSVRTOM NA BOSNU I HERCEGOVINU

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Izvorni naučni članak

Lejla Nikšić, dr.sc.¹

Marija Prskalo, mag. ing. el.²

Sažetak

Bird strike događaji predstavljaju jedan od stalnih sigurnosnih izazova u civilnom zrakoplovstvu, jer sudari zrakoplova s pticama mogu ugroziti sigurnost leta, operativnu pouzdanost i troškovnu učinkovitost zračnog prometa. Fenomen je globalno prisutan, a učestalost incidenata najveća je u neposrednoj blizini aerodroma i pri niskim visinama, gdje na njegovo pojavljivanje utječu migracijski obrasci ptica, sezonske klimatske varijacije i lokalni ekološki čimbenici. Razumijevanje i praćenje bird strike događaja ključno je za planiranje sigurnosnih mjera i učinkovito upravljanje rizikom. Cilj istraživanja je sagledati globalne i lokalne trendove, prikazati regulatorni okvir i sustave upravljanja sigurnošću, te istaknuti značaj preventivnih mjera u svakodnevnoj praksi. Poseban fokus stavljen je na pregled i analizu podataka o zabilježenim incidentima u Bosni i Hercegovini. To omogućuje uvid u učestalost, tipologiju i razine rizika incidenata te u provedbu preventivnih mjera i koordinaciju nadležnih tijela. Takav integrirani pristup omogućuje sustavno razumijevanje problema, podržava primjenu najboljih međunarodnih praksi i doprinosi jačanju sigurnosne kulture u zračnom prometu, pri čemu lokalni kontekst zahtijeva specifične mjere prilagođene okolišu i operativnim uvjetima.

Ključne riječi: *bird strike, sigurnost zračnog prometa, upravljanje rizicima, Bosna i Hercegovina.*

¹ E-mail: lejla.niksic@fsk.unsa.ba

² E-mail: marija.prskalo@bhansa.gov.ba

1. Uvod

Sigurnost zračnog prometa predstavlja temeljni prioritet civilnog zrakoplovstva i ključni je čimbenik održivosti i učinkovitosti globalnog zrakoplovnog sustava. Povećanje opsega zračnog prometa i rast složenosti operacija nameću potrebu za sustavnim, aktivnim pristupom upravljanju sigurnosnim rizicima.

Sustav upravljanja sigurnošću u zračnoj plovidbi (Safety Management System - SMS) čini osnovni okvir za nadzor i unapređenje sigurnosti. Temelji se na jasno definiranim pravilima i procedurama, a provodi se kroz suradnju regulatornih tijela, zračnih prijevoznika, aerodroma, proizvođača zrakoplova i drugih dionika. Zajedničkim aktivnostima, kontinuiranom edukacijom osoblja i praćenjem sigurnosnih pokazatelja postiže se stalno unapređenje sigurnosne kulture u zrakoplovstvu (Prskalo, 2024).

Unutar ovog sustava, sudari zrakoplova s pticama predstavljaju specifičan i kompleksan sigurnosni izazov s izraženim operativnim, tehničkim i ekonomskim posljedicama. Takvi incidenti mogu oštetiti ključne zrakoplovne sustave, ugroziti sigurnost leta i izazvati značajne troškove održavanja te kašnjenja letova. Njihova učestalost i ozbiljnost ovise o kombinaciji prirodnih, tehničkih i operativnih čimbenika, uključujući migracijske obrasce ptica, lokalne uvjete okoliša te stupanj implementacije preventivnih mjera.

Ovaj rad analizira bird strike događaje u kontekstu SMS-a u civilnom zrakoplovstvu, s posebnim naglaskom na Bosnu i Hercegovinu. Metodološki okvir uključuje detaljnu analizu dostupnih statističkih podataka i izvješća o incidentima, pregled relevantne nacionalne i međunarodne regulative, te analizu najboljih praksi i standarda u upravljanju rizicima od sudara zrakoplova s pticama. U okviru istraživanja provedena je deskriptivna statistička analiza prijavljenih bird strike događaja u razdoblju 2017-2024. godine, kojom su obuhvaćene sezonske i prostorne varijacije, distribucija događaja prema fazi leta i vrsti ptica, te trendna analiza učestalosti incidenata po aerodromima. Rezultati su dopunjeni stručnim kritičkim osvrtom s ciljem prepoznavanja mogućih uzroka uočenih obrazaca i procjene učinkovitosti postojećih mjera prevencije. Takav integrirani pristup omogućuje sustavno razumijevanje uzročno-posljedičnih veza i pruža znanstvenu osnovu za procjenu učinkovitosti postojećih sigurnosnih mehanizama u zrakoplovnom sustavu.

Cilj rada je pružiti cjelovit pregled aktualnog stanja, identificirati ključne čimbenike rizika te predložiti znanstveno utemeljene mjere za unapređenje SMS-a u zračnom prometu Bosne i Hercegovine.

2. Povijest i razvoj bird strike fenomena

Bird strike, odnosno sudar zrakoplova s pticama, predstavlja jedan od najozbiljnijih prirodnih rizika u civilnom zrakoplovstvu i globalni je fenomen. U međunarodnoj terminologiji često se koristi i pojam wildlife hazard, kojim se označava svaki rizik koje divlje životinje predstavljaju za sigurnost zračnog prometa. Takvi incidenti mogu se dogoditi u bilo kojoj fazi leta, ali su najčešći tijekom polijetanja i slijetanja, kada zrakoplov prolazi kroz područja s najvećom aktivnošću ptica u neposrednoj blizini aerodroma, uglavnom u dnevnim satima. Prvi zabilježeni bird strike dogodio se 1908. godine, kada je Orville Wright udario u pticu. Godine 1912., Calbraith Perry Rodgers postao je prva smrtna žrtva takvog incidenta nakon što je njegov Wright Flyer zapleo galeba i pao u more (ICAO, 2012).

Rani zrakoplovi, zbog krhke konstrukcije i slabih motora, bili su vrlo osjetljivi na oštećenja, iako je spora brzina omogućavala djelomično izbjegavanje sudara. Kako su konstrukcija i materijali napredovali, letjelice su postajale čvršće i otpornije, što je smanjilo učestalost teških posljedica sudara s pticama. Ipak, unatoč napretku u konstrukciji, incidenti nisu postali rijetki, što ukazuje na trajnu ranjivost zrakoplova na bird strike događaje. Posebno su ugroženi dijelovi zrakoplova koji su izloženi izravnim udarcima, poput kokpita, vjetrobrana, motora i okolnih strukturnih elemenata. U nekim slučajevima sudari su bili dovoljno ozbiljni da su dovodili do ozljeda članova posade ili narušavali kontrolu nad letjelicom. Ovi incidenti jasno pokazuju da, iako su suvremeni zrakoplovi znatno otporniji nego ranije verzije, bird strike i dalje predstavlja ozbiljan sigurnosni izazov za civilno zrakoplovstvo, zahtijevajući stalnu pozornost i primjenu preventivnih mjera.

Primjerice, Eastern Air Lines Flight 375 (1960) udario je u jato čvoraka pri polijetanju iz bostonske zračne luke Logan, što je dovelo do gubitka snage u tri od četiri motora i pogibije 62 od 72 osobe (Eastern Airlines, 1960). Također, nesreća United Airlines Flight 297 (1962) bila je posljedica sudara s jatam labudova na visini od 6.000 stopa, pri čemu je jedan labud prošao u horizontalni stabilizator, oslabio strukturnu cjelovitost i doveo do gubitka kontrole nad zrakoplovom s pogibijom svih putnika i posade (Civil Aeronautics Board, 1963). Primjeri ovih događaja ukazuju na ranjivost zrakoplova na sudare s velikim pticama, posebice u kritičnim fazama leta, i doveli su do podizanja kriterija otpornosti horizontalnih stabilizatora na udar ptica. Učestalost i posljedice sudara zrakoplova s pticama potaknule su razvoj sustavnog pristupa upravljanju ovim rizikom na globalnoj razini.

3. Pregled regulative i smjernica za upravljanje bird strike rizikom

Povijesni incidenti jasno su ukazali na ozbiljnost rizika koji bird strike predstavlja za sigurnost zrakoplova, što je potaknulo međunarodnu zajednicu na uspostavu sustavnih smjernica i standarda. Međunarodna organizacija civilnog zrakoplovstva (International Civil Aviation Organization - ICAO) ima ključnu ulogu u postavljanju globalnih standarda i preporuka vezanih uz sigurnost zračnog prometa, uključujući i upravljanje rizikom od udara ptica. Kao specijalizirana agencija Ujedinjenih naroda, ICAO djeluje kroz uspostavljanje međunarodnih standarda i preporučenih praksi koji se primjenjuju u državama članicama, a čine osnovu za nacionalne propise i operativne procedure.

Temeljni dokument koji se bavi ovom problematikom je Annex 14-Aerodromes, Volume I: Aerodrome Design and Operations, u kojem je definiran okvir za smanjenje rizika od sudara zrakoplova s divljim životinjama, prvenstveno pticama. ICAO (2018) naglašava da prisutnost ptica i drugih životinja na ili u blizini aerodroma predstavlja ozbiljnu prijetnju sigurnosti letova te propisuje obvezu država članica da uspostave sustavne procedure za praćenje i upravljanje ovim rizikom.

Prema Annexu 14, svaka država treba razviti nacionalni sustav evidentiranja i prijavljivanja udara divljih životinja te prikupljanja podataka o njihovoj prisutnosti na aerodromu i u okolnom području. Ključni element je kontinuirana procjena rizika koju provodi stručno osposobljeno osoblje, uz redovito izvješćivanje prema međunarodnoj bazi podataka ICAO Bird Strike Information System (IBIS) (ICAO, 2018). Ovaj sustav omogućuje globalnu analizu i razmjenu informacija o incidentima, što olakšava prepoznavanje trendova i donošenje učinkovitih mjera prevencije.

Prema podacima IBIS (2023), u razdoblju 2016.-2021. zabilježeno je 273.343 udara divljih životinja u 194 države i teritorija, pri čemu ptice čine najveći udio ovih incidenata. Ovi podaci naglašavaju važnost sustavnog praćenja prisutnosti divljih životinja na i oko aerodroma, procjene rizika te implementacije dobro organiziranih programa kontrole divljih životinja, s posebnim fokusom na ptice, kako bi se smanjili operativni rizici i povećala sigurnost zračnog prometa.

ICAO preporučuje provođenje preventivnih mjera za smanjenje rizika od sudara s divljim životinjama, uključujući kontrolu okoliša, uklanjanje izvora hrane i sprječavanje stvaranja staništa koja bi mogla privući ptice (ICAO, 2013). Dodatne tehničke smjernice sadržane su u Airport Services Manualu (Doc 9137, Part 3), koji detaljno opisuje metode identifikacije i odvrćanja ptica u području aerodroma.

U cjelini, Annex 14 postavlja sustavan i sveobuhvatan okvir za upravljanje rizikom od udara ptica, koji kombinira nadzor, izvješćivanje i preventivno djelovanje te čini osnovu za razvoj nacionalnih programa i procedura sigurnosti. Na europskoj razini, upravljanje rizikom od udara ptica i drugih divljih životinja temelji se na propisima Europske unije i standardima koje provodi Europska agencija za sigurnost zračnog prometa (European Union Aviation Safety Agency - EASA). Europska regulativa u potpunosti preuzima načela ICAO-a, ali ih nadopunjuje detaljnijim operativnim zahtjevima i obveznim procedurama.

Države članice Europske unije obvezne su uspostaviti nacionalne sustave za evidentiranje i izvješćivanje o incidentima, kontinuirano prikupljati informacije o prisutnosti životinja koje mogu ugroziti sigurnost operacija te provoditi redovitu procjenu rizika koju izrađuje stručno ovlašteno osoblje (EK, 2014).

Poseban naglasak stavljen je na razvoj i održavanje snažne sigurnosne kulture, budući da je dokazano kako organizacije koje potiču visoku razinu sigurnosne svijesti imaju nižu stopu incidenata i učinkovitiji sustav unutarnjeg nadzora (Prskalo i Šahić, 2024).

Temeljni pravni akt u ovom području je Uredba Komisije (EU) br. 139/2014 o zahtjevima za aerodrome, poznata i kao dio tzv. Easy Access Rules for Aerodromes. Uz nju, EASA objavljuje prateće dokumente AMC i GM (Acceptable Means of Compliance i Guidance Material), koji nude praktične smjernice za dokazivanje usklađenosti sa zahtjevima propisanim Uredbom.

Kronološki gledano, europski regulatorni okvir razvijao se paralelno s ICAO smjernicama, uz periodična ažuriranja AMC i GM materijala, čime je uspostavljen koherentan sustav koji osigurava visoku razinu sigurnosti, ali i fleksibilnost u primjeni prema lokalnim uvjetima i vrstama ptica koje predstavljaju prijetnju zračnom prometu.

U Sjedinjenim Američkim Državama, nadležnost za upravljanje rizikom od udara ptica pripada Federalnoj upravi za zrakoplovstvo (Federal Aviation Administration - FAA). FAA je među prvim tijelima koja je razvila sustavan pristup ovoj problematici, a njezine smjernice danas se koriste kao međunarodni referentni standard.

Temeljni dokument u ovom području je Advisory Circular (AC) 150/5200-33C-Hazardous Wildlife Attractants on or Near Airports, koji definira postupke za identifikaciju i upravljanje izvorima koji mogu privući divlje životinje u blizinu aerodroma. Sudari s pticama i drugim životinjama predstavljaju značajan sigurnosni i ekonomski rizik, a učinkovitost mjera ovisi o lokalnim uvjetima, prostornom planiranju i koordiniranom djelovanju nadležnih tijela (FAA, 2020). Dodatno, AC 150/5200-32C-Reporting Wildlife Aircraft Strikes propisuje obvezu prijavljivanja svih sudara s divljim životinjama, neovisno o razini štete, u

National Wildlife Strike Database - jednu od najopsežnijih baza podataka te vrste. Prema FAA (2020), oko 97 % svih zabilježenih udara uključuje ptice, a najčešće pogođene vrste su divlje patke, guske, galebovi i grabljivice. Iako samo manji udio incidenata uzrokuje ozbiljnu štetu, ekonomske posljedice su značajne.

Ptice i druge divlje životinje važan su ekološki i gospodarski resurs, ali mogu predstavljati ozbiljan rizik za sigurnost zračnog prometa. Od 1990. do 2024., u SAD-u je prijavljeno ukupno 319.047 udara divljih životinja, pri čemu su ptice činile najveći udio incidenata. Većina udara ptica događa se tijekom dana i u fazi prilaza aerodromu, a visina udara značajno utječe na opasnost - udari iznad 150 metara češće uzrokuju štetu. Ukupno je 88 udara rezultiralo uništenjem zrakoplova, a procijenjeni godišnji trošak za civilno zrakoplovstvo SAD-a u 2024. iznosio je 473 milijuna USD i 74.268 sati zastoja zrakoplova. (FAA, 2024).

Međunarodni regulatorni okvir (ICAO, EASA, FAA) zasniva se na konceptu upravljanja sigurnosnim rizicima SMS-a, koji zahtijeva proaktivno prepoznavanje i kontrolu prijetnji.

Slično tome, analiza ATC-povezanih avionskih nesreća pokazuje da ljudski, proceduralni i komunikacijski faktori mogu imati značajan utjecaj na sigurnost zrakoplovstva, što dodatno potvrđuje važnost proaktivnog pristupa u upravljanju rizicima, kao što je slučaj i kod problema bird strike događaja (Nikšić & Öztürk, 2023).

4. Upravljanje bird strike događajima u Bosni i Hercegovini

U Bosni i Hercegovini, aerodromi i nadležna tijela djeluju u skladu s međunarodnim standardima ICAO-a i EASA-e, kroz implementaciju okvira SMS-a i procedura za praćenje, izvješćivanje i prevenciju događaja. Svi događaji koji mogu ugroziti sigurnost zrakoplova, putnika ili posade klasificirani su prema smjernicama Direkcije za civilno zrakoplovstvo Bosne i Hercegovine (BHDCA), koja donosi regulativu u oblasti zračnog prometa Bosne i Hercegovine.

U skladu s BHDCA (2021), svi događaji koji imaju utjecaj na sigurnost leta kategoriziraju se prema vrsti aktivnosti i području na kojem su se dogodili. Bird strike, odnosno sudar zrakoplova s pticama, može se svrstati u više kategorija ovisno o okolnostima događaja i njegovim posljedicama.

Većina bird strike incidenata klasificirana je kao događaji vezani za aerodrome i zemaljske usluge, budući da se većina sudara događa u neposrednoj blizini aerodroma, gdje ptice pronalaze hranu, vodu i sklonište.

U slučajevima kada sudar uzrokuje fizičko oštećenje zrakoplova (npr. motora, radarske kupole, trupa ili elipse), događaj se može klasificirati i kao događaj povezan s tehničkim uvjetima, održavanjem i popravkom zrakoplova, budući da oštećenje može utjecati na strukturalnu čvrstoću ili performanse letjelice. Ako se incident dogodi tijekom polijetanja ili slijetanja, može biti obuhvaćen i kategorijom događaja vezanih za provođenje operacija zrakoplovom, osobito ako je imao utjecaj na sigurnost leta.

Manji, ponavljajući sudari koji ne uzrokuju značajnije posljedice, ali ukazuju na potencijalni rizik, mogu se evidentirati unutar skupine ostalih događaja, jer se smatraju faktorom koji dugoročno može utjecati na sigurnost operacija. Ovakva kategorizacija omogućuje učinkovitije praćenje, izvješćivanje i planiranje preventivnih mjera na razini aerodroma i zrakoplovnih operacija, u skladu s međunarodnim standardima i praksom koju primjenjuje ICAO.

Tablica 1. Podjela ozbiljnosti zrakoplovnih incidenata (Izvor: ESSAR 2)

OZBILJNOST	A	Ozbiljan incident	A1	A2	A3	A4	A5
	B	Glavni incident	B1	B2	B3	B4	B5
	C	Bitni incident	C1	C2	C3	C4	C5
	D	Nedefinirani	D1	D2	D3	D4	D5
	E	Bez utjecaja na sigurnost	E1	E2	E3	E4	E5
			1	2	3	4	5
			Vrlo učestalo	Učestalo	Povremeno	Rijetko	Vrlo rijetko
			UČESTALOST				

Tablica 2. Definiranje učestalosti nesreća/incidenata zrakoplova (Izvor: ESSAR 2)

UČESTALOST	DEFINICIJA
Vrlo rijetko	Nikada tijekom životnog vijeka sustava.
Rijetko	Samo nekoliko zabilježenih sličnih slučajeva u odnosu na veliki obim prometa ili bez zabilježenih slučajeva u odnosu na mali obim prometa.
Povremeno	Nekoliko zabilježenih sličnih ugrožavanja sigurnosti, nesreća i ozbiljnih nezgoda - više od jednog puta na istom mjestu.
Učestalo	Već ranije zabilježen značajan broj sličnih ugrožavanja sigurnosti, nesreća i ozbiljnih nezgoda - značajan broj ponavljanja na istom mjestu.
Vrlo učestalo	Vrlo veliki broj već ranije zabilježenih sličnih ugrožavanja sigurnosti, nesreća i ozbiljnih nezgoda - vrlo veliki broj ponavljanja na istom mjestu.

4.1. Studije slučaja

Bird strike predstavlja jedan od najčešćih sigurnosnih incidenata u civilnom zrakoplovstvu. Iako većina takvih događaja ne uzrokuje izravnu štetu ni ugrožava sigurnost leta, njihova evidencija i analiza ključni su za upravljanje rizikom unutar SMS-a. BHDCA sustavno bilježi ovakve događaje i procjenjuje ih prema ICAO matrici rizika, omogućujući preciznu klasifikaciju i razvoj preventivnih mjera. Prikazuju se tri zabilježena slučaja, s fokusom na različite kategorije rizika te pripadajuće preporuke za preventivne mjere i upravljanje rizikom.

Studija slučaja 1

Prema BHDCA (2021), dana 6.9.2021. godine tijekom zaustavljanja zrakoplova došlo je do sudara s pticom (jastreb). Nije zabilježeno oštećenje zrakoplova niti je sigurnost leta bila ugrožena. Stručno osoblje aerodroma obavijestilo je BHDCA, pregledalo uzletno-sletnu stazu i pronašlo pticu u jednom komadu. Prema ICAO matrici rizika, događaj je klasificiran kao 3E - niska vjerojatnost i zanemarive posljedice.

Preporuke:

- Nastaviti s redovitim nadzorom područja aerodroma.
- Održavati područje bez izvora hrane i vode koji mogu privući ptice.
- U razdobljima migracija pojačati dnevne inspekcije.
- Naglasak na praćenje i edukaciju osoblja.

Studija slučaja 2

Prema BHDCA (2024), dana 2.6.2024. godine zrakoplov je tijekom slijetanja, pri brzini od približno 150 čvorova, udario u pticu. Nije došlo do oštećenja zrakoplova, ali događaj je zabilježen i analiziran. Kategorija 4D označava rijetko ponavljanje događaja s manjim utjecajem. Takvi incidenti zahtijevaju praćenje trendova i aktivne mjere jer se događaju relativno često.

Preporuke:

- Sustavno provođenje programa kontrole ptica prema internim procedurama SMS-a.
- U vegetacijskom razdoblju provoditi aktivne metode rastjerivanja (plinski topovi, vozila sa sirenama, dresirani jastrebovi).
- Uključiti statističko praćenje i analizu sezonskih uzoraka (učestalost po mjesecima).
- Uspostaviti bazu podataka o bird strike događajima radi procjene trendova i učinkovitosti mjera.

Studija slučaja 3

Prema BHDCA (2025), dana 25.7.2025. godine kapetan zrakoplova prijavio je mogući sudar s pticom tijekom prilaza za slijetanje. Pregledom piste pronađena je uginula ptica, no zrakoplov nije pretrpio nikakvu štetu te je nastavio let. Prema

ICAO matrici rizika, događaj je ocijenjen kao 4E - povremena pojava s potpuno zanemarivim posljedicama, bez utjecaja na sigurnost.

Preporuke:

- Pojačati mjere rastjerivanja tijekom kritičnih faza leta (prilaz i slijetanje).
- Uvesti laserske uređaje kao suvremeno i ekološki prihvatljivo sredstvo rastjerivanja ptica.
- Redovito pregledavati vegetaciju i površine koje mogu privlačiti ptice.
- Uvesti obavezno dnevno izvješćivanje o prisutnosti faune na području aerodroma.

Stručni kritički osvrt

Sustav prijavljivanja i analize bird strike događaja u Bosni i Hercegovini funkcionira u skladu s ICAO standardima i nacionalnim propisima.

Kategorije 3E, 4D i 4E ukazuju na niske razine rizika, no njihova pojava zahtijeva stalno aktivno djelovanje. Analiza prikazanih slučajeva sudara zrakoplova s pticama u Bosni i Hercegovini pokazuje da, iako se radi o događajima niskog rizika, sustavno praćenje i procjena tih incidenata predstavljaju ključni element u funkcionalnom SMS-a. Različite kategorije rizika odražavaju varijabilnost vjerojatnosti pojave i potencijalnih posljedica, što naglašava potrebu za individualiziranim pristupom u planiranju preventivnih mjera. Primijećena učestalost incidenata u fazama prilaza i slijetanja ukazuje na kritične točke u operacijama aerodroma koje zahtijevaju pojačan nadzor i pravovremene preventivne intervencije. Strateški pristup, koji uključuje kombinaciju tehničkih, bioloških i edukativnih mjera, zajedno s uspostavom baze podataka i sustavnim analizama trendova, omogućuje ne samo smanjenje učestalosti incidenata, već i povećanje operativne otpornosti aerodroma.

Zaključno, ovi primjeri potvrđuju da aktivno upravljanje rizikom, predstavlja učinkovit okvir za očuvanje sigurnosti letenja i kontinuirani razvoj sigurnosne kulture u Bosni i Hercegovini.

5. Statistička analiza podataka

Analiza bird strike događaja u Bosni i Hercegovini provedena je na temelju dostupnih izvješća Agencije za pružanje usluga u zračnoj plovidbi Bosne i Hercegovine (BHANSA) u razdoblju od 2017. do 2024. godine. Cilj statističke obrade je kvantitativno prikazati učestalost i karakteristike bird strike događaja u zračnom prostoru Bosne i Hercegovine, identificirati prostorne i sezonske obrasce te utvrditi faze leta i vrste ptica najčešće uključene u ove incidente koji utječu na sigurnost zračnog prometa.

5.1. Deskriptivna analiza

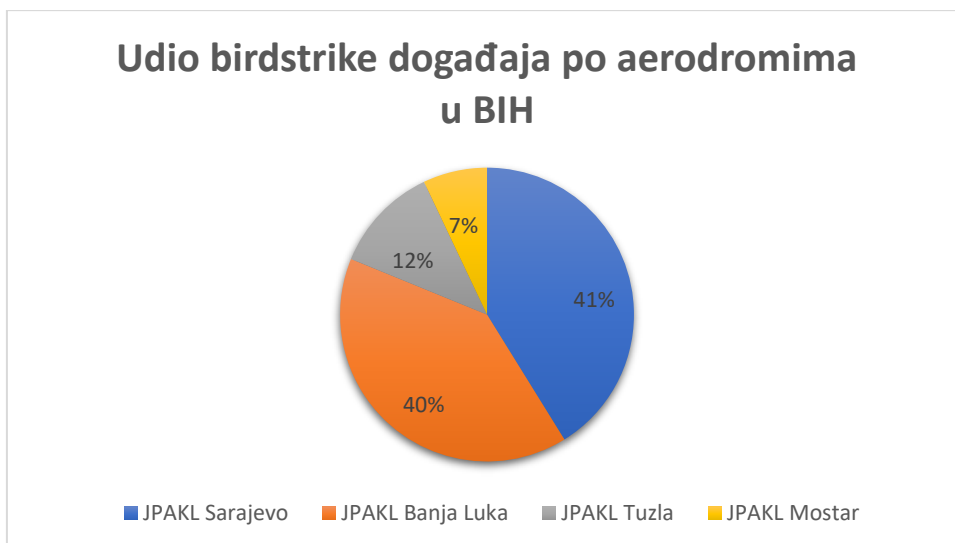
U analiziranom razdoblju zabilježeno je ukupno 84 bird strike događaja na četiri međunarodna aerodroma u Bosni i Hercegovini (Sarajevo, Banja Luka, Tuzla i Mostar). Najveći broj događaja zabilježen je na aerodromima Sarajevo i Banja Luka, što je u skladu s obimom prometa i lokalnim ekološkim uslovima koji pogoduju prisustvu ptica. Najmanji broj događaja prijavljen je 2020. godine (4 događaja), što se može dovesti u vezu sa smanjenim intenzitetom zračnog prometa tokom pandemije COVID-19, dok je najveći broj registrovan 2023. godine (21 događaj).

Promatrajući trend, primjetan je postepeni rast broja prijavljenih incidenata nakon 2021. godine, što se može tumačiti povećanjem obima operacija, ali i unapređenjem sistema prijavljivanja i praćenja događaja unutar SMS-a.



Grafikon 1. Broj bird strike događaja po godinama (2017–2024) (Izvor: BHANSA)

Analiza prema aerodromima pokazuje da se najveći broj incidenata dogodio na aerodromima Sarajevo (35) i Banja Luka (34), dok su aerodromi Tuzla (10) i Mostar (6) imali znatno manji broj zabilježenih slučajeva (Grafikon 2). Ovakva raspodjela u skladu je s obimom prometa - aerodromi s većim brojem operacija imaju i veću vjerojatnost pojave sudara s pticama.



Grafikon 2. Udio bird strike događaja po aerodromima (2017–2024) (Izvor: BHANSA)

Distribucija prema fazi leta

Analiza pokazuje da se bird strike događaji najčešće dešavaju u kritičnim fazama leta, pri polijetanju (27,4%) i slijetanju (27,4%), dok je 10,7% zabilježeno u fazama zaustavljanja i taksiranja. Kod 34,5% slučajeva faza leta nije jasno naznačena u izvještajima, što ukazuje na potrebu za dosljednijim opisom okolnosti pri prijavljivanju događaja.

Ovakva distribucija u potpunosti je u skladu s međunarodnim podacima (ICAO, 2018; FAA, 2024), prema kojima se većina bird strike incidenata događa u niskim visinama, tokom poletno-sletnih operacija, kada je vjerovatnoća susreta s pticama najveća. Sličan obrazac prisutan je i kod drugih kategorija sigurnosnih događaja i avionskih nesreća, gdje se najveći broj incidenata također javlja upravo u kritičnim fazama leta - polijetanju i slijetanju (Nikšić & Öztürk, 2022).

Distribucija prema vrsti ptica

U najvećem broju slučajeva (67,9%) vrsta ptice nije navedena u izvještajima. Od poznatih slučajeva, u 22,6% se navodi „nepoznata ptica“, dok su u manjem broju zabilježene konkretne vrste: vrabac (3%), jastreb (3%), orao (3%), te po 2% za svraku i sovu. Ovakva struktura pokazuje da, iako većina incidenata ne uključuje teže posljedice, postoji potreba za sistematičnijom identifikacijom ptica i saradnjom s ornitolozima, što bi doprinijelo boljoj procjeni rizika i planiranju preventivnih mjera.

Recentna istraživanja pokazuju da integracija DNA barcodinga i terenskih istraživanja omogućava precizniju identifikaciju vrsta ptica koje najčešće uzrokuju sudare s avionima, čime se mogu unaprijediti mjere prevencije i smanjenje rizika od incidenata (Chen et al., 2025).

Dodatno, procjena relativnog rizika i sezonskih razlika između vrsta ptica može pomoći u prioritarnom fokusiranju mjera upravljanja staništima i operacijama na aerodromima, posebno tokom migracijskih perioda kada je rizik od sudara najveći (Ross et al., 2025).

Sezonski i prostorni obrasci

Analiza datuma pokazuje izraženu sezonsku varijaciju; većina događaja javlja se tokom proljeća i ljeta (maj–avgust), u periodima povećane aktivnosti ptica i migracija grabljivica. Ovakav sezonski obrazac u skladu je s očekivanjima, budući da se u toplijim mjesecima bilježi povećano kretanje ptica, ali i intenzivniji zračni promet (Kelly, 2024; Tal et al., 2024).

Prostorna raspodjela pokazuje da su Sarajevo i Banja Luka glavni centri pojave ovih incidenata, što je povezano s većim obimom prometa, ali i s okolišnim faktorima koji pogoduju prisustvu ptica u zoni aerodroma. Iako Sarajevo ostvaruje znatno veći broj letnih operacija, broj bird strike događaja u Banjoj Luci gotovo je jednak, što može ukazivati na nekoliko mogućih uzroka:

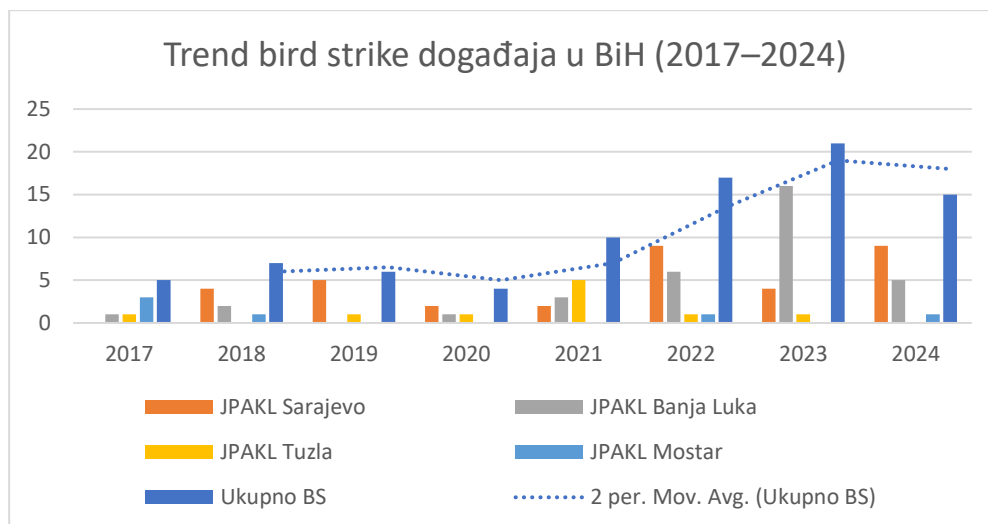
- a) povoljnije prostorne i ekološke uslove za prisustvo ptica (npr. blizina šumskih i poljoprivrednih površina),
- b) položaj aerodroma unutar mogućeg migracijskog koridora, ili
- c) potrebu za mogućim unapređenjem postojećih mjera kontrole i rastjerivanja ptica koje se provode na aerodromu Banja Luka.

Ovakva opažanja upućuju na potrebu za detaljnijom analizom lokalnih biotičkih i prostorno-ekoloških faktora, kao i za periodičnim vrednovanjem učinkovitosti postojećih programa upravljanja faunom (wildlife management) na aerodromima u Bosni i Hercegovini.

5.2. Trendna analiza

Analiza vremenskog kretanja broja bird strike događaja u periodu 2017–2024. godine omogućava uvid u dinamiku pojave incidenata kroz duži vremenski horizont.

U prvom dijelu posmatranog razdoblja (2017–2020.) bilježi se relativno nizak i stabilan broj događaja, dok nakon 2021. godine dolazi do značajnog porasta prijave, što ukazuje na promjenu u učestalosti ovih incidenata. Ovakav rast može biti rezultat kombinovanog uticaja povećanja obima zračnih operacija nakon pandemijskog perioda, poboljšanja u sistemu evidentiranja događaja, ali i promjena u ekološkim uslovima koji utiču na prisustvo ptica u blizini aerodroma.



Grafikon 3. Trend bird stike događaja u BIH (2017-2024) (Izvor: BHANSA)

Rezultati prikazani na Grafikonu 3. pokazuju da se broj bird strike događaja u Bosni i Hercegovini kontinuirano povećavao nakon 2021. godine, s najvišim vrijednostima zabilježenim tokom 2022. i 2023. godine.

Primjena dvogodišnjeg pokretnog prosjeka jasno potvrđuje uzlazni trend, što ukazuje na potrebu kontinuiranog praćenja i evaluacije rizika.

Usporedba među aerodromima pokazuje da Sarajevo i Banja Luka prednjače po broju zabilježenih događaja, dok aerodromi Tuzla i Mostar bilježe manji broj incidenata. Zanimljivo je, međutim, da Banja Luka, unatoč znatno manjem obimu zračnih operacija, bilježi gotovo isti broj incidenata kao i Sarajevo. Ovakav odnos može upućivati na to da je područje aerodroma Banja Luka prostorno pogodnije za prisustvo ptica, da se nalazi na migracijskom koridoru, ili da mjere kontrole faune nisu jednako učinkovite kao na drugim aerodromima. S druge strane, aerodromi Tuzla i Mostar bilježe manji broj događaja, što može biti povezano s manjim brojem letova, ali i lokalnim ekološkim uslovima koji manje pogoduju koncentraciji ptica.

Stručni kritički osvrt

Provedena analiza pokazuje da su bird strike događaji u zračnom prostoru Bosne i Hercegovine uglavnom niskog rizika, ali da njihova učestalost pokazuje uzlazni trend u posljednjih nekoliko godina. Ovaj trend ne mora nužno ukazivati na pogoršanje sigurnosnih uslova, već može odražavati bolju evidenciju i svijest o važnosti prijavljivanja incidenata u okviru SMS-a.

S druge strane, disproporcija između obima zračnih operacija i broja bird strike događaja, posebno u slučaju aerodroma Banja Luka, zahtijeva dodatnu pažnju. Ovakva pojava može ukazivati na specifične lokalne ekološke faktore, prisustvo ptica duž migracijskih koridora ili nedovoljnu učinkovitost postojećih mjera

kontrole faune. Preporučljivo je da se u narednom razdoblju provede detaljnija procjena rizika po aerodromima, s naglaskom na prostorne i sezonske varijacije, kako bi se utvrdili stvarni uzroci povećane učestalosti događaja. Nadalje, visok udio slučajeva u kojima vrsta ptice nije identificirana (gotovo 68%) ograničava mogućnost precizne procjene rizika i planiranja ciljano usmjerenih mjera. To naglašava potrebu za standardizacijom obrasca prijave bird strike događaja i jačanjem suradnje s ornitološkim stručnjacima radi poboljšanja identifikacije vrsta i razumijevanja njihovih migracijskih navika. Konačno, iako analizirani događaji u većini slučajeva nisu rezultirali ozbiljnim posljedicama po sigurnost letenja, činjenica da se najveći broj incidenata javlja u fazama polijetanja i slijetanja ukazuje na trajnu izloženost ključnih faza leta povećanom riziku. Zato je važno da aerodromi u BiH nastave s kontinuiranim praćenjem, evaluacijom učinkovitosti i unapređenjem mjera upravljanja faunom, u skladu s međunarodnim smjernicama (ICAO Annex 14, Doc 9137 – Airport Services Manual, Part 3). Dobijeni rezultati predstavljaju osnovu za formuliranje zaključaka i preporuka usmjerenih na unapređenje sigurnosti zračnog prometa i učinkovitije upravljanje rizikom od sudara zrakoplova s pticama.

6. Zaključak

Analiza bird strike događaja u zračnom prostoru Bosne i Hercegovine pokazala je da, iako se većina incidenata klasificira kao niskog rizika, njihova učestalost pokazuje uzlazni trend u posljednjih nekoliko godina. Ovaj porast može odražavati kombinovani uticaj povećanog broja letnih operacija, promjena u migracijskim obrascima ptica i poboljšanja u sistemu prijavljivanja incidenata. Najveći broj događaja zabilježen je na aerodromima Sarajevo i Banja Luka. Iako Sarajevo ima znatno veći promet, Banja Luka bilježi gotovo jednaku učestalost bird strike incidenata, što može ukazivati na lokalne ekološke faktore, blizinu područja pogodnih za okupljanje ptica ili razlike u provođenju mjera kontrole faune. Rezultati analize po fazama leta pokazuju da su najrizičnije faze polijetanje i slijetanje, što je u skladu s globalnim trendovima. Veći broj slučajeva u toplijem dijelu godine potvrđuje sezonsku varijaciju povezana s aktivnošću i migracijom ptica. Međutim, značajan udio prijava s neidentifikovanom vrstom ptica ukazuje na potrebu poboljšanja evidencije i suradnje s ornitološkim stručnjacima. Dalji napredak u upravljanju rizikom od bird strike događaja zahtijeva sistemski pristup: objedinjavanje podataka, standardizaciju prijavljivanja, procjenu rizika po aerodromima i kontinuiranu evaluaciju učinkovitosti mjera upravljanja faunom. Posebnu pažnju treba posvetiti razvoju integrisanih strategija koje kombinuju tehničke, biološke i edukativne mjere. Zaključno, bird strike događaji, iako u većini slučajeva ne predstavljaju visok sigurnosni rizik, ostaju relevantan faktor koji zahtijeva trajnu analitičku pažnju i koordinisano djelovanje svih aktera u sistemu zrakoplovne sigurnosti Bosne i Hercegovine.

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THE IMPACT OF BIRD STRIKE INCIDENTS ON AVIATION SAFETY WITH REFERENCE TO BOSNIA AND HERZEGOVINA

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Original Scientific Article

Lejla Nikšić, PhD.³

Marija Prskalo, M. Eng.⁴

Abstract

Bird strike incidents represent a persistent safety challenge in civil aviation, as collisions between aircraft and birds can compromise flight safety, operational reliability, and cost efficiency of air transport. This phenomenon is globally widespread, with the highest frequency of incidents occurring in the vicinity of airports and at low altitudes, where its occurrence is influenced by bird migration patterns, seasonal climatic variations, and local ecological factors. Understanding and monitoring bird strike incidents are essential for planning safety measures and for effective risk management. The objective of this research is to examine global and local trends, present the regulatory framework and safety management systems, and emphasize the importance of preventive measures in daily operations. Special attention is given to the review and analysis of reported bird strike incidents in Bosnia and Herzegovina, providing insight into the frequency, typology, and risk levels of such incidents, as well as the implementation of preventive actions and coordination among competent authorities. This integrated approach enables a systematic understanding of the problem, supports the application of international best practices, and contributes to strengthening the safety culture in aviation, while recognizing that the local context requires specific measures adapted to environmental and operational conditions.

Keywords: *bird strike, aviation safety, risk management, Bosnia and Herzegovina*

³ E-mail: lejla.niksic@fsk.unsa.ba

⁴ E-mail: marija.prskalo@bhansa.gov.ba

1. Introduction

Aviation safety represents a fundamental priority of civil aviation and is a key factor for the sustainability and efficiency of the global air transport system. The increasing scope of air traffic and the growing complexity of operations necessitate a systematic and proactive approach to managing safety risks.

The Safety Management System (SMS) forms the essential framework for monitoring and improving safety in air navigation. It is based on clearly defined rules and procedures and implemented through cooperation among regulatory authorities, air carriers, airports, aircraft manufacturers, and other stakeholders. Through joint activities, continuous staff training, and the monitoring of safety indicators, a continuous improvement of the safety culture in aviation is achieved (Prskalo, 2024).

Within this system, bird strikes represent a specific and complex safety challenge with significant operational, technical, and economic consequences. Such incidents can damage critical aircraft systems, endanger flight safety, and lead to substantial maintenance costs and flight delays. Their frequency and severity depend on a combination of natural, technical, and operational factors, including bird migration patterns, local environmental conditions, and the degree of implementation of preventive measures.

This paper analyses bird strike incidents within the context of the SMS, with a special focus on Bosnia and Herzegovina. The methodological framework includes a detailed analysis of available statistical data and incident reports, a review of relevant national and international regulations, and an evaluation of best practices and standards in managing bird strike risks.

The research includes a descriptive statistical analysis of reported bird strike events for the period 2017–2024, covering seasonal and spatial variations, distribution of events by flight phase and bird species, and trend analysis of incident frequency across airports. The results are supplemented with a professional critical review aimed at identifying potential causes of observed patterns and assessing the effectiveness of existing preventive measures.

This integrated approach enables a systematic understanding of cause-and-effect relationships and provides a scientific basis for evaluating the effectiveness of existing safety mechanisms within the aviation system. The objective of this paper is to provide a comprehensive overview of the current situation, identify key risk factors, and propose scientifically grounded measures to improve the SMS in the aviation sector of Bosnia and Herzegovina.

2. History and Development of the Bird Strike Phenomenon

Bird strike, or aircraft collision with birds, represents one of the most serious natural hazards in civil aviation and is a global phenomenon. In international terminology, the term wildlife hazard is often used to denote any risk posed by wild animals to the safety of air operations. Such incidents can occur during any phase of flight, but they are most common during take-off and landing, when aircraft pass through areas of highest bird activity in the immediate vicinity of airports, mostly during daylight hours. The first recorded bird strike occurred in 1908, when Orville Wright struck a bird. In 1912, Calbraith Perry Rodgers became the first fatal victim of such an incident after his Wright Flyer became entangled with a seagull and crashed into the sea (ICAO, 2012).

Early aircraft, due to their fragile structures and weak engines, were highly susceptible to damage, although their low speeds allowed partial avoidance of collisions. As aircraft structures and materials advanced, airplanes became stronger and more resistant, which reduced the frequency of severe consequences resulting from bird collisions. Nevertheless, despite technological progress, these incidents have not become rare, indicating the persistent vulnerability of aircraft to bird strike events. Parts of the aircraft that are particularly exposed to direct impact, such as the cockpit, windshield, engines, and adjacent structural components, remain especially at risk. In some cases, collisions have been severe enough to cause crew injuries or impair aircraft control. These incidents clearly demonstrate that, although modern aircraft are significantly more resilient than earlier models, bird strikes still pose a serious safety challenge to civil aviation, requiring continuous attention and the implementation of preventive measures.

For instance, Eastern Air Lines Flight 375 (1960) struck a flock of starlings during take-off from Boston Logan Airport, resulting in the loss of power in three out of four engines and the deaths of 62 of the 72 occupants (Eastern Airlines, 1960). Likewise, the United Airlines Flight 297 (1962) accident resulted from a collision with a flock of swans at an altitude of 6,000 feet, where one swan penetrated the horizontal stabilizer, weakened its structural integrity, and caused loss of aircraft control, leading to the deaths of all passengers and crew (Civil Aeronautics Board, 1963). These examples illustrate the vulnerability of aircraft to collisions with large birds, particularly during critical phases of flight, and led to the establishment of higher design standards for the bird strike resistance of horizontal stabilizers. The frequency and consequences of aircraft-bird collisions have prompted the development of a systematic, global approach to managing this hazard.

3. Overview of Regulations and Guidelines for Managing Bird Strike Risk

Historical incidents have clearly demonstrated the severity of the risk that bird strikes pose to aircraft safety, prompting the international community to establish systematic guidelines and standards.

The International Civil Aviation Organization (ICAO) plays a key role in setting global standards and recommendations related to aviation safety, including the management of bird strike hazards. As a specialized agency of the United Nations, ICAO operates through the development of international standards and recommended practices applied by member states, which form the basis for national regulations and operational procedures.

The fundamental document addressing this issue is Annex 14 - Aerodromes, Volume I: Aerodrome Design and Operations, which defines the framework for reducing the risk of aircraft collisions with wildlife, primarily birds. ICAO (2018) emphasizes that the presence of birds and other animals on or in the vicinity of aerodromes represents a serious threat to flight safety, and requires member states to establish systematic procedures for monitoring and managing this risk.

According to Annex 14, each state should develop a national system for recording and reporting wildlife strikes and for collecting data on their presence at and around aerodromes. A key element is the continuous risk assessment carried out by professionally trained personnel, with regular reporting to the international database ICAO Bird Strike Information System (IBIS) (ICAO, 2018). This system enables global analysis and information exchange on incidents, facilitating the identification of trends and the adoption of effective preventive measures.

According to IBIS data (2023), during the period 2016–2021 a total of 273,343 wildlife strikes were recorded across 194 states and territories, with birds representing the majority of these incidents. These data highlight the importance of systematic monitoring of wildlife presence on and around aerodromes, risk assessment, and the implementation of well-organized wildlife control programs, with a particular focus on birds in order, to reduce operational risks and enhance aviation safety.

ICAO recommends the implementation of preventive measures aimed at mitigating the risk of wildlife collisions, including environmental control, removal of food sources, and elimination of habitats that may attract birds (ICAO, 2013). Additional technical guidance is provided in the Airport Services Manual (Doc 9137, Part 3), which describes in detail the methods for identifying and dispersing birds in the aerodrome environment.

Overall, Annex 14 establishes a systematic and comprehensive framework for managing the risk of bird strikes, combining monitoring, reporting, and preventive actions, and serving as the foundation for the development of national safety programs and procedures.

At the European level, the management of risks related to bird and other wildlife strikes is based on European Union regulations and the standards implemented by the European Union Aviation Safety Agency (EASA). European regulations fully adopt the principles of ICAO but complement them with more detailed operational requirements and mandatory procedures.

EU member states are required to establish national systems for recording and reporting wildlife strike incidents, to continuously collect data on the presence of animals that may endanger operational safety, and to conduct regular risk assessments prepared by professionally qualified personnel (EC, 2014).

Particular emphasis is placed on the development and maintenance of a strong safety culture, as research has shown that organizations promoting a high level of safety awareness have lower incident rates and more effective internal oversight systems (Prskalo and Šahić, 2024).

The key legal act in this area is Commission Regulation (EU) No. 139/2014 on Aerodrome Requirements, also known as part of the Easy Access Rules for Aerodromes. In addition, EASA publishes accompanying documents Acceptable Means of Compliance (AMC) and Guidance Material (GM) which provide practical guidance for demonstrating compliance with the requirements established by the Regulation.

Chronologically, the European regulatory framework has evolved in parallel with ICAO guidance, with periodic updates of the AMC and GM materials, thereby establishing a coherent system that ensures a high level of safety while maintaining flexibility in application according to local conditions and the bird species that pose threats to aviation operations.

In the United States, responsibility for managing the risk of bird strikes lies with the Federal Aviation Administration (FAA). The FAA was among the first authorities to develop a systematic approach to this issue, and its guidance documents are now used as international reference standards.

The principal document in this field is Advisory Circular (AC) 150/5200-33C-Hazardous Wildlife Attractants on or Near Airports, which defines procedures for identifying and managing sources that may attract wildlife near aerodromes. Collisions with birds and other animals represent a significant safety and economic risk, and the effectiveness of mitigation measures depends on local conditions, spatial planning, and coordinated action among the competent authorities (FAA, 2020).

Additionally, Advisory Circular (AC) 150/5200-32C - Reporting Wildlife Aircraft Strikes establishes the requirement to report all wildlife collisions, regardless of the level of damage, to the National Wildlife Strike Database, one of the most comprehensive databases of its kind. According to FAA (2020), approximately 97% of all recorded strikes involve birds, with the most frequently affected species being wild ducks, geese, gulls, and raptors. Although only a small proportion of incidents result in significant damage, the economic consequences are substantial.

Birds and other wildlife represent an important ecological and economic resource, yet they can pose a serious safety risk to aviation operations. Between 1990 and 2024, a total of 319,047 wildlife strikes were reported in the United States, with birds accounting for the majority of these incidents. Most bird strikes occur during daylight hours and in the approach phase of flight, while altitude has a significant influence on the level of risk - strikes occurring above 150 meters are more likely to cause damage. In total, 88 strikes resulted in the destruction of aircraft, and the estimated annual cost to U.S. civil aviation in 2024 amounted to USD 473 million and 74,268 aircraft downtime hours (FAA, 2024).

The international regulatory framework (ICAO, EASA, FAA) is based on the concept of SMS risk management, which requires the proactive identification and control of hazards. Similarly, the analysis of air traffic control (ATC)-related aircraft accidents has shown that human, procedural, and communication factors can have a significant impact on aviation safety, further underscoring the importance of a proactive approach to risk management, as is the case with the bird strike phenomenon (Nikšić & Öztürk, 2023).

4. Management of Bird Strike Incidents in Bosnia and Herzegovina

In Bosnia and Herzegovina, aerodromes and the competent authorities operate in accordance with the international standards of ICAO and EASA, through the implementation of the SMS framework and procedures for monitoring, reporting, and preventing safety-related occurrences. All occurrences that may endanger the safety of aircraft, passengers, or crew are classified in accordance with the guidelines of the Civil Aviation Authority of Bosnia and Herzegovina (BHDCA), which issues regulations governing the field of civil aviation in the country.

According to BHDCA (2021), all occurrences affecting flight safety are categorized based on the type of activity and the area in which they occurred. A bird strike, or collision between an aircraft and birds, may fall into several categories depending on the circumstances of the event and its consequences.

Most bird strike incidents are classified as aerodrome and ground services-related events, since the majority of collisions occur in the immediate vicinity of aerodromes, where birds find sources of food, water, and shelter.

In cases where a collision causes physical damage to the aircraft (e.g., to the engine, radar dome, fuselage, or wing leading edge), the event may also be categorized as technical conditions, maintenance, and repair-related, as such damage can affect the structural integrity or performance of the aircraft. If the incident occurs during take-off or landing, it may additionally fall under aircraft operations-related events, particularly when it has an impact on flight safety.

Minor or recurring collisions that do not cause significant consequences but indicate a potential risk can be recorded within the “other events” category, as they are considered a factor that may influence operational safety in the long term. This categorization enables more effective monitoring, reporting, and planning of preventive measures at both the aerodrome and operational levels, in line with international standards and ICAO-recommended practices.

Table 1. Classification of Aviation Incident Severity (Source: ESSAR 2)

SEVERITY	A	Serious Incident	A1	A2	A3	A4	A5
	B	Major Incident	B1	B2	B3	B4	B5
	C	Significant Incident	C1	C2	C3	C4	C5
	D	Undefined	D1	D2	D3	D4	D5
	E	No Safety Impact	E1	E2	E3	E4	E5
			1	2	3	4	5
			Very Frequent	Frequent	Occasional	Rare	Very Rare
			FREQUENCY				

Table 2. Definition of Aircraft Accident/Incident Frequency (Source: ESSAR 2)

FREQUENCY	DEFINITION
Very Rare	Never observed during the system's operational lifetime.
Rare	Only a few similar cases recorded in relation to high traffic volume, or none recorded in relation to low traffic volume.
Occasional	Several similar safety threats, accidents, or serious incidents recorded - more than once at the same location.
Frequent	A significant number of similar safety threats, accidents, or serious incidents previously recorded - repeated occurrences at the same location.
Very Frequent	A very high number of similar safety threats, accidents, or serious incidents previously recorded - very frequent repetition at the same location.

4.1. Case Studies

Bird strikes represent one of the most common safety incidents in civil aviation. Although the majority of such events do not cause direct damage or compromise flight safety, their recording and analysis are essential for risk management within the SMS. The BHDCA systematically records these events and assesses them using the ICAO risk matrix, enabling accurate classification and the development of preventive measures.

Three recorded cases are presented, focusing on different risk categories and the corresponding recommendations for preventive actions and risk management.

Case Study 1

According to BHDCA (2021), on 6 September 2021, a bird strike occurred while the aircraft was taxiing (hawk). No damage to the aircraft was reported, and flight safety was not compromised. Airport personnel notified BHDCA, inspected the runway, and found the bird intact. According to the ICAO risk matrix, the incident was classified as 3E - low probability and negligible consequences.

Recommendations:

- Continue regular monitoring of the airport area.
- Maintain the area free of food and water sources that could attract birds.
- Increase daily inspections during migration periods.
- Emphasize monitoring and staff training.

Case Study 2

According to BHDCA (2024), on 2 June 2024, an aircraft struck a bird during landing at approximately 150 knots. No damage occurred, but the incident was recorded and analysed. Category 4D indicates a rarely recurring incident with minor impact. Such incidents require trend monitoring and proactive measures as they occur relatively frequently.

Recommendations:

- Systematic implementation of bird control programs according to internal SMS procedures.
- Use active dispersal methods during vegetative periods (pyrotechnics, vehicle-mounted sirens, trained hawks).
- Include statistical monitoring and analysis of seasonal patterns (frequency by month).
- Establish a bird strike database to assess trends and the effectiveness of measures.

Case Study 3

According to BHDCA (2025), on 25 July 2025, the aircraft captain reported a possible bird strike during approach for landing. Inspection of the runway revealed a dead bird, but the aircraft sustained no damage and continued the flight. According to the ICAO risk matrix, the incident was assessed as 4E - occasional occurrence with completely negligible consequences, no impact on flight safety.

Recommendations:

- Strengthen dispersal measures during critical flight phases (approach and landing).

- Introduce laser devices as a modern and environmentally friendly bird deterrent.
- Regularly inspect vegetation and surfaces that may attract birds.
- Implement mandatory daily reporting on wildlife presence at the airport.

Expert Critical Review

The bird strike reporting and analysis system in Bosnia and Herzegovina operates in accordance with ICAO standards and national regulations. Categories 3E, 4D, and 4E indicate low-risk levels, yet their occurrence requires continuous active management. Analysis of the presented bird strike incidents in Bosnia and Herzegovina demonstrates that, although they are low-risk events, systematic monitoring and assessment of these incidents are key elements within an effective SMS.

The different risk categories reflect variability in the probability of occurrence and potential consequences, highlighting the need for a tailored approach in planning preventive measures. Observed incident frequency during approach and landing phases indicates critical points in airport operations that require enhanced monitoring and timely preventive interventions.

A strategic approach combining technical, biological, and educational measures, together with the establishment of a database and systematic trend analyses, enables not only the reduction of incident frequency but also the enhancement of airport operational resilience.

In conclusion, these examples confirm that active risk management provides an effective framework for maintaining flight safety and continuously developing a safety culture in Bosnia and Herzegovina.

5. Statistical Data Analysis

The analysis of bird strike incidents in Bosnia and Herzegovina was conducted based on available reports from the Bosnia and Herzegovina Air Navigation Services Agency (BHANSA) for the period 2017–2024.

The aim of the statistical processing is to quantitatively present the frequency and characteristics of bird strike incidents in the airspace of Bosnia and Herzegovina, identify spatial and seasonal patterns, and determine the flight phases and bird species most frequently involved in these incidents that affect aviation safety.

5.1. Descriptive Analysis

During the analyzed period, a total of 84 bird strike events were recorded at four international airports in Bosnia and Herzegovina (Sarajevo, Banja Luka, Tuzla, and Mostar). The highest number of incidents occurred at Sarajevo and Banja Luka airports, which corresponds to their traffic volume and local ecological conditions that favor the presence of birds. The lowest number of events was

reported in 2020 (four incidents), likely due to the reduced air traffic intensity during the COVID-19 pandemic, while the highest number was recorded in 2023 (21 incidents). Observing the overall trend, a gradual increase in reported incidents has been evident since 2021, which may be attributed both to the growth in flight operations and to improvements in the reporting and monitoring system within the SMS.

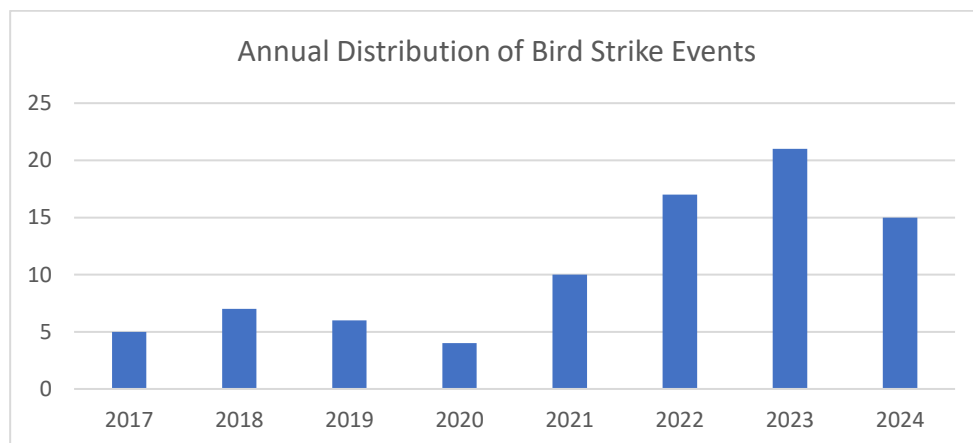


Figure 1. Annual Distribution of Bird Strike Events (2017–2024) (Source: BHANSA)

The analysis by airport shows that the highest number of incidents occurred at Sarajevo (35) and Banja Luka (34) airports, while Tuzla (10) and Mostar (6) recorded significantly fewer cases (Figure 2).

This distribution corresponds to the volume of air traffic - airports with a higher number of operations generally have a greater likelihood of bird strike occurrences.

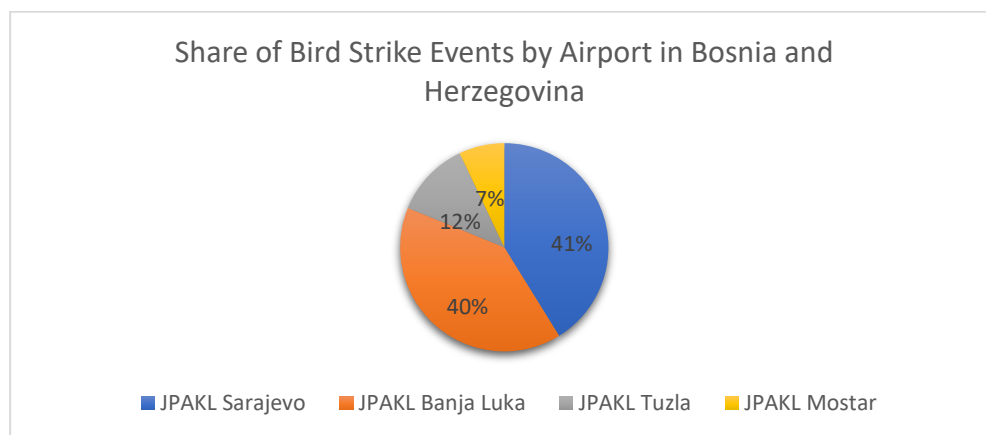


Figure 2. Share of Bird Strike Events by Airport in Bosnia and Herzegovina (2017–2024) (Source: BHANSA)

Distribution by Flight Phase

The analysis shows that bird strike events most frequently occur during the critical phases of flight - take-off (27.4%) and landing (27.4%) - while 10.7% were recorded during taxiing and deceleration phases. In 34.5% of cases, the flight phase was not clearly indicated in the reports, highlighting the need for a more consistent description of circumstances when reporting such events.

This distribution is fully consistent with international data (ICAO, 2018; FAA, 2024), according to which most bird strike incidents occur at low altitudes, during take-off and landing operations, when the likelihood of bird encounters is highest. A similar pattern has been observed for other categories of safety events and aviation accidents, where the majority of incidents also occur during these critical flight phases - take-off and landing (Nikšić & Öztürk, 2022).

Distribution by Bird Species

In the largest number of (67.9%), the bird species was not specified in the reports. Of the known cases, 22.6% are reported as “unknown bird”, while in a smaller number, specific species were recorded: sparrow (3%), hawk (3%), eagle (3%), and 2% each for magpie and owl. Such a structure indicates that, although the majority of incidents do not involve severe consequences, there is a need for a more systematic identification of birds and collaboration with ornithologists, which would contribute to a better assessment of risk and planning of preventive measures. Recent research shows that the integration of DNA barcoding and field surveys enables a more precise identification of bird species that most frequently cause collisions with aircraft, which can improve preventive measures and reduce the risk of incidents (Chen et al., 2025). Additionally, the assessment of relative risk and seasonal differences between bird species can assist in the prioritized focusing of habitat management measures and airport operations, particularly during migration periods when the risk of collisions is highest (Ross et al., 2025).

Seasonal and Spatial Patterns

Analysis of dates shows a pronounced seasonal variation; the majority of events occur during spring and summer (May–August), periods of increased bird activity and raptor migrations. Such a seasonal pattern is consistent with expectations, as warmer months are associated with increased bird movements as well as higher air traffic intensity (Kelly, 2024; Tal et al., 2024).

Spatial distribution indicates that Sarajevo and Banja Luka are the main centres for these incidents, which is related both to higher traffic volume and environmental factors that favour bird presence in the airport vicinity.

Although Sarajevo experiences a significantly higher number of flight operations, the number of bird strike events in Banja Luka is almost equal, which may point to several possible causes:

- a) more favourable spatial and ecological conditions for bird presence (e.g., proximity to forests and agricultural areas),
- b) the location of the airport within a potential migratory corridor, or
- c) the need for potential improvement of existing bird control and dispersal measures implemented at Banja Luka Airport.

These observations indicate the need for a more detailed analysis of local biotic and spatial-ecological factors, as well as for periodic evaluation of the effectiveness of existing wildlife management programs at airports in Bosnia and Herzegovina.

5.2. Trend Analysis

Analysis of the temporal progression of the number of bird strike events in the period 2017–2024 allows insight into the dynamics of incident occurrence over a longer time horizon.

In the first part of the observed period (2017–2020), a relatively low and stable number of events is recorded, whereas after 2021 there is a significant increase in reports, indicating a change in the frequency of these incidents.

Such an increase may result from the combined influence of the growth in air traffic volume following the pandemic period, improvements in the event recording system, as well as changes in ecological conditions that affect the presence of birds in the vicinity of airports.

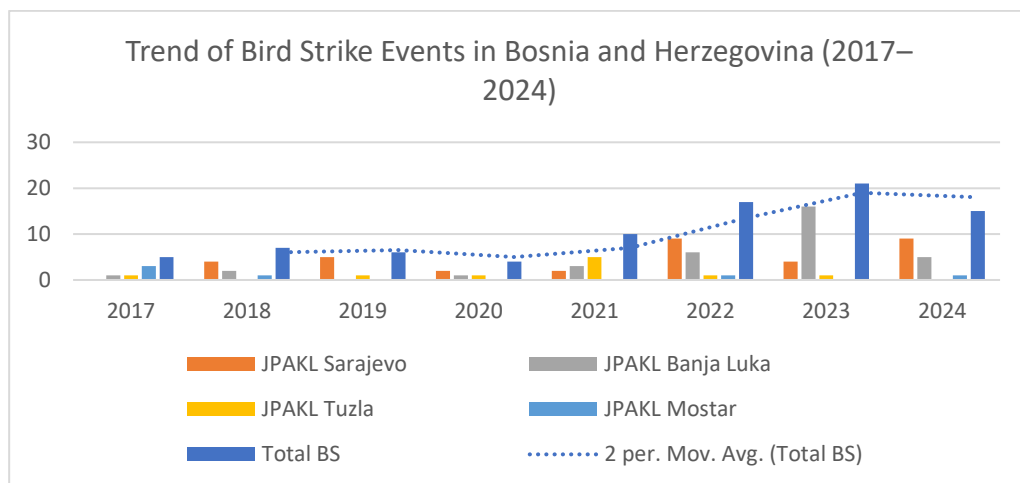


Figure 3. Trend of Bird Strike Events in Bosnia and Herzegovina (2017–2024) (Source: BHANSA)

The results presented in Figure 3 show that the number of bird strike events in Bosnia and Herzegovina continuously increased after 2021, with the highest values recorded during 2022 and 2023.

The application of a two-year moving average clearly confirms the upward trend, indicating the need for continuous monitoring and risk evaluation.

Comparison among airports shows that Sarajevo and Banja Luka lead in the number of recorded events, whereas Tuzla and Mostar airports record a smaller number of incidents. Interestingly, however, Banja Luka, despite a significantly lower volume of air traffic, records almost the same number of incidents as Sarajevo. Such a pattern may suggest that the area surrounding Banja Luka Airport is spatially more favourable for bird presence, that it is located within a migratory corridor, or that wildlife control measures are not as effective as at other airports. On the other hand, Tuzla and Mostar airports record fewer events, which may be associated with a smaller number of flights, as well as local ecological conditions that are less favourable for bird concentration.

Expert Critical Review

The conducted analysis shows that bird strike events in the airspace of Bosnia and Herzegovina are generally of low risk, but their frequency demonstrates an upward trend over the past several years. This trend does not necessarily indicate a deterioration of safety conditions, but may reflect improved record-keeping and awareness of the importance of reporting incidents within the framework of the SMS.

On the other hand, the disproportion between the volume of air traffic and the number of bird strike events, particularly in the case of Banja Luka Airport, requires additional attention. Such a phenomenon may point to specific local ecological factors, the presence of birds along migratory corridors, or insufficient effectiveness of existing wildlife control measures. It is advisable that a more detailed risk assessment be conducted at airports in the forthcoming period, with an emphasis on spatial and seasonal variations, in order to determine the actual causes of the increased frequency of events.

Furthermore, the high proportion of cases in which the bird species is not identified (almost 68%) limits the possibility of precise risk assessment and planning of targeted measures. This highlights the need for standardization of the bird strike reporting form and strengthening cooperation with ornithological experts to improve species identification and understanding of their migratory habits.

Finally, although the analysed events in most cases did not result in serious consequences for flight safety, the fact that the highest number of incidents occurs during take-off and landing phases indicates a continued exposure of critical flight stages to increased risk. Therefore, it is important that airports in Bosnia and

Herzegovina continue with continuous monitoring, evaluation of effectiveness, and improvement of wildlife management measures, in accordance with international guidelines (ICAO Annex 14, Doc 9137 – Airport Services Manual, Part 3).

The obtained results provide a basis for formulating conclusions and recommendations aimed at enhancing air traffic safety and more effective management of the risk of aircraft-bird collisions.

6. Conclusion

The analysis of bird strike events in the airspace of Bosnia and Herzegovina has shown that, although the majority of incidents are classified as low risk, their frequency demonstrates an upward trend over the past several years. This increase may reflect the combined influence of a growing number of flight operations, changes in bird migration patterns, and improvements in the incident reporting system.

The highest number of events was recorded at Sarajevo and Banja Luka airports. Although Sarajevo experiences significantly higher traffic, Banja Luka records almost the same frequency of bird strike incidents, which may indicate local ecological factors, proximity to areas favourable for bird congregation, or differences in the implementation of wildlife control measures. Analysis by flight phases shows that the riskiest stages are take-off and landing, which is consistent with global trends. A higher number of cases during the warmer part of the year confirms the seasonal variation associated with bird activity and migration. However, a significant proportion of reports with unidentified bird species highlights the need for improved record-keeping and cooperation with ornithological experts.

Further advancement in the management of bird strike risk requires a systemic approach: data integration, standardization of reporting, airport-specific risk assessment, and continuous evaluation of the effectiveness of wildlife management measures. Particular attention should be given to the development of integrated strategies that combine technical, biological, and educational measures.

In conclusion, bird strike events, although in most cases not representing a high safety risk, remain a relevant factor requiring continuous analytical attention and coordinated action by all actors within the aviation safety system of Bosnia and Herzegovina.

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