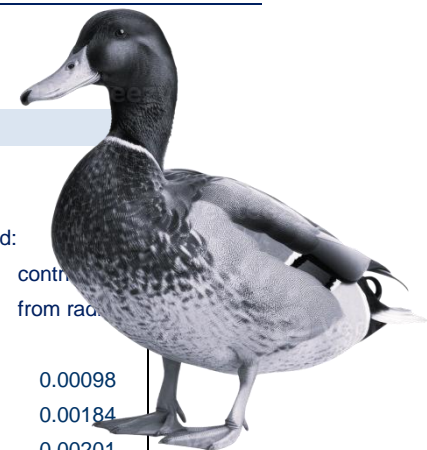


CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Зеленоглава патица/ *Anas platyrhynchos*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.58	m
Wingspan	0.89	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	22	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.65	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	6.1E-2	2.7E-2	4.4E-2	7.6E-4	3.4E-4	5.5E-4
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

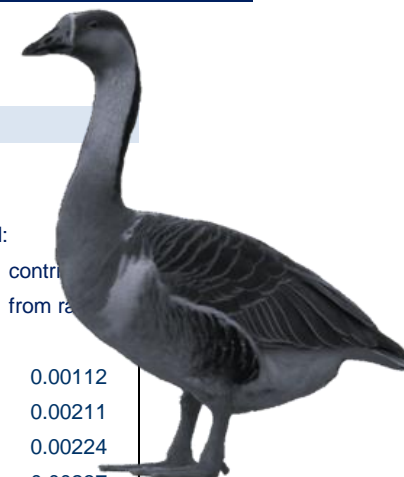
r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	7.63	29.58	0.82	0.00103	28.04	0.78	0.00098
0.075	0.575	2.54	10.38	0.29	0.00217	8.83	0.25	0.00184
0.125	0.702	1.53	7.67	0.21	0.00267	5.79	0.16	0.00201
0.175	0.860	1.09	6.83	0.19	0.00333	4.52	0.13	0.00220
0.225	0.994	0.85	6.32	0.18	0.00396	3.65	0.10	0.00228
0.275	0.947	0.69	5.19	0.14	0.00397	2.64	0.07	0.00202
0.325	0.899	0.59	4.44	0.12	0.00401	2.02	0.06	0.00183
0.375	0.851	0.51	3.90	0.11	0.00407	1.61	0.04	0.00168
0.425	0.804	0.45	3.47	0.10	0.00411	1.31	0.04	0.00155
0.475	0.756	0.40	3.12	0.09	0.00413	1.09	0.03	0.00144
0.525	0.708	0.36	2.82	0.08	0.00413	0.92	0.03	0.00134
0.575	0.660	0.33	2.57	0.07	0.00411	0.79	0.02	0.00127
0.625	0.613	0.31	2.34	0.07	0.00408	0.69	0.02	0.00121
0.675	0.565	0.28	2.14	0.06	0.00402	0.62	0.02	0.00117
0.725	0.517	0.26	1.96	0.05	0.00395	0.59	0.02	0.00120
0.775	0.470	0.25	1.79	0.05	0.00387	0.63	0.02	0.00136
0.825	0.422	0.23	1.64	0.05	0.00376	0.66	0.02	0.00151
0.825	0.422	0.23	1.49	0.04	0.00364	0.67	0.02	0.00164
0.925	0.327	0.21	1.36	0.04	0.00349	0.68	0.02	0.00175
0.975	0.279	0.20	1.23	0.03	0.00334	0.68	0.02	0.00185

Overall p(collision) =	Upwind	7.2%	Downwind	3.2%
	Average	5.2%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Голяма белочела гъска / *Anser albifrons*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.72	m
Wingspan	1.47	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	17.8	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.49	

Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	1.6E-3	7.6E-4	1.2E-3	2.0E-5	9.6E-6	1.5E-5
Cavoid – collision with avoidance						
Af – avoidance rate 99.8%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

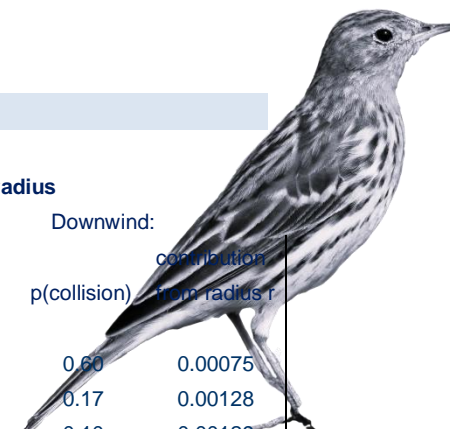
r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	6.17	27.66	0.95	0.00119	26.11	0.90	0.00112
0.075	0.575	2.06	9.74	0.33	0.00251	8.19	0.28	0.00211
0.125	0.702	1.23	7.11	0.24	0.00306	5.22	0.18	0.00224
0.175	0.860	0.88	6.26	0.22	0.00377	3.95	0.14	0.00237
0.225	0.994	0.69	5.77	0.20	0.00447	3.09	0.11	0.00239
0.275	0.947	0.56	4.77	0.16	0.00451	2.22	0.08	0.00210
0.325	0.899	0.47	4.07	0.14	0.00455	1.65	0.06	0.00185
0.375	0.851	0.41	3.62	0.12	0.00467	1.33	0.05	0.00172
0.425	0.804	0.36	3.27	0.11	0.00477	1.10	0.04	0.00161
0.475	0.756	0.32	2.97	0.10	0.00485	0.94	0.03	0.00153
0.525	0.708	0.29	2.72	0.09	0.00491	0.81	0.03	0.00147
0.575	0.660	0.27	2.50	0.09	0.00494	0.72	0.02	0.00143
0.625	0.613	0.25	2.30	0.08	0.00495	0.79	0.03	0.00169
0.675	0.565	0.23	2.13	0.07	0.00494	0.83	0.03	0.00193
0.725	0.517	0.21	1.97	0.07	0.00491	0.86	0.03	0.00215
0.775	0.470	0.20	1.82	0.06	0.00486	0.88	0.03	0.00235
0.825	0.422	0.19	1.68	0.06	0.00478	0.89	0.03	0.00253
0.875	0.374	0.18	1.56	0.05	0.00468	0.89	0.03	0.00269
0.925	0.327	0.17	1.43	0.05	0.00456	0.89	0.03	0.00282
0.975	0.279	0.16	1.32	0.05	0.00442	0.87	0.03	0.00293

Overall p(collision) =	Upwind	8.6%	Downwind	4.1%
	Average	6.4%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Червеногуша бърбица / *Anthus cervinus*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.15	m
Wingspan	0.17	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	10.5	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.88	
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Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	1.4E-3	5.2E-4	9.9E-4	1.8E-5	6.5E-6	1.2E-5
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.64	11.90	0.69	0.00087	10.36	0.60	0.00075
0.075	0.575	1.21	4.48	0.26	0.00196	2.94	0.17	0.00128
0.125	0.702	0.73	3.66	0.21	0.00267	1.77	0.10	0.00129
0.175	0.860	0.52	3.55	0.21	0.00363	1.24	0.07	0.00126
0.225	0.994	0.40	3.51	0.20	0.00460	0.83	0.05	0.00109
0.275	0.947	0.33	3.00	0.17	0.00481	0.45	0.03	0.00072
0.325	0.899	0.28	2.62	0.15	0.00497	0.20	0.01	0.00039
0.375	0.851	0.24	2.33	0.14	0.00510	0.26	0.02	0.00056
0.425	0.804	0.21	2.10	0.12	0.00519	0.37	0.02	0.00091
0.475	0.756	0.19	1.89	0.11	0.00525	0.44	0.03	0.00122
0.525	0.708	0.17	1.72	0.10	0.00526	0.49	0.03	0.00149
0.575	0.660	0.16	1.56	0.09	0.00524	0.51	0.03	0.00172
0.625	0.613	0.15	1.42	0.08	0.00518	0.53	0.03	0.00192
0.675	0.565	0.13	1.29	0.08	0.00509	0.53	0.03	0.00208
0.725	0.517	0.13	1.17	0.07	0.00496	0.52	0.03	0.00220
0.775	0.517	0.13	1.17	0.07	0.00496	0.52	0.03	0.00220
0.825	0.470	0.12	1.06	0.06	0.00479	0.51	0.03	0.00228
0.875	0.422	0.11	0.95	0.06	0.00458	0.48	0.03	0.00233
0.925	0.374	0.10	0.85	0.05	0.00433	0.46	0.03	0.00234
0.975	0.327	0.10	0.75	0.04	0.00405	0.43	0.02	0.00231
1.000	0.279	0.09	0.66	0.04	0.00373	0.39	0.02	0.00224
Overall p(collision) =			Upwind			Downwind		
			8.6%			3.0%		
			Average			5.8%		

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Царски орел / *Aquila heliaca*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.78	m
Wingspan	1.97	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	13.1	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.40	
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Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	3.6E-3	1.8E-3	2.7E-3	4.5E-5	2.3E-5	3.4E-5
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius
0.025	0.575	4.54	19.58	0.92	0.00114	18.03	0.84	0.00105
0.075	0.575	1.51	7.04	0.33	0.00247	5.50	0.26	0.00193
0.125	0.702	0.91	5.28	0.25	0.00309	3.39	0.16	0.00198
0.175	0.860	0.65	4.77	0.22	0.00390	2.46	0.11	0.00201
0.225	0.994	0.50	4.49	0.21	0.00472	1.81	0.08	0.00191
0.275	0.947	0.41	3.75	0.18	0.00483	1.21	0.06	0.00155
0.325	0.899	0.35	3.57	0.17	0.00542	1.15	0.05	0.00174
0.375	0.851	0.30	3.22	0.15	0.00564	0.93	0.04	0.00163
0.425	0.804	0.27	2.94	0.14	0.00584	0.78	0.04	0.00156
0.475	0.756	0.24	2.70	0.13	0.00600	0.89	0.04	0.00198
0.525	0.708	0.22	2.50	0.12	0.00614	0.96	0.05	0.00237
0.575	0.660	0.20	2.32	0.11	0.00624	1.01	0.05	0.00272
0.625	0.613	0.18	2.16	0.10	0.00632	1.05	0.05	0.00305
0.675	0.565	0.17	2.02	0.09	0.00637	1.06	0.05	0.00335
0.725	0.517	0.16	1.88	0.09	0.00638	1.07	0.05	0.00362
0.775	0.470	0.15	1.76	0.08	0.00637	1.07	0.05	0.00386
0.825	0.422	0.14	1.64	0.08	0.00632	1.06	0.05	0.00407
0.875	0.374	0.13	1.53	0.07	0.00625	1.04	0.05	0.00425
0.925	0.327	0.12	1.42	0.07	0.00614	1.02	0.05	0.00440
0.975	0.279	0.12	1.32	0.06	0.00601	0.99	0.05	0.00452

Overall p(collision) =	Upwind	10.6%	Downwind	5.4%
	Average	8.0%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Сива чапла / *Ardea cinerea*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	1.02	m
Wingspan	1.75	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	11.2	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

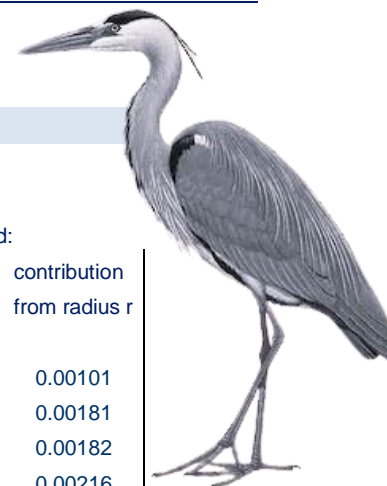
Bird aspect ratio: β	0.58	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	4.0E-2	2.3E-2	3.2E-2	5.0E-4	2.9E-4	3.9E-4
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.88	16.31	0.89	0.00111	14.76	0.81	0.00101
0.075	0.575	1.29	5.95	0.33	0.00244	4.40	0.24	0.00181
0.125	0.702	0.78	4.54	0.25	0.00311	2.66	0.15	0.00182
0.175	0.860	0.55	4.57	0.25	0.00438	2.26	0.12	0.00216
0.225	0.994	0.43	4.51	0.25	0.00555	1.84	0.10	0.00226
0.275	0.947	0.35	3.97	0.22	0.00597	1.42	0.08	0.00214
0.325	0.899	0.30	3.58	0.20	0.00636	1.16	0.06	0.00206
0.375	0.851	0.26	3.27	0.18	0.00671	1.06	0.06	0.00217
0.425	0.804	0.23	3.02	0.17	0.00702	1.18	0.06	0.00274
0.475	0.756	0.20	2.81	0.15	0.00730	1.26	0.07	0.00328
0.525	0.708	0.18	2.63	0.14	0.00755	1.32	0.07	0.00378
0.575	0.660	0.17	2.47	0.13	0.00776	1.35	0.07	0.00424
0.625	0.613	0.16	2.32	0.13	0.00794	1.37	0.07	0.00467
0.675	0.565	0.14	2.19	0.12	0.00808	1.37	0.08	0.00506
0.725	0.517	0.13	2.06	0.11	0.00818	1.37	0.07	0.00542
0.775	0.470	0.13	1.95	0.11	0.00825	1.36	0.07	0.00575
0.825	0.422	0.12	1.84	0.10	0.00829	1.34	0.07	0.00604
0.875	0.374	0.11	1.73	0.09	0.00829	1.32	0.07	0.00629
0.925	0.327	0.10	1.63	0.09	0.00825	1.29	0.07	0.00651
0.975	0.279	0.10	1.53	0.08	0.00818	1.26	0.07	0.00669

Overall p(collision) =	Upwind	13.1%	Downwind	7.6%
	Average	10.3%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Обикновен мишелов / Buteo buteo



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.55	m
Wingspan	1.25	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	11	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.44	
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Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	5.05	2.44	3.74	6.3E-2	3.0E-2	4.7E-2
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

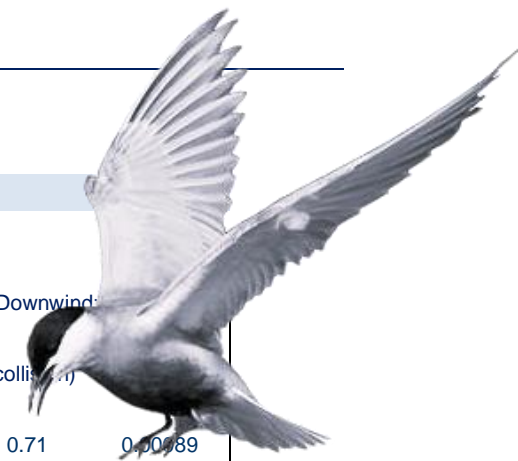
r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.81	14.82	0.82	0.00103	13.27	0.74	0.0005
0.075	0.575	1.27	5.46	0.30	0.00228	3.91	0.22	0.00163
0.125	0.702	0.76	4.24	0.24	0.00295	2.35	0.13	0.00163
0.175	0.860	0.54	3.94	0.22	0.00384	1.63	0.09	0.00159
0.225	0.994	0.42	4.00	0.22	0.00501	1.33	0.07	0.00166
0.275	0.947	0.35	3.47	0.19	0.00531	0.92	0.05	0.00141
0.325	0.899	0.29	3.08	0.17	0.00558	0.66	0.04	0.00120
0.375	0.851	0.25	2.78	0.15	0.00581	0.61	0.03	0.00127
0.425	0.804	0.22	2.54	0.14	0.00600	0.73	0.04	0.00172
0.475	0.756	0.20	2.33	0.13	0.00616	0.81	0.04	0.00213
0.525	0.708	0.18	2.15	0.12	0.00628	0.86	0.05	0.00251
0.575	0.660	0.17	1.99	0.11	0.00636	0.89	0.05	0.00285
0.625	0.613	0.15	1.84	0.10	0.00641	0.91	0.05	0.00315
0.675	0.565	0.14	1.71	0.10	0.00643	0.91	0.05	0.00342
0.725	0.517	0.13	1.59	0.09	0.00641	0.90	0.05	0.00365
0.775	0.470	0.12	1.47	0.08	0.00635	0.89	0.05	0.00385
0.825	0.422	0.12	1.36	0.08	0.00626	0.87	0.05	0.00401
0.875	0.374	0.11	1.26	0.07	0.00613	0.85	0.05	0.00413
0.925	0.327	0.10	1.16	0.06	0.00596	0.82	0.05	0.00422
0.975	0.279	0.10	1.06	0.06	0.00576	0.79	0.04	0.00428

Overall p(collision) =	Upwind	10.6%	Downwind	5.1%
	Average	7.9%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Белобуза рибарка / *Chlidonias hybridus*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.26	m
Wingspan	0.65	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	12.3	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.40	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	1.0E-2	3.8E-3	6.9E-3	1.3E-4	4.7E-5	8.6E-5
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	
0.025	0.575	4.26	15.86	0.79	0.00099	14.31	0.71	0.00089
0.075	0.575	1.42	5.80	0.29	0.00217	4.25	0.21	0.00159
0.125	0.702	0.85	4.50	0.22	0.00280	2.61	0.13	0.00163
0.175	0.860	0.61	4.18	0.21	0.00365	1.87	0.09	0.00163
0.225	0.994	0.47	4.01	0.20	0.00449	1.34	0.07	0.00150
0.275	0.947	0.39	3.38	0.17	0.00462	0.83	0.04	0.00113
0.325	0.899	0.33	2.95	0.15	0.00477	0.53	0.03	0.00086
0.375	0.851	0.28	2.62	0.13	0.00489	0.33	0.02	0.00062
0.425	0.804	0.25	2.35	0.12	0.00498	0.33	0.02	0.00070
0.475	0.756	0.22	2.13	0.11	0.00503	0.43	0.02	0.00101
0.525	0.708	0.20	1.94	0.10	0.00506	0.49	0.02	0.00128
0.575	0.660	0.19	1.76	0.09	0.00505	0.53	0.03	0.00153
0.625	0.613	0.17	1.61	0.08	0.00501	0.56	0.03	0.00174
0.675	0.565	0.16	1.47	0.07	0.00493	0.57	0.03	0.00192
0.725	0.517	0.15	1.34	0.07	0.00483	0.57	0.03	0.00207
0.775	0.470	0.14	1.22	0.06	0.00469	0.57	0.03	0.00219
0.825	0.422	0.13	1.10	0.05	0.00452	0.55	0.03	0.00228
0.875	0.374	0.12	0.99	0.05	0.00432	0.53	0.03	0.00233
0.925	0.327	0.12	0.89	0.04	0.00409	0.51	0.03	0.00235
0.975	0.279	0.11	0.79	0.04	0.00383	0.48	0.02	0.00234

Overall p(collision) =	Upwind	8.5%	Downwind	3.2%
	Average	5.8%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Бял щъркел / *Ciconia ciconia*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	1.15	m
Wingspan	2.05	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	12.5	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

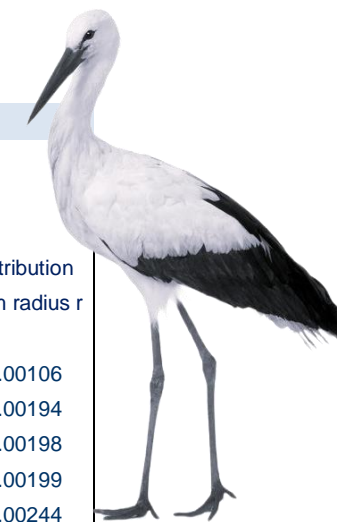
Bird aspect ratio: β	0.56	

Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	25.7	15.0	20.4	3.2E-1	1.9E-1	2.5E-1
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.33	18.94	0.93	0.00116	17.39	0.85	0.00106
0.075	0.575	1.44	6.83	0.33	0.00251	5.28	0.26	0.00194
0.125	0.702	0.87	5.13	0.25	0.00314	3.24	0.16	0.00198
0.175	0.860	0.62	4.64	0.23	0.00398	2.32	0.11	0.00199
0.225	0.994	0.48	4.89	0.24	0.00539	2.22	0.11	0.00244
0.275	0.947	0.39	4.30	0.21	0.00579	1.75	0.09	0.00236
0.325	0.899	0.33	3.86	0.19	0.00615	1.44	0.07	0.00230
0.375	0.851	0.29	3.53	0.17	0.00648	1.24	0.06	0.00228
0.425	0.804	0.25	3.26	0.16	0.00679	1.20	0.06	0.00250
0.475	0.756	0.23	3.03	0.15	0.00706	1.30	0.06	0.00303
0.525	0.708	0.21	2.84	0.14	0.00729	1.37	0.07	0.00352
0.575	0.660	0.19	2.66	0.13	0.00750	1.41	0.07	0.00398
0.625	0.613	0.17	2.51	0.12	0.00768	1.44	0.07	0.00441
0.675	0.565	0.16	2.37	0.12	0.00782	1.46	0.07	0.00481
0.725	0.517	0.15	2.23	0.11	0.00793	1.46	0.07	0.00518
0.775	0.470	0.14	2.11	0.10	0.00802	1.45	0.07	0.00551
0.825	0.422	0.13	2.00	0.10	0.00807	1.44	0.07	0.00582
0.875	0.374	0.12	1.89	0.09	0.00808	1.42	0.07	0.00609
0.925	0.327	0.12	1.78	0.09	0.00807	1.40	0.07	0.00633
0.975	0.279	0.11	1.68	0.08	0.00803	1.37	0.07	0.00654

Overall p(collision) =	Upwind	12.7%	Downwind	7.4%
	Average	10.1%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Черен щъркел / *Ciconia nigra*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.96	m
Wingspan	1.49	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	12.5	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.64	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	1.6E-1	8.9E-2	1.3E-1	2.0E-3	1.1E-3	1.6E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.33	17.40	0.85	0.00107	15.85	0.78	0.0009
0.075	0.575	1.44	6.31	0.31	0.00232	4.77	0.23	0.00175
0.125	0.702	0.87	4.82	0.24	0.00295	2.93	0.14	0.00179
0.175	0.860	0.62	4.79	0.23	0.00411	2.48	0.12	0.00212
0.225	0.994	0.48	4.70	0.23	0.00518	2.03	0.10	0.00223
0.275	0.947	0.39	4.11	0.20	0.00553	1.56	0.08	0.00210
0.325	0.899	0.33	3.67	0.18	0.00585	1.25	0.06	0.00200
0.375	0.851	0.29	3.34	0.16	0.00614	1.05	0.05	0.00193
0.425	0.804	0.25	3.07	0.15	0.00639	1.01	0.05	0.00211
0.475	0.756	0.23	2.84	0.14	0.00661	1.11	0.05	0.00259
0.525	0.708	0.21	2.65	0.13	0.00681	1.18	0.06	0.00303
0.575	0.660	0.19	2.47	0.12	0.00697	1.22	0.06	0.00345
0.625	0.613	0.17	2.32	0.11	0.00710	1.25	0.06	0.00383
0.675	0.565	0.16	2.18	0.11	0.00719	1.27	0.06	0.00418
0.725	0.517	0.15	2.04	0.10	0.00726	1.27	0.06	0.00450
0.775	0.470	0.14	1.92	0.09	0.00729	1.26	0.06	0.00479
0.825	0.422	0.13	1.81	0.09	0.00730	1.25	0.06	0.00505
0.875	0.374	0.12	1.70	0.08	0.00727	1.23	0.06	0.00528
0.925	0.327	0.12	1.59	0.08	0.00721	1.21	0.06	0.00547
0.975	0.279	0.11	1.49	0.07	0.00712	1.18	0.06	0.00563

Overall p(collision) =	Upwind	11.8%	Downwind	6.5%
	Average	9.1%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Орел змия / *Circaetus gallicus*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.64	m
Wingspan	1.8	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	13.4	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.36	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	1.2E-1	5.9E-2	9.2E-2	1.6E-3	7.3E-4	1.1E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.64	19.51	0.89	0.00111	17.96	0.82	0.00111
0.075	0.575	1.55	7.02	0.32	0.00241	5.47	0.25	0.00187
0.125	0.702	0.93	5.28	0.24	0.00302	3.39	0.16	0.00194
0.175	0.860	0.66	4.78	0.22	0.00383	2.47	0.11	0.00197
0.225	0.994	0.52	4.51	0.21	0.00463	1.83	0.08	0.00188
0.275	0.947	0.42	3.77	0.17	0.00473	1.22	0.06	0.00153
0.325	0.899	0.36	3.23	0.15	0.00480	0.81	0.04	0.00121
0.375	0.851	0.31	3.11	0.14	0.00533	0.82	0.04	0.00140
0.425	0.804	0.27	2.82	0.13	0.00548	0.66	0.03	0.00128
0.475	0.756	0.24	2.59	0.12	0.00561	0.73	0.03	0.00158
0.525	0.708	0.22	2.38	0.11	0.00571	0.81	0.04	0.00193
0.575	0.660	0.20	2.20	0.10	0.00578	0.86	0.04	0.00226
0.625	0.613	0.19	2.04	0.09	0.00582	0.89	0.04	0.00255
0.675	0.565	0.17	1.89	0.09	0.00582	0.91	0.04	0.00281
0.725	0.517	0.16	1.75	0.08	0.00581	0.92	0.04	0.00305
0.775	0.470	0.15	1.63	0.07	0.00576	0.92	0.04	0.00325
0.825	0.422	0.14	1.51	0.07	0.00568	0.91	0.04	0.00343
0.875	0.374	0.13	1.39	0.06	0.00557	0.89	0.04	0.00358
0.925	0.327	0.13	1.29	0.06	0.00543	0.87	0.04	0.00369
0.975	0.279	0.12	1.18	0.05	0.00527	0.85	0.04	0.00378

Overall p(collision) =	Upwind	9.8%	Downwind	4.6%
	Average	7.2%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Тръстиков блатар / *Circus aeruginosus*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.52	m
Wingspan	1.22	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	11.6	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.43	
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Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	6.1E-1	2.8E-2	4.4E-2	7.6E-3	3.5E-4	5.6E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.02	15.51	0.82	0.00102	13.96	0.74	0.00092
0.075	0.575	1.34	5.69	0.30	0.00225	4.14	0.22	0.00164
0.125	0.702	0.80	4.40	0.23	0.00290	2.51	0.13	0.00166
0.175	0.860	0.57	4.09	0.22	0.00377	1.77	0.09	0.00163
0.225	0.994	0.45	3.92	0.21	0.00465	1.24	0.07	0.00147
0.275	0.947	0.37	3.53	0.19	0.00513	0.98	0.05	0.00143
0.325	0.899	0.31	3.13	0.17	0.00536	0.71	0.04	0.00121
0.375	0.851	0.27	2.81	0.15	0.00557	0.52	0.03	0.00103
0.425	0.804	0.24	2.56	0.13	0.00573	0.65	0.03	0.00145
0.475	0.756	0.21	2.34	0.12	0.00587	0.73	0.04	0.00184
0.525	0.708	0.19	2.15	0.11	0.00597	0.79	0.04	0.00219
0.575	0.660	0.17	1.99	0.10	0.00604	0.83	0.04	0.00252
0.625	0.613	0.16	1.84	0.10	0.00607	0.85	0.04	0.00280
0.675	0.565	0.15	1.70	0.09	0.00607	0.86	0.05	0.00306
0.725	0.517	0.14	1.58	0.08	0.00603	0.86	0.05	0.00328
0.775	0.470	0.13	1.46	0.08	0.00596	0.85	0.04	0.00346
0.825	0.422	0.12	1.35	0.07	0.00586	0.83	0.04	0.00361
0.875	0.374	0.11	1.24	0.07	0.00572	0.81	0.04	0.00373
0.925	0.327	0.11	1.14	0.06	0.00555	0.78	0.04	0.00381
0.975	0.279	0.10	1.04	0.05	0.00535	0.75	0.04	0.00386

Overall p(collision) =	Upwind	10.1%	Downwind	4.7%
	Average	7.4%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Полски блатар / *Circus cyaneus*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.48	m
Wingspan	1.1	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	11.4	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.44	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	5.3E-2	2.4E-2	3.9E-2	6.7E-4	3.0E-4	4.9E-4
Cavoid – collision with avoidance						
Af – avoidance rate 99%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.95	14.95	0.80	0.00100	13.40	0.72	0.00090
0.075	0.575	1.32	5.50	0.30	0.00222	3.95	0.21	0.00159
0.125	0.702	0.79	4.28	0.23	0.00287	2.39	0.13	0.00161
0.175	0.860	0.56	3.99	0.21	0.00375	1.68	0.09	0.00158
0.225	0.994	0.44	3.84	0.21	0.00464	1.16	0.06	0.00140
0.275	0.947	0.36	3.46	0.19	0.00511	0.91	0.05	0.00135
0.325	0.899	0.30	3.06	0.16	0.00534	0.64	0.03	0.00112
0.375	0.851	0.26	2.75	0.15	0.00554	0.50	0.03	0.00101
0.425	0.804	0.23	2.50	0.13	0.00571	0.62	0.03	0.00142
0.475	0.756	0.21	2.29	0.12	0.00583	0.71	0.04	0.00181
0.525	0.708	0.19	2.10	0.11	0.00593	0.76	0.04	0.00215
0.575	0.660	0.17	1.94	0.10	0.00599	0.80	0.04	0.00247
0.625	0.613	0.16	1.79	0.10	0.00601	0.82	0.04	0.00275
0.675	0.565	0.15	1.66	0.09	0.00600	0.83	0.04	0.00299
0.725	0.517	0.14	1.53	0.08	0.00596	0.82	0.04	0.00320
0.775	0.470	0.13	1.41	0.08	0.00588	0.81	0.04	0.00338
0.825	0.422	0.12	1.30	0.07	0.00577	0.79	0.04	0.00352
0.875	0.374	0.11	1.20	0.06	0.00562	0.77	0.04	0.00363
0.925	0.327	0.11	1.09	0.06	0.00544	0.74	0.04	0.00370
0.975	0.279	0.10	1.00	0.05	0.00522	0.71	0.04	0.00374

Overall p(collision) =	Upwind	10.0%	Downwind	4.5%
	Average	7.3%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Гарван / Corvus corax

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.7	m
Wingspan	1.3	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	11.3	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.54	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	1.5E-1	7.6E-2	1.1E-1	1.9E-3	9.5E-4	1.4E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.92	15.33	0.83	0.00104	13.78	0.75	0.00093
0.075	0.575	1.31	5.62	0.30	0.00229	4.08	0.22	0.00166
0.125	0.702	0.78	4.35	0.24	0.00295	2.46	0.13	0.00167
0.175	0.860	0.56	4.04	0.22	0.00383	1.72	0.09	0.00163
0.225	0.994	0.44	4.21	0.23	0.00513	1.54	0.08	0.00187
0.275	0.947	0.36	3.67	0.20	0.00546	1.12	0.06	0.00167
0.325	0.899	0.30	3.27	0.18	0.00576	0.85	0.05	0.00150
0.375	0.851	0.26	2.96	0.16	0.00602	0.73	0.04	0.00148
0.425	0.804	0.23	2.71	0.15	0.00624	0.85	0.05	0.00196
0.475	0.756	0.21	2.50	0.14	0.00643	0.93	0.05	0.00241
0.525	0.708	0.19	2.32	0.13	0.00659	0.99	0.05	0.00282
0.575	0.660	0.17	2.15	0.12	0.00671	1.02	0.06	0.00319
0.625	0.613	0.16	2.01	0.11	0.00680	1.04	0.06	0.00353
0.675	0.565	0.15	1.87	0.10	0.00685	1.05	0.06	0.00384
0.725	0.517	0.14	1.75	0.09	0.00686	1.05	0.06	0.00411
0.775	0.470	0.13	1.63	0.09	0.00684	1.03	0.06	0.00434
0.825	0.422	0.12	1.52	0.08	0.00679	1.02	0.06	0.00454
0.875	0.374	0.11	1.41	0.08	0.00670	0.99	0.05	0.00471
0.925	0.327	0.11	1.31	0.07	0.00658	0.97	0.05	0.00484
0.975	0.279	0.10	1.22	0.07	0.00642	0.93	0.05	0.00494

Overall p(collision) =	Upwind	11.2%	Downwind	5.8%
	Average	8.5%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Голяма бяла чапла / *Egretta alba*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	1	m
Wingspan	1.5	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	11.6	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

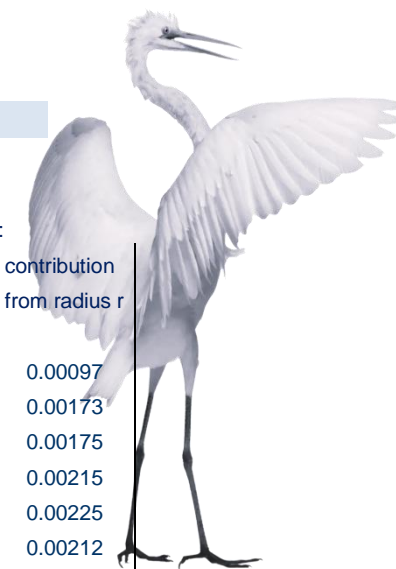
Bird aspect ratio: β	0.67	

Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	8.5E-3	4.9E-3	6.7E-3	1.1E-4	6.1E-5	8.4E-5
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.02	16.23	0.86	0.00107	14.68	0.77	0.00097
0.075	0.575	1.34	5.92	0.31	0.00235	4.38	0.23	0.00173
0.125	0.702	0.80	4.55	0.24	0.00300	2.66	0.14	0.00175
0.175	0.860	0.57	4.64	0.24	0.00428	2.32	0.12	0.00215
0.225	0.994	0.45	4.57	0.24	0.00543	1.89	0.10	0.00225
0.275	0.947	0.37	4.01	0.21	0.00582	1.46	0.08	0.00212
0.325	0.899	0.31	3.61	0.19	0.00619	1.19	0.06	0.00204
0.375	0.851	0.27	3.29	0.17	0.00652	1.00	0.05	0.00198
0.425	0.804	0.24	3.04	0.16	0.00681	1.13	0.06	0.00253
0.475	0.756	0.21	2.82	0.15	0.00707	1.21	0.06	0.00304
0.525	0.708	0.19	2.63	0.14	0.00730	1.27	0.07	0.00352
0.575	0.660	0.17	2.47	0.13	0.00749	1.31	0.07	0.00397
0.625	0.613	0.16	2.32	0.12	0.00765	1.33	0.07	0.00439
0.675	0.565	0.15	2.18	0.12	0.00778	1.34	0.07	0.00477
0.725	0.517	0.14	2.06	0.11	0.00787	1.34	0.07	0.00511
0.775	0.470	0.13	1.94	0.10	0.00793	1.33	0.07	0.00542
0.825	0.422	0.12	1.83	0.10	0.00795	1.31	0.07	0.00570
0.875	0.374	0.11	1.72	0.09	0.00794	1.29	0.07	0.00595
0.925	0.327	0.11	1.62	0.09	0.00790	1.26	0.07	0.00616
0.925	0.327	0.11	1.62	0.09	0.00790	1.26	0.07	0.00616

Overall p(collision) =	Upwind	12.6%	Downwind	7.2%
	Average	9.9%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Малка бяла чапла / Egretta garzetta

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.6	m
Wingspan	0.97	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	13	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.62	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	6.6E-3	3.1E-3	4.8E-3	8.3E-4	3.8E-5	6.0E-5
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

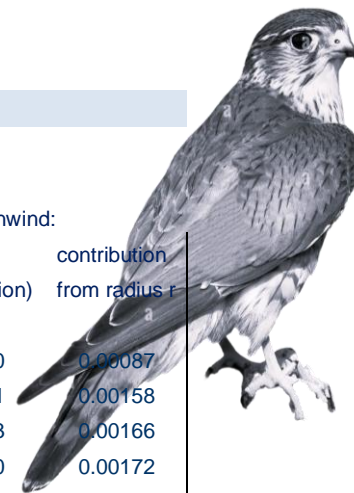
r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.51	16.57	0.78	0.00098	15.02	0.71	0.00088
0.075	0.575	1.50	6.04	0.28	0.00213	4.49	0.21	0.00159
0.125	0.702	0.90	4.68	0.22	0.00275	2.79	0.13	0.00164
0.175	0.860	0.64	4.34	0.20	0.00357	2.02	0.10	0.00167
0.225	0.994	0.50	4.44	0.21	0.00470	1.76	0.08	0.00187
0.275	0.947	0.41	3.82	0.18	0.00495	1.27	0.06	0.00165
0.325	0.899	0.35	3.37	0.16	0.00517	0.96	0.04	0.00146
0.375	0.851	0.30	3.03	0.14	0.00535	0.74	0.03	0.00130
0.425	0.804	0.27	2.75	0.13	0.00551	0.61	0.03	0.00122
0.475	0.756	0.24	2.52	0.12	0.00563	0.72	0.03	0.00160
0.525	0.708	0.21	2.32	0.11	0.00573	0.79	0.04	0.00195
0.575	0.660	0.20	2.14	0.10	0.00579	0.84	0.04	0.00227
0.625	0.613	0.18	1.98	0.09	0.00583	0.87	0.04	0.00256
0.675	0.565	0.17	1.83	0.09	0.00583	0.89	0.04	0.00282
0.725	0.517	0.16	1.70	0.08	0.00580	0.89	0.04	0.00305
0.775	0.470	0.15	1.57	0.07	0.00575	0.89	0.04	0.00325
0.825	0.422	0.14	1.46	0.07	0.00566	0.88	0.04	0.00341
0.875	0.374	0.13	1.35	0.06	0.00555	0.86	0.04	0.00355
0.925	0.327	0.12	1.24	0.06	0.00540	0.84	0.04	0.00366
0.975	0.279	0.12	1.14	0.05	0.00522	0.81	0.04	0.00374

Overall p(collision) =	Upwind	9.7%	Downwind	4.5%
	Average	7.1%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Малък сокол / *Falco columbarius*



K: [1D or 3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.28	m
Wingspan	0.55	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	14.4	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.51	

Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	2.9E-2	1.1E-2	2.0E-2	3.7E-4	1.3E-4	2.5E-4
Cavoid – collision with avoidance						
Af – avoidance rate 95%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.99	17.93	0.76	0.00095	16.39	0.70	0.00087
0.075	0.575	1.66	6.49	0.28	0.00207	4.95	0.21	0.00158
0.125	0.702	1.00	5.01	0.21	0.00266	3.12	0.13	0.00166
0.175	0.860	0.71	4.63	0.20	0.00344	2.31	0.10	0.00172
0.225	0.994	0.55	4.41	0.19	0.00422	1.74	0.07	0.00166
0.275	0.947	0.45	3.71	0.16	0.00434	1.16	0.05	0.00136
0.325	0.899	0.38	3.22	0.14	0.00445	0.80	0.03	0.00111
0.375	0.851	0.33	2.85	0.12	0.00454	0.56	0.02	0.00089
0.425	0.804	0.29	2.55	0.11	0.00460	0.38	0.02	0.00069
0.475	0.756	0.26	2.29	0.10	0.00463	0.30	0.01	0.00061
0.525	0.708	0.24	2.08	0.09	0.00464	0.39	0.02	0.00087
0.575	0.660	0.22	1.89	0.08	0.00462	0.45	0.02	0.00110
0.625	0.613	0.20	1.72	0.07	0.00457	0.49	0.02	0.00130
0.675	0.565	0.18	1.57	0.07	0.00449	0.52	0.02	0.00148
0.725	0.517	0.17	1.42	0.06	0.00439	0.53	0.02	0.00163
0.775	0.470	0.16	1.29	0.05	0.00426	0.53	0.02	0.00175
0.825	0.422	0.15	1.17	0.05	0.00410	0.53	0.02	0.00185
0.875	0.374	0.14	1.05	0.04	0.00391	0.52	0.02	0.00192
0.925	0.327	0.13	0.94	0.04	0.00370	0.50	0.02	0.00196
0.975	0.279	0.13	0.83	0.04	0.00346	0.48	0.02	0.00197

Overall p(collision) =	Upwind	7.8%	Downwind	2.8%
	Average	5.3%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Сокол скитник / *Falco peregrinus*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.58	m
Wingspan	1.2	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	17.1	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.48	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	1.4E-2	6.2E-3	1.0E-2	1.8E-4	7.8E-5	1.3E-4
Cavoid – collision with avoidance						
Af – avoidance rate 95%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

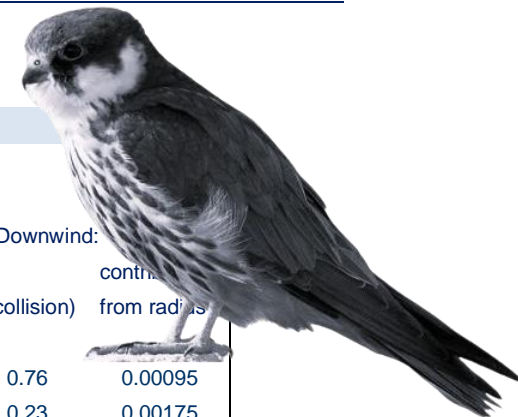
r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	5.93	25.00	0.90	0.00112	23.46	0.84	0.00105
0.075	0.575	1.98	8.85	0.32	0.00238	7.30	0.26	0.00190
0.125	0.702	1.19	6.54	0.23	0.00293	4.66	0.17	0.00208
0.175	0.860	0.85	5.83	0.21	0.00365	3.52	0.13	0.00220
0.225	0.994	0.66	5.42	0.19	0.00436	2.74	0.10	0.00221
0.275	0.947	0.54	4.48	0.16	0.00441	1.93	0.07	0.00190
0.325	0.899	0.46	3.85	0.14	0.00448	1.43	0.05	0.00166
0.375	0.851	0.40	3.42	0.12	0.00459	1.12	0.04	0.00151
0.425	0.804	0.35	3.07	0.11	0.00467	0.91	0.03	0.00138
0.475	0.756	0.31	2.78	0.10	0.00473	0.75	0.03	0.00127
0.525	0.708	0.28	2.54	0.09	0.00477	0.63	0.02	0.00119
0.575	0.660	0.26	2.32	0.08	0.00478	0.61	0.02	0.00126
0.625	0.613	0.24	2.13	0.08	0.00478	0.68	0.02	0.00151
0.675	0.565	0.22	1.96	0.07	0.00475	0.72	0.03	0.00173
0.725	0.517	0.20	1.81	0.06	0.00469	0.75	0.03	0.00193
0.775	0.470	0.19	1.66	0.06	0.00461	0.76	0.03	0.00211
0.825	0.422	0.18	1.53	0.05	0.00452	0.77	0.03	0.00227
0.875	0.374	0.17	1.40	0.05	0.00439	0.77	0.03	0.00240
0.925	0.327	0.16	1.28	0.05	0.00425	0.76	0.03	0.00251
0.975	0.279	0.15	1.17	0.04	0.00408	0.74	0.03	0.00259

Overall p(collision) =	Upwind	8.3%	Downwind	3.7%
	Average	6.0%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Сокол орко / *Falco subbuteo*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.36	m
Wingspan	0.84	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	15.5	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.43	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	1.8E-1	6.2E-2	1.2E-1	2.2E-3	8.5E-4	1.5E-3
Cavoid – collision with avoidance						
Af – avoidance rate 95%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	5.37	20.80	0.82	0.00103	19.25	0.76	0.00095
0.075	0.575	1.79	7.45	0.29	0.00221	5.90	0.23	0.00175
0.125	0.702	1.07	5.63	0.22	0.00278	3.74	0.15	0.00185
0.175	0.860	0.77	5.12	0.20	0.00354	2.80	0.11	0.00194
0.225	0.994	0.60	4.82	0.19	0.00428	2.14	0.08	0.00191
0.275	0.947	0.49	4.01	0.16	0.00435	1.46	0.06	0.00158
0.325	0.899	0.41	3.44	0.14	0.00441	1.02	0.04	0.00130
0.375	0.851	0.36	3.04	0.12	0.00450	0.75	0.03	0.00110
0.425	0.804	0.32	2.72	0.11	0.00456	0.55	0.02	0.00093
0.475	0.756	0.28	2.45	0.10	0.00460	0.42	0.02	0.00078
0.525	0.708	0.26	2.22	0.09	0.00461	0.40	0.02	0.00084
0.575	0.660	0.23	2.02	0.08	0.00460	0.47	0.02	0.00108
0.625	0.613	0.21	1.85	0.07	0.00456	0.52	0.02	0.00129
0.675	0.565	0.20	1.69	0.07	0.00449	0.56	0.02	0.00148
0.725	0.517	0.19	1.54	0.06	0.00440	0.57	0.02	0.00165
0.775	0.470	0.17	1.40	0.06	0.00429	0.58	0.02	0.00179
0.825	0.422	0.16	1.27	0.05	0.00415	0.58	0.02	0.00190
0.875	0.374	0.15	1.15	0.05	0.00398	0.58	0.02	0.00199
0.925	0.327	0.15	1.04	0.04	0.00379	0.56	0.02	0.00205
0.975	0.279	0.14	0.93	0.04	0.00357	0.54	0.02	0.00209

Overall p(collision) =	Upwind	7.9%	Downwind	3.0%
	Average	5.4%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Керкенец / *Falco tinnunculus*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.39	m
Wingspan	0.82	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	13.1	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.48	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	3.0E-1	1.2E-1	2.1E-1	3.8E-3	1.5E-3	2.7E-3
Cavoid – collision with avoidance						
Af – avoidance rate 95%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

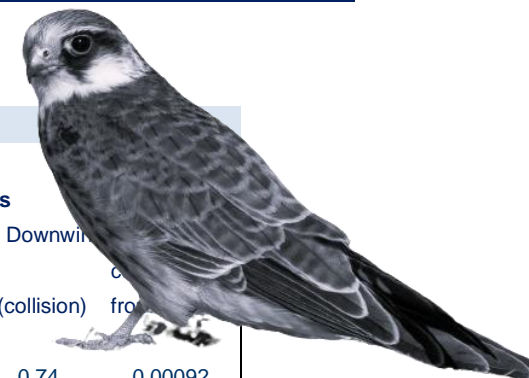
r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.54	17.61	0.82	0.00103	16.06	0.75	0.00094
0.075	0.575	1.51	6.39	0.30	0.00224	4.84	0.23	0.00170
0.125	0.702	0.91	4.89	0.23	0.00286	3.00	0.14	0.00175
0.175	0.860	0.65	4.49	0.21	0.00367	2.18	0.10	0.00178
0.225	0.994	0.50	4.27	0.20	0.00449	1.60	0.07	0.00168
0.275	0.947	0.41	3.63	0.17	0.00466	1.08	0.05	0.00139
0.325	0.899	0.35	3.18	0.15	0.00483	0.76	0.04	0.00115
0.375	0.851	0.30	2.83	0.13	0.00496	0.54	0.03	0.00094
0.425	0.804	0.27	2.55	0.12	0.00506	0.39	0.02	0.00078
0.475	0.756	0.24	2.31	0.11	0.00514	0.50	0.02	0.00111
0.525	0.708	0.22	2.11	0.10	0.00518	0.57	0.03	0.00141
0.575	0.660	0.20	1.93	0.09	0.00520	0.62	0.03	0.00168
0.625	0.613	0.18	1.77	0.08	0.00518	0.66	0.03	0.00192
0.675	0.565	0.17	1.63	0.08	0.00514	0.67	0.03	0.00212
0.725	0.517	0.16	1.49	0.07	0.00506	0.68	0.03	0.00230
0.775	0.470	0.15	1.37	0.06	0.00495	0.68	0.03	0.00245
0.825	0.422	0.14	1.25	0.06	0.00482	0.67	0.03	0.00257
0.875	0.374	0.13	1.14	0.05	0.00465	0.65	0.03	0.00266
0.925	0.327	0.12	1.03	0.05	0.00446	0.63	0.03	0.00272
0.975	0.279	0.12	0.93	0.04	0.00423	0.60	0.03	0.00274

Overall p(collision) =	Upwind	8.8%	Downwind	3.6%
	Average	6.2%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Вечерна ветрушка / *Falco vespertinus*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.34	m
Wingspan	0.75	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	14	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.45	
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Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	4.6E-1	1.8E-1	3.2E-1	5.8E-3	2.2E-3	4.0E-3
Cavoid – collision with avoidance						
Af – avoidance rate 95%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R	c/C	α	Upwind:				Downwind:			
			collide length	p(collision)	contribution from radius r		collide length	p(collision)	contribution from radius r	
0.025	0.575	4.85	18.43	0.81	0.00101		16.88	0.74	0.00092	
0.075	0.575	1.62	6.66	0.29	0.00218		5.11	0.22	0.00168	
0.125	0.702	0.97	5.09	0.22	0.00278		3.20	0.14	0.00175	
0.175	0.860	0.69	4.67	0.20	0.00358		2.36	0.10	0.00180	
0.225	0.994	0.54	4.44	0.19	0.00436		1.76	0.08	0.00173	
0.275	0.947	0.44	3.71	0.16	0.00446		1.16	0.05	0.00140	
0.325	0.899	0.37	3.24	0.14	0.00460		0.82	0.04	0.00116	
0.375	0.851	0.32	2.87	0.13	0.00470		0.58	0.03	0.00095	
0.425	0.804	0.29	2.57	0.11	0.00478		0.41	0.02	0.00076	
0.475	0.756	0.26	2.33	0.10	0.00483		0.39	0.02	0.00081	
0.525	0.708	0.23	2.11	0.09	0.00486		0.47	0.02	0.00108	
0.575	0.660	0.21	1.93	0.08	0.00485		0.53	0.02	0.00133	
0.625	0.613	0.19	1.76	0.08	0.00482		0.57	0.02	0.00155	
0.675	0.565	0.18	1.61	0.07	0.00475		0.59	0.03	0.00174	
0.725	0.517	0.17	1.47	0.06	0.00466		0.60	0.03	0.00191	
0.775	0.470	0.16	1.34	0.06	0.00455		0.60	0.03	0.00204	
0.825	0.422	0.15	1.22	0.05	0.00440		0.60	0.03	0.00215	
0.875	0.374	0.14	1.10	0.05	0.00423		0.58	0.03	0.00223	
0.925	0.327	0.13	0.99	0.04	0.00402		0.56	0.02	0.00228	
0.975	0.279	0.12	0.89	0.04	0.00379		0.54	0.02	0.00231	

Overall p(collision) =	Upwind	8.2%	Downwind	3.2%
	Average	5.7%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Сив жерав / Grus grus

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	1.15	m
Wingspan	2	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	13	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.58	

Collision risk						
$C = Nb * Overall(p) * 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C * (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	6.1E-2	3.5E-2	4.8E-2	7.6E-4	4.4E-4	6.0E-4
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.51	19.52	0.92	0.00115	17.98	0.85	0.00106
0.075	0.575	1.50	7.02	0.33	0.00248	5.48	0.26	0.00193
0.125	0.702	0.90	5.27	0.25	0.00310	3.38	0.16	0.00199
0.175	0.860	0.64	4.76	0.22	0.00392	2.44	0.12	0.00201
0.225	0.994	0.50	4.99	0.23	0.00529	2.31	0.11	0.00245
0.275	0.947	0.41	4.37	0.21	0.00566	1.82	0.09	0.00236
0.325	0.899	0.35	3.92	0.18	0.00601	1.51	0.07	0.00230
0.375	0.851	0.30	3.58	0.17	0.00632	1.29	0.06	0.00228
0.425	0.804	0.27	3.30	0.16	0.00661	1.16	0.05	0.00233
0.475	0.756	0.24	3.07	0.14	0.00686	1.27	0.06	0.00283
0.525	0.708	0.21	2.87	0.13	0.00709	1.34	0.06	0.00331
0.575	0.660	0.20	2.69	0.13	0.00728	1.39	0.07	0.00376
0.625	0.613	0.18	2.53	0.12	0.00745	1.42	0.07	0.00418
0.675	0.565	0.17	2.38	0.11	0.00758	1.44	0.07	0.00457
0.725	0.517	0.16	2.25	0.11	0.00768	1.44	0.07	0.00493
0.775	0.470	0.15	2.12	0.10	0.00776	1.44	0.07	0.00525
0.825	0.422	0.14	2.01	0.09	0.00780	1.43	0.07	0.00555
0.875	0.374	0.13	1.90	0.09	0.00781	1.41	0.07	0.00582
0.925	0.327	0.12	1.79	0.08	0.00779	1.39	0.07	0.00605
0.975	0.279	0.12	1.69	0.08	0.00775	1.36	0.06	0.00626

Overall p(collision) =	Upwind	12.3%	Downwind	7.1%
	Average	9.7%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Малък орел / *Hieraetus pennatus*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.4	m
Wingspan	1.32	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	12.5	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.30	

Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	1.1E-1	4.7E-2	7.9E-2	1.4E-3	5.8E-4	9.9E-4
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.33	16.93	0.83	0.00104	15.38	0.75	0.00094
0.075	0.575	1.44	6.16	0.30	0.00226	4.61	0.23	0.00169
0.125	0.702	0.87	4.73	0.23	0.00289	2.84	0.14	0.00174
0.175	0.860	0.62	4.35	0.21	0.00373	2.04	0.10	0.00175
0.225	0.994	0.48	4.15	0.20	0.00457	1.47	0.07	0.00162
0.275	0.947	0.39	3.48	0.17	0.00468	0.93	0.05	0.00125
0.325	0.899	0.33	2.99	0.15	0.00477	0.58	0.03	0.00092
0.375	0.851	0.29	2.78	0.14	0.00511	0.49	0.02	0.00090
0.425	0.804	0.25	2.51	0.12	0.00523	0.45	0.02	0.00094
0.475	0.756	0.23	2.28	0.11	0.00531	0.55	0.03	0.00128
0.525	0.708	0.21	2.09	0.10	0.00537	0.62	0.03	0.00159
0.575	0.660	0.19	1.91	0.09	0.00539	0.66	0.03	0.00187
0.625	0.613	0.17	1.76	0.09	0.00538	0.69	0.03	0.00212
0.675	0.565	0.16	1.62	0.08	0.00534	0.71	0.03	0.00233
0.725	0.517	0.15	1.48	0.07	0.00527	0.71	0.03	0.00251
0.775	0.470	0.14	1.36	0.07	0.00517	0.70	0.03	0.00267
0.825	0.422	0.13	1.25	0.06	0.00504	0.69	0.03	0.00279
0.875	0.374	0.12	1.14	0.06	0.00487	0.67	0.03	0.00288
0.925	0.327	0.12	1.03	0.05	0.00467	0.65	0.03	0.00293
0.975	0.279	0.11	0.93	0.05	0.00445	0.62	0.03	0.00296

Overall p(collision) =	Upwind	9.1%	Downwind	3.8%
	Average	6.4%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Жълтокрака чайка / *Larus michahellis*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.61	m
Wingspan	1.4	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	12.5	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.44	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	2.6E-1	1.3E-1	1.9E-1	3.3E-3	1.6E-3	2.4E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.33	17.15	0.84	0.00105	15.60	0.76	0.00096
0.075	0.575	1.44	6.23	0.31	0.00229	4.68	0.23	0.00172
0.125	0.702	0.87	4.77	0.23	0.00292	2.88	0.14	0.00176
0.175	0.860	0.62	4.38	0.21	0.00376	2.07	0.10	0.00177
0.225	0.994	0.48	4.17	0.20	0.00460	1.50	0.07	0.00165
0.275	0.947	0.39	3.76	0.18	0.00506	1.21	0.06	0.00163
0.325	0.899	0.33	3.32	0.16	0.00529	0.90	0.04	0.00144
0.375	0.851	0.29	2.99	0.15	0.00549	0.70	0.03	0.00128
0.425	0.804	0.25	2.72	0.13	0.00566	0.66	0.03	0.00138
0.475	0.756	0.23	2.49	0.12	0.00580	0.76	0.04	0.00177
0.525	0.708	0.21	2.30	0.11	0.00591	0.83	0.04	0.00213
0.575	0.660	0.19	2.12	0.10	0.00598	0.87	0.04	0.00246
0.625	0.613	0.17	1.97	0.10	0.00602	0.90	0.04	0.00276
0.675	0.565	0.16	1.83	0.09	0.00604	0.92	0.04	0.00303
0.725	0.517	0.15	1.69	0.08	0.00602	0.92	0.04	0.00326
0.775	0.470	0.14	1.57	0.08	0.00597	0.91	0.04	0.00346
0.825	0.422	0.13	1.46	0.07	0.00588	0.90	0.04	0.00364
0.875	0.374	0.12	1.35	0.07	0.00577	0.88	0.04	0.00378
0.925	0.327	0.12	1.24	0.06	0.00562	0.86	0.04	0.00388
0.975	0.279	0.11	1.14	0.06	0.00545	0.83	0.04	0.00396

Overall p(collision) =	Upwind	10.1%	Downwind	4.8%
	Average	7.4%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Черна каня / *Milvus migrans*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.6	m
Wingspan	1.8	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	11.7	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.33	

Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	9.9E-2	4.9E-2	7.4E-2	1.2E-3	6.0E-4	9.2E-4
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

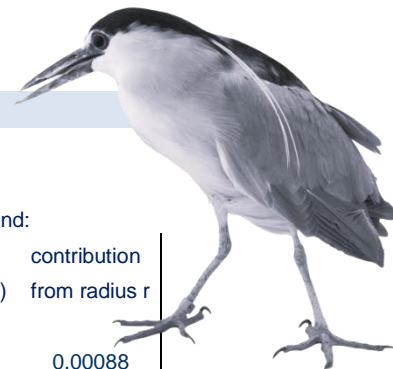
r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.06	17.13	0.90	0.00112	15.59	0.82	0.00102
0.075	0.575	1.35	6.23	0.33	0.00244	4.68	0.24	0.00184
0.125	0.702	0.81	4.73	0.25	0.00309	2.84	0.15	0.00186
0.175	0.860	0.58	4.32	0.23	0.00396	2.01	0.11	0.00184
0.225	0.994	0.45	4.11	0.21	0.00483	1.43	0.07	0.00168
0.275	0.947	0.37	3.45	0.18	0.00496	0.90	0.05	0.00130
0.325	0.899	0.31	3.22	0.17	0.00547	0.80	0.04	0.00136
0.375	0.851	0.27	2.90	0.15	0.00569	0.61	0.03	0.00120
0.425	0.804	0.24	2.64	0.14	0.00588	0.72	0.04	0.00160
0.475	0.756	0.21	2.43	0.13	0.00603	0.81	0.04	0.00201
0.525	0.708	0.19	2.24	0.12	0.00615	0.87	0.05	0.00238
0.575	0.660	0.18	2.07	0.11	0.00624	0.90	0.05	0.00272
0.625	0.613	0.16	1.92	0.10	0.00629	0.93	0.05	0.00303
0.675	0.565	0.15	1.79	0.09	0.00631	0.93	0.05	0.00330
0.725	0.517	0.14	1.66	0.09	0.00630	0.93	0.05	0.00354
0.775	0.470	0.13	1.54	0.08	0.00625	0.92	0.05	0.00375
0.825	0.422	0.12	1.43	0.07	0.00617	0.91	0.05	0.00392
0.875	0.374	0.12	1.32	0.07	0.00605	0.89	0.05	0.00406
0.925	0.327	0.11	1.22	0.06	0.00590	0.86	0.04	0.00416
0.975	0.279	0.10	1.12	0.06	0.00572	0.83	0.04	0.00423

Overall p(collision) =	Upwind	10.5%	Downwind	5.1%
	Average	7.8%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Нощна чапла / *Nycticorax nycticorax*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.6	m
Wingspan	1	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	11.5	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.60	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	1.1E-2	5.2E-3	8.0E-3	1.3E-4	6.5E-5	1.0E-4
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.99	14.82	0.79	0.00099	13.28	0.71	0.00088
0.075	0.575	1.33	5.46	0.29	0.00218	3.91	0.21	0.00156
0.125	0.702	0.80	4.26	0.23	0.00284	2.37	0.13	0.00158
0.175	0.860	0.57	4.22	0.22	0.00393	1.90	0.10	0.00177
0.225	0.994	0.44	4.15	0.22	0.00497	1.47	0.08	0.00177
0.275	0.947	0.36	3.60	0.19	0.00527	1.05	0.06	0.00154
0.325	0.899	0.31	3.19	0.17	0.00553	0.77	0.04	0.00134
0.375	0.851	0.27	2.88	0.15	0.00575	0.61	0.03	0.00122
0.425	0.804	0.23	2.63	0.14	0.00595	0.74	0.04	0.00166
0.475	0.756	0.21	2.41	0.13	0.00610	0.82	0.04	0.00208
0.525	0.708	0.19	2.23	0.12	0.00623	0.88	0.05	0.00245
0.575	0.660	0.17	2.06	0.11	0.00632	0.91	0.05	0.00280
0.625	0.613	0.16	1.92	0.10	0.00637	0.93	0.05	0.00311
0.675	0.565	0.15	1.78	0.09	0.00639	0.94	0.05	0.00338
0.725	0.517	0.14	1.65	0.09	0.00638	0.94	0.05	0.00362
0.775	0.470	0.13	1.54	0.08	0.00634	0.93	0.05	0.00383
0.825	0.422	0.12	1.42	0.08	0.00625	0.91	0.05	0.00401
0.875	0.374	0.11	1.32	0.07	0.00614	0.89	0.05	0.00414
0.925	0.327	0.11	1.22	0.06	0.00599	0.86	0.05	0.00425
0.975	0.279	0.10	1.12	0.06	0.00581	0.83	0.04	0.00432

Overall p(collision) =	Upwind	10.6%	Downwind	5.1%
	Average	7.9%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Розов пеликан / *Pelecanus onocrotalus*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	1.57	m
Wingspan	2.9	m
F: Flapping (0) or gliding (+1)	1	

Bird speed	12.8	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.54	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	9.7E-1	6.2E-1	7.9E-1	1.2E-2	7.7E-3	9.9E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.44	21.78	1.00	0.00125	20.23	0.97	0.00121
0.075	0.575	1.48	7.78	0.37	0.00279	6.23	0.30	0.00223
0.125	0.702	0.89	5.71	0.27	0.00341	3.82	0.18	0.00228
0.175	0.860	0.63	5.07	0.24	0.00424	2.75	0.13	0.00230
0.225	0.994	0.49	5.37	0.26	0.00578	2.69	0.13	0.00290
0.275	0.947	0.40	4.76	0.23	0.00626	2.21	0.11	0.00291
0.325	0.899	0.34	4.32	0.21	0.00672	1.90	0.09	0.00296
0.375	0.851	0.30	3.98	0.19	0.00714	1.69	0.08	0.00303
0.425	0.804	0.26	3.70	0.18	0.00753	1.60	0.08	0.00325
0.475	0.756	0.23	3.47	0.17	0.00789	1.70	0.08	0.00386
0.525	0.708	0.21	3.27	0.16	0.00822	1.77	0.08	0.00445
0.575	0.660	0.19	3.10	0.15	0.00852	1.82	0.09	0.00500
0.625	0.613	0.18	2.94	0.14	0.00879	1.85	0.09	0.00553
0.675	0.565	0.16	2.80	0.13	0.00903	1.86	0.09	0.00602
0.725	0.517	0.15	2.66	0.13	0.00924	1.87	0.09	0.00648
0.775	0.470	0.14	2.54	0.12	0.00941	1.86	0.09	0.00691
0.825	0.422	0.13	2.42	0.12	0.00956	1.85	0.09	0.00731
0.875	0.374	0.13	2.31	0.11	0.00968	1.84	0.09	0.00768
0.925	0.327	0.12	2.21	0.11	0.00976	1.81	0.09	0.00802
0.975	0.279	0.11	2.10	0.10	0.00982	1.79	0.09	0.00833

Overall p(collision) =	Upwind	14.5%	Downwind	9.3%
	Average	11.9%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Златиста булка / *Pluvialis apricaria*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.24	m
Wingspan	0.5	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	14	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.48	

Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	4.2E-1	1.5E-1	2.8E-1	5.3E-3	1.8E-3	3.5E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.85	17.21	0.75	0.00094	15.67	0.69	0.00086
0.075	0.575	1.62	6.25	0.27	0.00205	4.71	0.21	0.00154
0.125	0.702	0.97	4.85	0.21	0.00265	2.96	0.13	0.00162
0.175	0.860	0.69	4.50	0.20	0.00344	2.18	0.10	0.00167
0.225	0.994	0.54	4.30	0.19	0.00423	1.62	0.07	0.00160
0.275	0.947	0.44	3.61	0.16	0.00434	1.06	0.05	0.00128
0.325	0.899	0.37	3.14	0.14	0.00446	0.72	0.03	0.00102
0.375	0.851	0.32	2.77	0.12	0.00454	0.48	0.02	0.00078
0.425	0.804	0.29	2.47	0.11	0.00460	0.31	0.01	0.00058
0.475	0.756	0.26	2.23	0.10	0.00463	0.29	0.01	0.00060
0.525	0.708	0.23	2.01	0.09	0.00463	0.37	0.02	0.00085
0.575	0.660	0.21	1.83	0.08	0.00460	0.43	0.02	0.00108
0.625	0.613	0.19	1.66	0.07	0.00454	0.47	0.02	0.00128
0.675	0.565	0.18	1.51	0.07	0.00446	0.49	0.02	0.00145
0.725	0.517	0.17	1.37	0.06	0.00435	0.50	0.02	0.00159
0.775	0.470	0.16	1.24	0.05	0.00421	0.50	0.02	0.00170
0.825	0.422	0.15	1.12	0.05	0.00404	0.50	0.02	0.00179
0.875	0.374	0.14	1.00	0.04	0.00384	0.48	0.02	0.00185
0.925	0.327	0.13	0.89	0.04	0.00362	0.46	0.02	0.00188
0.975	0.279	0.12	0.79	0.03	0.00337	0.44	0.02	0.00188

Overall p(collision) =	Upwind	7.8%	Downwind	2.7%
	Average	5.2%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Хвойнов дрозд / *Turdus pilaris*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.25	m
Wingspan	0.41	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	11.2	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.61	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	9.7E-1	3.7E-1	6.7E-1	1.2E-2	4.6E-3	8.4E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.88	13.58	0.74	0.00093	12.03	0.66	0.00082
0.075	0.575	1.29	5.04	0.28	0.00207	3.49	0.19	0.00143
0.125	0.702	0.78	4.00	0.22	0.00273	2.11	0.12	0.00144
0.175	0.860	0.55	3.80	0.21	0.00364	1.49	0.08	0.00142
0.225	0.994	0.43	3.74	0.20	0.00460	1.07	0.06	0.00131
0.275	0.947	0.35	3.20	0.18	0.00481	0.65	0.04	0.00098
0.325	0.899	0.30	2.81	0.15	0.00499	0.39	0.02	0.00069
0.375	0.851	0.26	2.50	0.14	0.00513	0.29	0.02	0.00059
0.425	0.804	0.23	2.25	0.12	0.00523	0.41	0.02	0.00095
0.475	0.756	0.20	2.04	0.11	0.00530	0.49	0.03	0.00128
0.525	0.708	0.18	1.86	0.10	0.00534	0.55	0.03	0.00157
0.575	0.660	0.17	1.70	0.09	0.00534	0.58	0.03	0.00182
0.625	0.613	0.16	1.55	0.08	0.00530	0.60	0.03	0.00204
0.675	0.565	0.14	1.42	0.08	0.00523	0.60	0.03	0.00222
0.725	0.517	0.13	1.29	0.07	0.00513	0.60	0.03	0.00237
0.775	0.470	0.13	1.18	0.06	0.00499	0.59	0.03	0.00249
0.825	0.422	0.12	1.07	0.06	0.00481	0.57	0.03	0.00256
0.875	0.374	0.11	0.96	0.05	0.00460	0.55	0.03	0.00261
0.925	0.327	0.10	0.86	0.05	0.00436	0.52	0.03	0.00262
0.975	0.279	0.10	0.76	0.04	0.00408	0.49	0.03	0.00259

Overall p(collision) =	Upwind	8.9%	Downwind	3.4%
	Average	6.1%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Имелов дрозд / *Turdus viscivorus*

K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.27	m
Wingspan	0.41	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	11.2	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

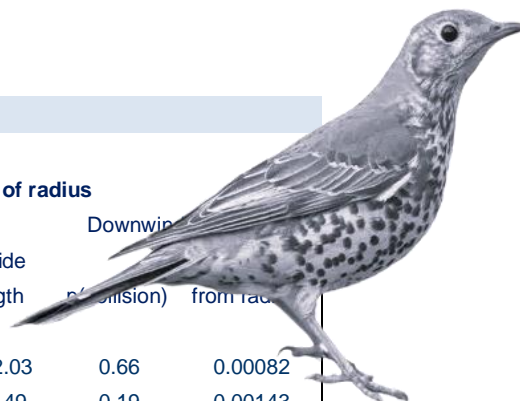
Bird aspect ratio: β	0.66	

Collision risk						
$C = Nb \cdot \text{Overall}(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$C_{\text{avoid}} = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - collision	3.5E-1	1.4E-1	2.4E-1	4.4E-3	1.7E-3	3.0E-3
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

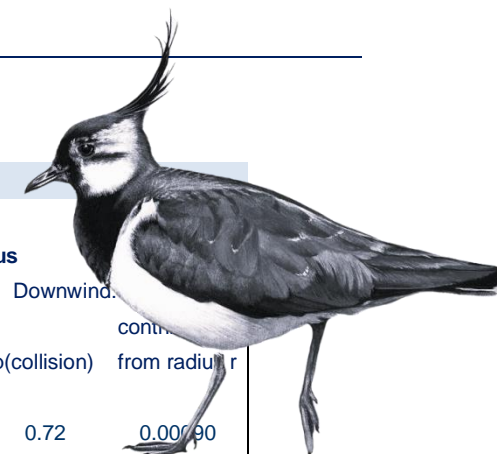
r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	3.88	13.58	0.74	0.00093	12.03	0.66	0.00082
0.075	0.575	1.29	5.04	0.28	0.00207	3.49	0.19	0.00143
0.125	0.702	0.78	4.00	0.22	0.00273	2.11	0.12	0.00144
0.175	0.860	0.55	3.82	0.21	0.00366	1.51	0.08	0.00144
0.225	0.994	0.43	3.76	0.21	0.00463	1.09	0.06	0.00134
0.275	0.947	0.35	3.22	0.18	0.00484	0.67	0.04	0.00101
0.325	0.899	0.30	2.83	0.15	0.00502	0.41	0.02	0.00073
0.375	0.851	0.26	2.52	0.14	0.00517	0.31	0.02	0.00063
0.425	0.804	0.23	2.27	0.12	0.00528	0.43	0.02	0.00100
0.475	0.756	0.20	2.06	0.11	0.00536	0.51	0.03	0.00133
0.525	0.708	0.18	1.88	0.10	0.00540	0.57	0.03	0.00162
0.575	0.660	0.17	1.72	0.09	0.00540	0.60	0.03	0.00188
0.625	0.613	0.16	1.57	0.09	0.00537	0.62	0.03	0.00211
0.675	0.565	0.14	1.44	0.08	0.00531	0.62	0.03	0.00230
0.725	0.517	0.13	1.31	0.07	0.00521	0.62	0.03	0.00245
0.775	0.470	0.13	1.20	0.07	0.00507	0.61	0.03	0.00257
0.825	0.422	0.12	1.09	0.06	0.00490	0.59	0.03	0.00265
0.875	0.374	0.11	0.98	0.05	0.00470	0.57	0.03	0.00270
0.925	0.327	0.10	0.88	0.05	0.00446	0.54	0.03	0.00272
0.975	0.279	0.10	0.78	0.04	0.00418	0.51	0.03	0.00270

Overall p(collision) =	Upwind	9.0%	Downwind	3.5%
	Average	6.2%		



CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA – STAGE 2

Обикновена калугерица / *Vanellus vanellus*



K: [1D or [3D] (0 or 1)	1	
NoBlades	3	
MaxChord	5.2	m
Pitch (degrees)	15	

BirdLength	0.34	m
Wingspan	0.68	m
F: Flapping (0) or gliding (+1)	0	

Bird speed	13	m/sec
RotorDiam	180	m
RotationPeriod	4.90	sec

Bird aspect ratio: β	0.50	

Collision risk						
$C = Nb \cdot Overall(p) \cdot 0.85$	Cavoid			Cavoid/WTG		
$Cavoid = C \cdot (1 - (Af/100))$	Up	Dwn	Avg	Up	Dwn	Avg
C - colission	8.4E-2	3.3E-2	5.9E-2	1.1E-3	4.1E-4	7.3E-4
Cavoid – collision with avoidance						
Af – avoidance rate 98%						
Nb – number of bird						
85% - WTG annual operation time						
WTG – wind turbine						

Calculation of alpha and p(collision) as a function of radius

r/R radius	c/C chord	α alpha	Upwind:			Downwind:		
			collide length	p(collision)	contribution from radius r	collide length	p(collision)	contribution from radius r
0.025	0.575	4.51	16.85	0.79	0.00099	15.30	0.72	0.00090
0.075	0.575	1.50	6.13	0.29	0.00217	4.59	0.22	0.00162
0.125	0.702	0.90	4.73	0.22	0.00279	2.84	0.13	0.00167
0.175	0.860	0.64	4.38	0.21	0.00361	2.06	0.10	0.00170
0.225	0.994	0.50	4.18	0.20	0.00443	1.50	0.07	0.00159
0.275	0.947	0.41	3.56	0.17	0.00461	1.01	0.05	0.00131
0.325	0.899	0.35	3.11	0.15	0.00477	0.70	0.03	0.00106
0.375	0.851	0.30	2.77	0.13	0.00489	0.48	0.02	0.00085
0.425	0.804	0.27	2.49	0.12	0.00499	0.35	0.02	0.00070
0.475	0.756	0.24	2.26	0.11	0.00505	0.46	0.02	0.00102
0.525	0.708	0.21	2.06	0.10	0.00508	0.53	0.02	0.00131
0.575	0.660	0.20	1.88	0.09	0.00509	0.58	0.03	0.00157
0.625	0.613	0.18	1.72	0.08	0.00506	0.61	0.03	0.00180
0.675	0.565	0.17	1.57	0.07	0.00500	0.63	0.03	0.00199
0.725	0.517	0.16	1.44	0.07	0.00492	0.63	0.03	0.00216
0.775	0.470	0.15	1.31	0.06	0.00480	0.63	0.03	0.00230
0.825	0.422	0.14	1.20	0.06	0.00465	0.62	0.03	0.00240
0.875	0.374	0.13	1.09	0.05	0.00447	0.60	0.03	0.00248
0.925	0.327	0.12	0.98	0.05	0.00427	0.58	0.03	0.00253
0.975	0.279	0.12	0.88	0.04	0.00403	0.55	0.03	0.00254

Overall p(collision) =	Upwind	8.6%	Downwind	3.4%
	Average	6.0%		

