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Research Paper

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A Study of Optimization of Aircraft Separation using the Time Based Separation at Tribhuvan International Airport

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***Abstract*—** The Tribhuvan International Airport (TIA) uses the conventional distance-based separation minima for separation of two consecutive aircraft in approach and a basic Time-based separation (TBS) for aircraft in open airspace. The possibility of saving time by switching from the Distanced Based Separation (DBS) system to a fully Enhanced Time Based Separation (ETBS) can improve TIA's approach procedure. This paper focuses on a study of the comparative analysis between the DBS and the ETBS system for TIA, using Monte-Carlo simulation-based upon various parameters that affect separation between the aircraft. The preliminary setup includes random number mapping for weight class of the plane, wind speed, approach speed, and wind direction in MS Excel. However, few limitations and exceptions are considered for the research. An average daily time lag of 79 minutes was observed between DBS and TBS. Hence, implementation of the ETBS system can save TIA almost 20 days of operation annually.

***Keywords*—**DBS, TBS, ETBS, Wake Vortices, Aircraft, Seperation, Approach, TIA

I. INTRODUCTION

The separation between aircraft is a concept used by the air traffic control at various airports to maintain a safe distance between aircraft to minimize the risks of accidents via collision. Air traffic control uses a term called separation minima as a fundamental separation to be maintained between aircraft. However, several factors affect separation or determine whether aircraft need controlled separation at all.

In a broader sense, ATC controlled separation depends on the class of airspace and the set of flight rules adopted by the pilot. Airspace class ranks from A to G, in the decreasing order of necessity of control. While basic flight rules include: Visual Flight Rules (VFR), Instrumental Flight Rules (IFR), and Special Visual Flight Rules (SVFR) [7].

Separation is primarily maintained to lower the risk of collision between two aircraft while also avoid in wake turbulence (turbulent vortex exerted by the preceding aircraft). Most aircraft use distance-based separation in the form of horizontal and vertical separation. While this concept is fool-proof with regards to risk aversion, in certain scenarios this separation causes time-delays leading to extended holding, cancelled flights, and so forth, like in the case of strong headwinds.

Time- Based Separation (TBS) is a new concept aimed to reduce the gap in landing rates in light and strong headwind conditions [3]. The concept is based on the fact that wake turbulence is easily dissipated in strong headwinds allowing aircraft to reduce the distance subsequently the rates [1,6]. The TBS has jointly developed the concept by National Air Traffic Service (NATS) and Leidos (formerly Lockheed-Martin), as a separation system to fully unlock the runway capacity irrespective of wind conditions.

At TIA, special provisions are assigned for vertical and horizontal separation of aircrafts and which category require controlled separation minima.

TIA, one of the oldest and busiest airports in Nepal, is the only airport for international flights. Inaugurated in 1955, the airport is located around 5 kilometres from the city centre of Kathmandu. TIA has a single runway with two headings 20 and 02 and is around 3050 meters. Statistically, TIA encountered an air traffic movement of around 130,000 aircraft in numbers in 2018 [4]. According to the Civil Aviation Authority of Nepal (CAAN), TIA uses a basic TBS for separation of aircraft s flying at the same track and the same with a plain angle up to 45 degrees between them. The TBS specifies the following [6]:

a) A separation of 15 minutes for aircraft still in air
b) 10 minutes, if the navigation aid permits clearance with frequent confirmation of speed and position
c) 5 minutes for a true airspeed of up to 20 knots.
d) 3 minutes for a true air speed up to 40 knots.

This paper aims to simulate a model to compute time saving by the application of ETBS at Tribhuwan

International airport. Furthermore, this research aims to provide effective and efficient way to manage aircraft separations on final approach at TIA.

Section I contain the introduction of Separation, TBS, DBS and Problem Statement, Section II contain the related work of TBS on London Heathrow Airport, Section III contains some measures of TBS technique in TIA using Monte Carlo in Excel, Section IV contain the results got from simulation., besides this it also explains the risk analysis, Section V concludes research work with future directions.

II. RELATED WORK

Based on conventional separation, in 2010 and 2011, London's Heathrow Airport experienced a delay of over 200000 minutes per annum while days affected reached a gigantic 80 days [3]. The primary cause of the delay being wind conditions.

The system is operational at London's Heathrow Airport, after over 150000 assessments on wake vortices of inbound flights. Using a time-based separation instead of distance not only increases runway usage, decreasing delays but also ensures safety.

III. METHODOLOGY

Several assumptions are made beforehand.

a) Separation in IFR condition is calculated where TIA's final approach for Runway 02 Top of Descent (TOD) begins.

b) Linear Unidirectional wind conditions.

c) Aircraft clearing time from the runway after landing is neglected.

d) Empirical relations were computed for dissipation of wake turbulence by wind conditions.

e) Only scheduled International Flights were considered.

Various data's are collected from various sources such as Various data are collected from various sources such as the International Civil Aviation Organization (ICAO), CAAN, flightradar24.com, metro blue for parameters such as Aircraft Arrival and Departure rate, Weight Class, Wake Turbulence, Weather Patterns (Wind).

Monte Carlo Simulation was used to estimate the time saved per year by the use of ETBS. Aircraft arrival data was collected from Flightradar24.com for 12 hours (18:00 to 06:00). There were 20 light, 95 medium, 12 heavy aircrafts approaching TIA. The weight class are taken according to ICAO weight classification [7].

Wind speeds were collected from metro blue along with temperature variation of the trial period at a specific height where TBS was to be applied. Velocity at height is calculated for an altitude of 3505 (m.). i.e. 11500 (ft.) where Approach TOD for runway 02 start's using the following equation:

$V = v \times (H/10)^{\alpha}$, where α = Hellman Constant 0.27

V= Velocity at Height
v = Measured Velocity
H= Height

The separation minima and true absolute approach speed of aircraft for different categories of aircraft are based upon the ICAO. For each parameter, a probability distribution is found and is mapped with Random numbers, which was generated in MS Excel. For which the Monte Carlo Simulation could be performed for various parameters mentioned above. Different parameters mapped with Random Numbers are shown in Table 2.

IV. RESULTS AND DISCUSSION

Results

Altogether 214 samples were taken for simulation as the number of scheduled flights at TIA is 214 per 24 hour period. The preliminary setup includes random number mapping for weight class of the plane, wind speed, approach speed, and wind direction as shown in Table 2. Next the distance of separation Minima is based upon the ICAO rule and it compares the preceding flights with the following flight. Each simulation resulted in one unique time lag for 24 hour period which was iterated for 20 times as shown in Table 1 that ensued 79.2 minutes with a deviation of 2.24 minutes for 24 hour period.

Table 1. Average Time Lag and Standard Deviation

SN	*Time Lag*
1	**81.88**
2	77.83
3	79.21
4	76.29
5	75.62
6	77.21
7	80.83
8	80.07
9	81.446
10	79.66
11	79.61
12	79.54
13	80.8
14	75.21
15	80.74
16	75.87
17	80.4
18	77.5
19	83.45
20	81.22
Mean	79.2038
Standard Deviation	2.241813

Using estimates, if on a single day 80 minutes can be saved using the TBS, Annually around 29200 minutes can be saved which means 20 out of 365 working days have been saved by TBS. In the case of TIA, the delay period will be reduced by 5 percent as compared to a third of the time at Heathrow. This is almost similar to Heathrow's airport where 82 days and nearly 118000 minutes were saved per annum using the TBS.

Table 2: Different Parameters mapped with Random Numbers in MS-Excel

Sample	Plane type Random number	ICAO Weight Class	Wind speed Random Number	Wind speed (Knots)	Direction random number	Wind Direction	Final Approach Speed (Knots)	Mean Distance (Nautical Miles)	Separation Time based on Distance	Time-Based Separation	Time Lag (minutes)
1	23	M	33	45	42	Headwind	120	0	0	0	0
2	49	M	55	65	72	Tailwind	118	3	1.5	0.972972973	0.527027027
3	47	M	98	95	57	Headwind	134	3	1.525423729	0.845070423	0.680353306
4	68	M	82	75	85	Tailwind	147	3	1.343283582	0.861244019	0.482039563
5	49	M	70	65	22	Headwind	122	3	1.224489796	0.849056604	0.375433192
6	62	M	24	45	50	Headwind	156	3	1.475409836	1.077844311	0.397565525
7	23	M	8	35	67	Tailwind	125	3	1.153846154	0.942408377	0.211437777
8	34	M	58	65	50	Headwind	120	3	1.44	0.947368421	0.492631579
9	47	M	29	45	5	Headwind	126	3	1.5	1.090909091	0.409090909
10	14	L	56	65	39	Headwind	109	4	1.904761905	1.256544503	0.648217402
11	97	H	83	75	32	Headwind	168	0	2	2	0
12	8	L	67	65	98	Tailwind	88	6	2.142857143	1.545064378	0.597792765
13	7	L	22	45	24	Headwind	87	3	2.045454545	1.353383459	0.692071087
14	27	M	23	45	21	Headwind	129	0	2	2	0
15	71	M	57	65	12	Headwind	160	3	1.395348837	0.927835052	0.467513786
16	72	M	54	55	98	Tailwind	128	3	1.125	0.837209302	0.287790698
17	77	M	64	65	15	Headwind	138	3	1.40625	0.932642487	0.473607513
18	66	M	48	55	94	Tailwind	123	3	1.304347826	0.932642487	0.371705339
19	10	L	42	55	90	Tailwind	102	4	1.951219512	1.348314607	0.602904905
20	98	H	88	85	45	Headwind	154	0	2	2	0
21	92	H	95	95	16	Headwind	165	4	1.558441558	0.963855422	0.594586137
22	5	L	81	75	59	Tailwind	99	6	2.181818182	1.5	0.681818182
23	4	L	58	65	69	Tailwind	121	3	1.818181818	1.097560976	0.720620843
24	92	H	54	55	21	Headwind	147	0	2	2	0
25	15	L	36	45	27	Headwind	120	6	2.448979592	1.875	0.573979592
26	40	M	12	45	85	Tailwind	148	0	2	2	0
27	79	M	6	35	64	Tailwind	120	3	1.216216216	0.983606557	0.232609659
28	34	M	65	65	23	Headwind	156	3	1.5	0.972972973	0.527027027
29	5	L	10	35	72	Tailwind	106	4	1.538461538	1.256544503	0.281917036
30	75	M	12	45	75	Tailwind	153	0	2	2	0
31	24	M	61	65	40	Headwind	150	3	1.176470588	0.825688073	0.350782515
32	1	L	27	45	47	Headwind	93	4	1.6	1.230769231	0.369230769
33	43	M	20	45	76	Tailwind	119	0	2	2	0
34	77	M	98	95	23	Headwind	121	3	1.512605042	0.841121495	0.671483547
35	78	M	70	65	56	Headwind	119	3	1.487603306	0.967741935	0.51986137
36	21	M	87	85	69	Tailwind	151	3	1.512605042	0.882352941	0.630252101
37	42	M	36	45	59	Tailwind	120	3	1.19205298	0.918367347	0.273685633
38	12	L	78	75	87	Tailwind	94	4	2	1.230769231	0.769230769
39	56	M	6	35	6	Headwind	137	0	3	3	0
40	89	M	1	35	23	Headwind	115	3	1.313868613	1.046511628	0.267356985
41	26	M	51	55	84	Tailwind	132	3	1.565217391	1.058823529	0.506393862
42	13	L	10	35	10	Headwind	130	4	1.818181818	1.437125749	0.38105607
43	57	M	23	45	45	Headwind	149	0	2	2	0
44	47	M	39	55	92	Tailwind	127	3	1.208053691	0.882352941	0.32570075
45	12	L	93	85	5	Headwind	99	4	1.88976378	1.132075472	0.757688308
46	81	M	85	85	6	Headwind	147	0	2	2	0
47	95	H	70	65	68	Tailwind	152	0	2	2	0
48	6	L	20	45	97	Tailwind	126	6	2.368421053	1.827411168	0.541009885
49	98	H	64	65	47	Headwind	151	0	2	2	0
50	13	L	16	45	23	Headwind	119	6	2.38410596	1.836734694	0.547371266
51	39	M	89	85	59	Tailwind	122	0	2	2	0

52	8	L	13	45	51	Headwind	111	4	1.967213115	1.437125749	0.530087366
53	68	M	33	45	89	Tailwind	149	0	2	2	0
54	34	M	67	65	67	Tailwind	137	3	1.208053691	0.841121495	0.366932196
55	73	M	93	85	70	Tailwind	154	3	1.313868613	0.810810811	0.503057802
56	68	M	32	45	89	Tailwind	128	3	1.168831169	0.904522613	0.264308556
57	25	M	43	55	33	Headwind	149	3	1.40625	0.983606557	0.422643443
58	56	M	27	45	28	Headwind	132	3	1.208053691	0.927835052	0.28021864
59	4	L	66	65	38	Headwind	97	4	1.818181818	1.218274112	0.599907707
60	27	M	22	45	22	Headwind	149	0	2	2	0
61	62	M	30	45	17	Headwind	119	3	1.208053691	0.927835052	0.28021864
62	61	M	65	65	84	Tailwind	158	3	1.512605042	0.97826087	0.534344172
63	97	H	95	95	13	Headwind	161	0	2	2	0
64	85	M	88	85	95	Tailwind	131	5	1.863354037	1.219512195	0.643841842
65	89	M	1	35	96	Tailwind	152	3	1.374045802	1.084337349	0.289708452
66	36	M	49	55	94	Tailwind	117	3	1.184210526	0.869565217	0.314645309
67	73	M	91	85	14	Headwind	159	3	1.538461538	0.891089109	0.64737243
68	40	M	1	35	4	Headwind	152	3	1.132075472	0.927835052	0.20424042
69	74	M	95	95	53	Headwind	154	3	1.184210526	0.728744939	0.455465587
70	43	M	81	75	43	Headwind	146	3	1.168831169	0.786026201	0.382804968
71	40	M	19	45	23	Headwind	131	3	1.232876712	0.942408377	0.290468335
72	27	M	87	85	78	Tailwind	128	3	1.374045802	0.833333333	0.540712468
73	91	H	80	75	53	Headwind	135	0	2	2	0
74	97	H	88	85	98	Tailwind	133	4	1.777777778	1.090909091	0.686868687
75	51	M	79	75	15	Headwind	125	5	2.255639098	1.442307692	0.813331405
76	64	M	35	45	22	Headwind	153	3	1.44	1.058823529	0.381176471
77	49	M	66	65	56	Headwind	115	3	1.176470588	0.825688073	0.350782515
78	15	L	41	55	19	Headwind	115	4	2.086956522	1.411764706	0.675191816
79	27	M	16	45	37	Headwind	137	0	2	2	0
80	65	M	30	45	74	Tailwind	132	3	1.313868613	0.989010989	0.324857624
81	20	M	99	95	62	Tailwind	137	3	1.363636364	0.792951542	0.570684822
82	32	M	96	95	53	Headwind	143	3	1.313868613	0.775862069	0.538006544
83	42	M	90	85	1	Headwind	125	3	1.258741259	0.789473684	0.469267575
84	11	L	99	95	54	Headwind	96	4	1.92	1.090909091	0.829090909
85	66	M	25	45	16	Headwind	123	0	2	2	0
86	91	H	49	55	28	Headwind	143	0	2	2	0
87	51	M	25	45	52	Headwind	159	5	2.097902098	1.595744681	0.502157417
88	50	M	63	65	86	Tailwind	149	3	1.132075472	0.803571429	0.328504043
89	80	M	89	85	96	Tailwind	131	3	1.208053691	0.769230769	0.438822922
90	96	H	40	55	74	Tailwind	138	0	2	2	0
91	34	M	60	65	98	Tailwind	136	5	2.173913043	1.477832512	0.696080531
92	75	M	83	75	75	Tailwind	116	3	1.323529412	0.853080569	0.470448843
93	11	L	51	55	76	Tailwind	113	4	2.068965517	1.403508772	0.665456745
94	44	M	65	65	24	Headwind	144	0	2	2	0
95	91	H	3	35	86	Tailwind	144	0	3	3	0
96	66	M	62	65	51	Headwind	159	5	2.083333333	1.435406699	0.647926635
97	26	M	88	85	75	Tailwind	149	3	1.132075472	0.737704918	0.394370554
98	73	M	32	45	36	Headwind	127	3	1.208053691	0.927835052	0.28021864
99	14	L	2	35	77	Tailwind	87	4	1.88976378	1.481481481	0.408282298
100	94	H	21	45	33	Headwind	139	0	2	2	0
101	65	M	19	45	7	Headwind	132	5	2.158273381	1.630434783	0.527838599
102	86	M	94	85	52	Headwind	145	3	1.363636364	0.829493088	0.534143276
103	9	L	82	75	92	Tailwind	118	4	1.655172414	1.090909091	0.564263323
104	4	L	93	85	44	Headwind	88	3	1.525423729	0.886699507	0.638724221
105	56	M	25	45	37	Headwind	141	0	2	2	0
106	32	M	47	55	6	Headwind	126	3	1.276595745	0.918367347	0.358228398

107	94	H	97	95	63	Tailwind	177	0	2	2	0
108	51	M	23	45	88	Tailwind	126	5	1.694915254	1.351351351	0.343563903
109	28	M	75	75	54	Headwind	134	3	1.428571429	0.895522388	0.533049041
110	60	M	86	85	3	Headwind	144	3	1.343283582	0.821917808	0.521365774
111	22	M	54	55	71	Tailwind	152	3	1.25	0.904522613	0.345477387
112	35	M	36	45	42	Headwind	134	3	1.184210526	0.913705584	0.270504943
113	86	M	47	55	23	Headwind	152	3	1.343283582	0.952380952	0.39090263
114	56	M	34	45	17	Headwind	132	3	1.184210526	0.913705584	0.270504943
115	51	M	94	85	69	Tailwind	151	3	1.363636364	0.829493088	0.534143276
116	13	L	53	55	51	Headwind	130	4	1.589403974	1.165048544	0.42435543
117	65	M	62	65	80	Tailwind	136	0	2	2	0
118	40	M	28	45	85	Tailwind	142	3	1.323529412	0.994475138	0.329054274
119	23	M	17	45	2	Headwind	156	3	1.267605634	0.962566845	0.305038789
120	88	M	7	35	44	Headwind	146	3	1.153846154	0.942408377	0.211437777
121	69	M	31	45	87	Tailwind	148	3	1.232876712	0.942408377	0.290468335
122	62	M	22	45	41	Headwind	137	3	1.216216216	0.932642487	0.283573729
123	61	M	66	65	10	Headwind	159	3	1.313868613	0.891089109	0.422779504
124	65	M	91	85	78	Tailwind	132	3	1.132075472	0.737704918	0.394370554
125	48	M	54	55	99	Tailwind	158	3	1.363636364	0.962566845	0.401069519
126	21	M	37	45	24	Headwind	129	3	1.139240506	0.886699507	0.252540999
127	49	M	15	45	60	Tailwind	149	3	1.395348837	1.034482759	0.360866079
128	9	L	15	45	64	Tailwind	130	4	1.610738255	1.237113402	0.373624853
129	56	M	8	35	77	Tailwind	152	0	3	3	0
130	52	M	67	65	43	Headwind	152	3	1.184210526	0.829493088	0.354717439
131	63	M	23	45	26	Headwind	155	3	1.184210526	0.913705584	0.270504943
132	49	M	7	35	70	Tailwind	136	3	1.161290323	0.947368421	0.213921902
133	45	M	52	55	17	Headwind	151	3	1.323529412	0.942408377	0.381121035
134	25	M	3	35	8	Headwind	155	3	1.19205298	0.967741935	0.224311045
135	12	L	27	45	73	Tailwind	117	4	1.548387097	1.2	0.348387097
136	61	M	18	45	84	Tailwind	142	0	2	2	0
137	87	M	36	45	59	Tailwind	116	3	1.267605634	0.962566845	0.305038789
138	44	M	61	65	27	Headwind	156	3	1.551724138	0.994475138	0.557249
139	43	M	89	85	30	Headwind	127	3	1.153846154	0.746887967	0.406958187
140	26	M	34	45	80	Tailwind	152	3	1.417322835	1.046511628	0.370811207
141	10	L	85	85	91	Tailwind	99	4	1.578947368	1.012658228	0.566289141
142	59	M	49	55	72	Tailwind	118	0	2	2	0
143	32	M	97	95	63	Tailwind	133	3	1.525423729	0.845070423	0.680353306
144	78	M	37	45	33	Headwind	134	3	1.353383459	1.011235955	0.342147504
145	53	M	92	85	72	Tailwind	154	3	1.343283582	0.821917808	0.521365774
146	31	M	57	65	33	Headwind	148	3	1.168831169	0.821917808	0.346913361
147	10	L	14	45	37	Headwind	115	4	1.621621622	1.243523316	0.378098306
148	28	M	58	65	29	Headwind	142	0	2	2	0
149	98	H	79	75	15	Headwind	155	0	2	2	0
150	48	M	30	45	57	Headwind	155	5	1.935483871	1.5	0.435483871
151	0	L	35	45	11	Headwind	102	4	1.548387097	1.2	0.348387097
152	91	H	72	75	32	Headwind	132	0	2	2	0
153	56	M	71	65	64	Tailwind	132	5	2.272727273	1.52284264	0.749884633
154	55	M	34	45	82	Tailwind	144	3	1.363636364	1.016949153	0.346687211
155	2	L	77	75	41	Headwind	121	4	1.666666667	1.095890411	0.570776256
156	6	L	64	65	52	Headwind	109	3	1.487603306	0.967741935	0.51986137
157	56	M	29	45	54	Headwind	125	0	2	2	0
158	83	M	83	75	55	Headwind	128	3	1.44	0.9	0.54
159	82	M	62	65	42	Headwind	128	3	1.40625	0.932642487	0.473607513
160	83	M	50	55	95	Tailwind	156	3	1.40625	0.983606557	0.422643443
161	92	H	15	45	72	Tailwind	161	0	2	2	0

162	20	M	38	55	17	Headwind	116	5	1.863354037	1.388888889	0.474465148
163	57	M	95	95	45	Headwind	128	3	1.551724138	0.853080569	0.698643569
164	49	M	50	55	54	Headwind	144	3	1.40625	0.983606557	0.422643443
165	81	M	73	75	29	Headwind	133	3	1.25	0.821917808	0.428082192
166	34	M	41	55	68	Tailwind	132	3	1.353383459	0.957446809	0.39593665
167	78	M	94	85	23	Headwind	127	3	1.363636364	0.829493088	0.534143276
168	82	M	96	95	47	Headwind	118	3	1.417322835	0.810810811	0.606512024
169	31	M	30	45	28	Headwind	146	3	1.525423729	1.104294479	0.42112925
170	24	M	20	45	63	Tailwind	154	3	1.232876712	0.942408377	0.290468335
171	25	M	39	55	17	Headwind	127	3	1.168831169	0.861244019	0.30758715
172	20	M	41	55	21	Headwind	122	3	1.417322835	0.989010989	0.428311846
173	73	M	21	45	46	Headwind	131	3	1.475409836	1.077844311	0.397565525
174	24	M	9	35	75	Tailwind	127	3	1.374045802	1.084337349	0.289708452
175	53	M	89	85	0	Headwind	128	3	1.417322835	0.849056604	0.568266231
176	10	L	53	55	39	Headwind	119	4	1.875	1.31147541	0.56352459
177	21	M	45	55	74	Tailwind	137	0	2	2	0
178	10	L	82	75	26	Headwind	87	4	1.751824818	1.132075472	0.619749346
179	40	M	59	65	25	Headwind	120	0	2	2	0
180	31	M	37	45	65	Tailwind	159	3	1.5	1.090909091	0.409090909
181	68	M	25	45	85	Tailwind	126	3	1.132075472	0.882352941	0.249722531
182	47	M	87	85	18	Headwind	150	3	1.428571429	0.853080569	0.57549086
183	78	M	69	65	33	Headwind	152	3	1.2	0.837209302	0.362790698
184	24	M	45	55	87	Tailwind	134	3	1.184210526	0.869565217	0.314645309
185	3	L	16	45	5	Headwind	90	4	1.791044776	1.340782123	0.450262653
186	0	L	11	45	81	Tailwind	115	3	2	1.333333333	0.666666667
187	19	M	92	85	1	Headwind	152	0	2	2	0
188	26	M	0	25	96	Tailwind	142	3	1.184210526	1.016949153	0.167261374
189	54	M	57	65	14	Headwind	151	3	1.267605634	0.869565217	0.398040416
190	35	M	14	45	43	Headwind	140	3	1.19205298	0.918367347	0.273685633
191	47	M	1	35	53	Headwind	156	3	1.285714286	1.028571429	0.257142857
192	92	H	10	35	84	Tailwind	149	0	3	3	0
193	92	H	64	65	18	Headwind	153	4	1.610738255	1.121495327	0.489242928
194	20	M	36	45	18	Headwind	129	5	1.960784314	1.515151515	0.445632799
195	1	L	13	45	48	Headwind	116	4	1.860465116	1.379310345	0.481154771
196	35	M	31	45	50	Headwind	131	0	2	2	0
197	44	M	86	85	23	Headwind	133	3	1.374045802	0.833333333	0.540712468
198	63	M	48	55	22	Headwind	147	3	1.353383459	0.957446809	0.39593665
199	82	M	31	45	12	Headwind	137	3	1.224489796	0.9375	0.286989796
200	12	L	11	45	49	Headwind	95	4	1.751824818	1.318681319	0.433143499
201	75	M	92	85	88	Tailwind	122	0	2	2	0
202	16	M	22	45	53	Headwind	158	3	1.475409836	1.077844311	0.397565525
203	88	M	5	35	50	Headwind	134	3	1.139240506	0.932642487	0.206598019
204	24	M	56	65	78	Tailwind	158	3	1.343283582	0.904522613	0.438760969
205	7	L	61	65	74	Tailwind	113	4	1.518987342	1.076233184	0.442754158
206	44	M	84	85	27	Headwind	155	0	2	2	0
207	12	L	69	65	94	Tailwind	93	4	1.548387097	1.090909091	0.457478006
208	24	M	80	75	39	Headwind	148	0	2	2	0
209	65	M	7	35	54	Headwind	126	3	1.216216216	0.983606557	0.232609659
210	13	L	20	45	60	Tailwind	110	4	1.904761905	1.403508772	0.501253133
211	13	L	81	75	20	Headwind	112	3	1.636363636	0.972972973	0.663390663
212	48	M	32	45	36	Headwind	150	0	2	2	0
213	9	L	1	35	91	Tailwind	94	4	1.6	1.297297297	0.302702703
214	97	H	56	65	55	Headwind	151	0	2	2	0

DISCUSSION

The TIA uses a thorough Time-based approach to separation in the aerodrome during the approach. As considered in the study, two aircraft's at the same level have longitudinal separations of a few minutes as assigned by the TIA. For low true airspeeds the separation may be up to 10 minutes to up to 2 minutes. Using Heathrow's ETBS, a comparative analysis can be made between the two. The buffer can be added to avoid uncertainty in terms of immediate wind changes, flying patterns, and so on Further, TBS is a system based on the fundamental assumption that strong winds dissipate wake vortices rapidly, making the time estimates workable in such that in terms of the designated period, the preceding aircraft won't affect the following aircraft. However, due to some gaps and limitations in the study, it cannot be credible to fully claim that the TBS is risk-free for the TIA.

V. CONCLUSION AND FUTURE SCOPE

In a country with a single international airport and a demanding schedule, time saving is a key criteria to maintain/ future proof TIA's operations. With an increase in flight activity by 5.7 percent over the last two years, the TIA is continually growing as a busy airport. Further the availability of a single runway with harsh conditions, delays and cancellations have become a norm to the TIA.

Using the TBS an annual saving of 20 days can be predicted using the empirical model. A tentative idea can be drawn from the concept that TBS will be fruitful in terms of time-saving for the TIA. It can be concluded however, that to fully establish the credibility and feasibility of the TBS at TIA, further works must be assessed and the limitations mentioned above should be fully complied.

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