



ICAO

International Civil Aviation Organization

The Seventh Meeting of the Asia/Pacific Aerodrome Design and Operations Task Force (AP-ADO/TF/7)

(Bangkok, Thailand, 17 to 20 February 2026)

Agenda Item 4: Planning, Design, Construction and Operation of Aerodromes

INTERSECTION TAKE OFF HOLDING POSITION INDICATOR – CONCEPT

(Presented by INDIA/BANGALORE INTERNATIONAL AIRPORT LIMITED)

SUMMARY

Intersection take-offs are a routine operational choice for many Code C aircraft at major international airports and a tool for capacity enhancement. However, limited lateral separation between center lines of runway and parallel taxiway introduces potential safety hazards, particularly wingtip/tail tip collision risks. This paper presents the results of a study conducted at Kempegowda International Airport (VOBL), Bengaluru, focusing on the development and implementation of a specialized Intersection Take Off Holding Indicator system. This working paper proposes visual and illuminated guidance solutions to ensure safe alignment and clearance for departing aircraft during intersection take-offs.

1. INTRODUCTION

1.1 A presentation on introduction of Intersection Take Off Holding Position Indicator Concept was presented by India (Kempegowda International Airport, Bengaluru) in the Ninth Meeting of Aerodrome Operations and Planning Sub-Group (AOP/SG/9) at Bangkok, Thailand from 30 June to 4 July 2025. The paper was widely accepted by the APAC & FAA members, and it was directed at the meeting to present in the next Asia/Pacific Aerodrome Design and Operations Task Force (AP-ADO/TF) meeting, considering the requirement for further technical analysis.

1.2 The International Civil Aviation Organization (ICAO) and the Directorate General of Civil Aviation (DGCA) India have established design standards for minimum taxiway separation distances through ICAO Annex 14, Volume I, Paragraph 3.9.7, Table 3-1 (Recommendation), and DGCA CAR Section 4BI, Paragraph 3.9.7, Table 3-1 (Standard), respectively. These documents serve as the foundational references for aerodrome design in this context.

Table 3-1. Taxiway minimum separation distances

Code letter	Distance between taxiway centre line and runway centre line (metres)								Taxiway centre line to taxiway centre line (metres)	Taxiway, other than aircraft stand taxiway, centre line to object (metres)	Aircraft stand centre line to aircraft stand taxiway centre line (metres)	Aircraft stand taxiway centre line to object (metres)
	Instrument runways				Non-instrument runways							
	Code number	Code number	Code number	Code number	Code number	Code number	Code number	Code number				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	77.5	77.5	–	–	37.5	47.5	–	–	23	15.5	19.5	12
B	82	82	152	–	42	52	67	–	32	20	28.5	16.5
C	88	88	158	158	48	58	73	93	44	26	40.5	22.5
D	–	–	166	166	–	–	81	101	63	37	59.5	33.5
E	–	–	172.5	172.5	–	–	87.5	107.5	76	43.5	72.5	40
F	–	–	180	180	–	–	95	115	91	51	87.5	47.5

1.3 A critical note from the referenced table states: **“Note 2: The distances in columns (2) to (9) do not guarantee sufficient clearance behind a holding aeroplane to permit the passing of another aeroplane on a parallel taxiway. See the ICAO Aerodrome Design Manual, Part 2.”** This highlights the necessity of conducting an aeronautical study to assess and ensure adequate clearance in such scenarios.

1.4 Operational data indicates frequent use of intersection take-offs by Code C aircraft, prompting a reassessment of the associated safety and efficiency implications. The current aerodrome layout, particularly the lateral separation between the runway centre line and the adjacent parallel taxiway, presents a potential safety risk. This is especially critical during aircraft holding and departure phases, where the risk of wingtip collisions must be carefully evaluated.

1.5 This paper proposes the development and implementation of visual and illuminated guidance systems aimed at enhancing situational awareness and ensuring safe aircraft alignment and clearance during intersection take-offs. These solutions are intended to mitigate the identified risks and support safe and efficient ground operations.

2. DISCUSSION

Problem Statement

2.1 The separation distances between critical taxiway and runway infrastructure at Kempegowda International Airport (VOBL - Code 4F) are as follows:

- Taxiway Centre Line (TCL) to Runway Centre Line (RCL): 190 m (As per Table 3-1 180 m is adequate)
- Runway Centre Line (RCL) to Runway-Holding Position (RHP): 107.5 m (As per the note 3 of Table 3-2, 100 m is adequate during Code F ops)
- Remaining Distance from TCL to RHP: 82.5 m

2.2 Despite adherence to regulatory minima, practical operational constraints — especially visual reference limitations of pilots to align with the RHP and the mindset of pilots that it is required to see the RHP marking from where they stop to avoid potential runway incursion — reduce effective usage of the available area. During simultaneous operations involving taxiing aircraft on a parallel taxiway and a Code C aircraft holding for an intersection departure, the margin for error is significantly reduced.



Image 1: Aircraft Holding for Intersection Take Off before Runway Holding Position
Methodology

2.3 This aeronautical study was conducted using the following approaches:

- On-site observations during peak operations
- Aircraft performance data for typical Code C aircraft (e.g., A321, B737, ATR72)
- Line-of-sight (Cockpit cut of angle) analysis from cockpit eye-level positions
- Consultation with air traffic controllers and airline pilots (Through RST)
- Consideration of ICAO Annex 14 guidance on separation and holding practices

Analysis and Observations

2.4 Aircraft Limitations:

- The Pilot-in-Command (PIC) experiences restricted visibility during final alignment at the holding position due to aircraft-specific longitudinal down angles (Cockpit cut off angle) with reference to the Pilot’s Eye Position:
- Airbus A321/320/319 series: 20°
- Boeing 737 series: 15°
- ATR series: 18°

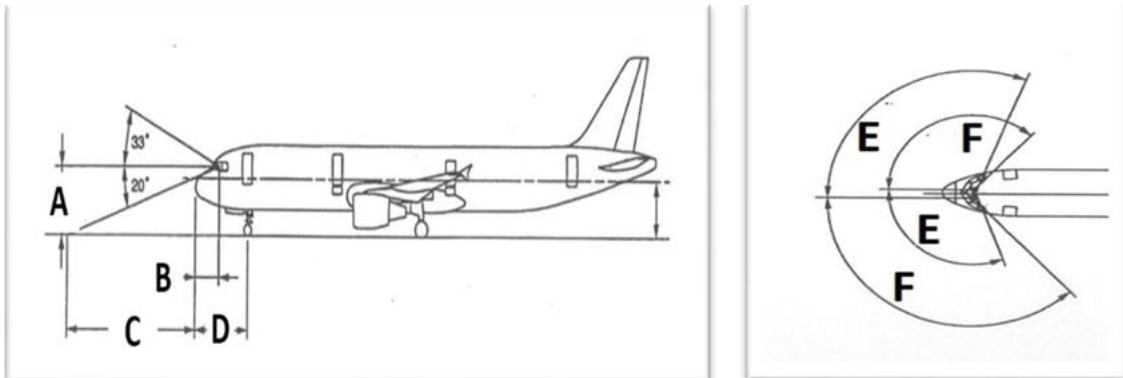


Image 2: Aircraft Characteristics

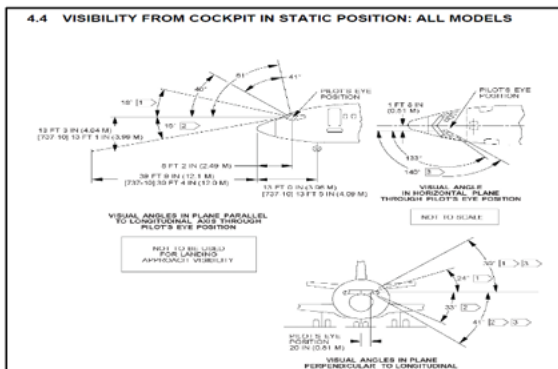


Image 3: Cut off Angle Boeing 737

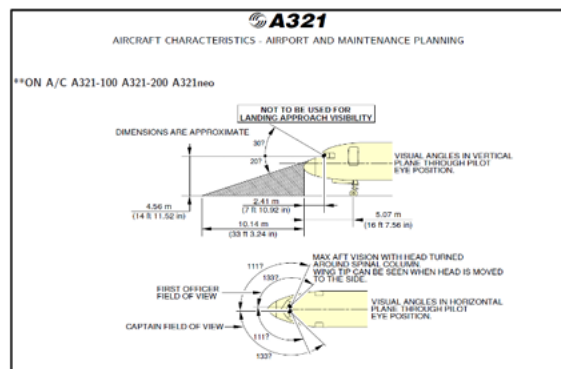


Image 4: Cut off Angle Airbus 321

Table 1: Aircraft Characteristics

TYPE	LENGTH (M)	B (M)	C (M)	Length + C (M)	B+C (M)	A (M)	D (M)	E (°Deg)	F (°Deg)
A321	44.5	2.41	10.14	54.64	12.55	4.56	5.07	111	133
A320	37.6	2.405	10.14	47.74	12.545	4.56	5.07	111	133
B737-8-200	42.11	2.49	12.1	54.21	14.59	4.04	4.09	133	140
B737-8	39.47	2.49	11.46	50.93	13.95	3.74	4.09	133	140
ATR 72	27.166	2.18	5.17	32.336	7.35	2.53	1.73	122	122
ATR 42	22.670	2.18	5.976	28.646	8.156	2.65	1.727	122	122

2.5 Based on the comparison of Aircraft Characteristics for various aircrafts as shown in above Image 2 and Table 1, A321 is selected as the critical aircraft for this study.

Table 2: Minimum Separation Distances b/w RWY Centre Line & TWY Centre Line (All Dimensions in Meter)

Code Letter	RWY Code 1/2	RWY Code 3/4
A	77.5	
B	82	152
C	88	158
D		166
E		172.5
F		180

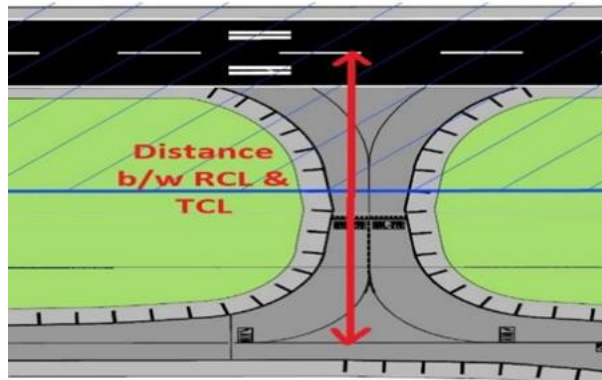
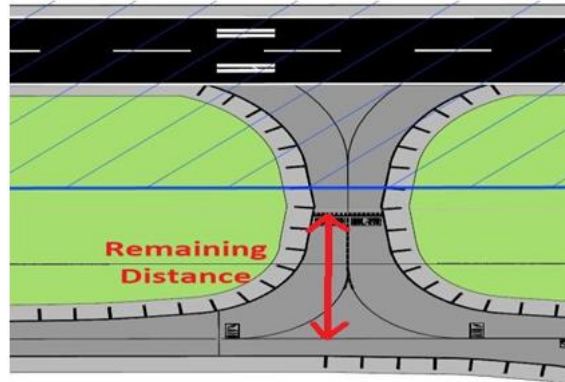


Table 3: Minimum Separation Distance b/w RWY Centre Line and RWY Holding Position (All Dimensions in Meter)

Type of RWY	RWY Code 1/2	RWY Code 3/4
Non-Instrument	30/40	75
Non-Precision Approach (Non-PA)	40	75
PA CAT 1	60	90
PA CAT 2		90
Code F		100
Take Off	30/40	75

Table 4: Remaining Separation Distances from RHP to TCL
(All Dimensions in Meter)

Code Letter	RWY Code 1	RWY Code 2	RWY Code 3	RWY Code 4
A	17.5			
B		22	62	62
C		28	68	68
D				76
E				82.5
F				80



2.6 When the data from Table 3 computed with the effective length (Actual Length + C) of Airbus 321 i.e. 54.64 m. Considering the visual limitations of the Pilot-in-Command (PIC) for various types of Code C aircraft, and the width of Pattern A2 type RHP which is 2.1 m (Pattern A1 will not be valid after 2026), the maximum remaining distance available behind the tail is as follows (All Dimensions in Meter):

Code Letter	RWY Code 3/4 (Remaining Distance – A321 Effective Length – RHP width)
C	$68 - 54.64 - 2.1 = 11.26$
D	$76 - 54.64 - 2.1 = 19.26$
E	$82.5 - 54.64 - 2.1 = 25.76$
F	$80 - 54.64 - 2.1 = \mathbf{23.26}$

2.7 These values indicate that the available clearance is insufficient to prevent wingtip overlap with aircraft on the adjacent taxiway. For a Code 4F Airport Operator, merely a distance of 5.26 m is remaining {Requirement is 8 m (18 m ½ wingspan + 8 m separation = 26 m)} from wingtip of a Code C aircraft taxiing behind to the A321 holding on an intersection. Therefore, simultaneous operations involving a Code C aircraft holding for intersection take-off and another Code C aircraft taxiing parallel pose a significant risk of wingtip collision.

2.8 Further, these calculations reveal that taxiing an aircraft on a parallel taxiway behind an aircraft holding is possible only when both types of aircraft are Code C and below, when the aircraft holding on RHP is positioned as close as possible without considering the cockpit cut of angle. These calculations are possible when the runway is 4E or 4F wherein the separation from runway centre line to taxiway centre line is at least 180 m and runway holding position is at 90 m for Code E & 100 m for code F.

2.9

Safety Risk:

- Presence of an aircraft on the adjacent taxiway during intersection hold can result in near misses or loss of separation.
- Existing painted markings provide situational awareness towards front only as the markings are towards front of the aircraft.
- Existing Stop bar lights / Runway Guard Lights provide situational awareness towards front under low visibility conditions as they are aligned with RHP markings.



Image 5: RHP Marking for a Code F Taxiway

2.10

Operational Constraints:

- ATC routinely issues intersection take-off clearances to optimize runway occupancy.
- While Code D/E/F aircraft typically use the full runway length — minimizing intersection conflicts — Code C aircraft face alignment and clearance challenges during intersection departures.
- When a Code D/E/F aircraft is holding on the intersection take off taxiways, no other aircraft is permitted to taxi behind on parallel taxiway and when Code C aircraft is holding on the intersection take off taxiways, Code D/E/F aircraft is not permitted to taxi behind on parallel taxiway. (at VOBL)

Hence, it is required to take advantage of sidewise visibility of cockpits where cockpit cut off angle is minimal.



Image 6: B737 When held on RHP – Sidewise view

Proposed Mitigation Measures

2.11

To address the identified safety and operational risks associated with intersection take offs, the implementation of an Intersection Take Off Holding Position Indicator (ITOHPI) system is proposed. This system integrates visual, lighting, and informational enhancements to improve pilot situational awareness and ensure safe aircraft alignment.

Visual Marking Enhancements

- **Chevron or Zigzag Pattern Markings:** Application of distinctive surface markings at designated holding positions to enhance visual recognition during day operations.
- **High-Contrast Reflective Paint:** Use of reflective materials optimized for visibility under both daytime and nighttime conditions.



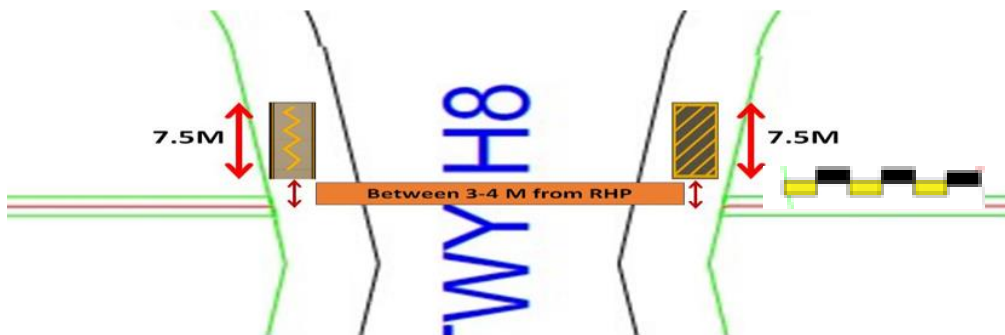
Marking Sample 1



Marking Sample 2



Marking Sample 3



Marking Sample 1

Marking Sample 2

Marking Sample 3

- Concept for Markings are displayed as Marking Sample 1 and Marking Sample 2, which can be marked on shoulders for optimizing the available distance for positioning before RHP.
- Considering the 'B' values from Table 1 Aircraft Characteristics, the ITOHPI marking to be placed between 3-4m from RHP.
- Length & Width can be optimized with a range from 7-10 m & 2-4 m, respectively, for conspicuity.

Lighting Systems

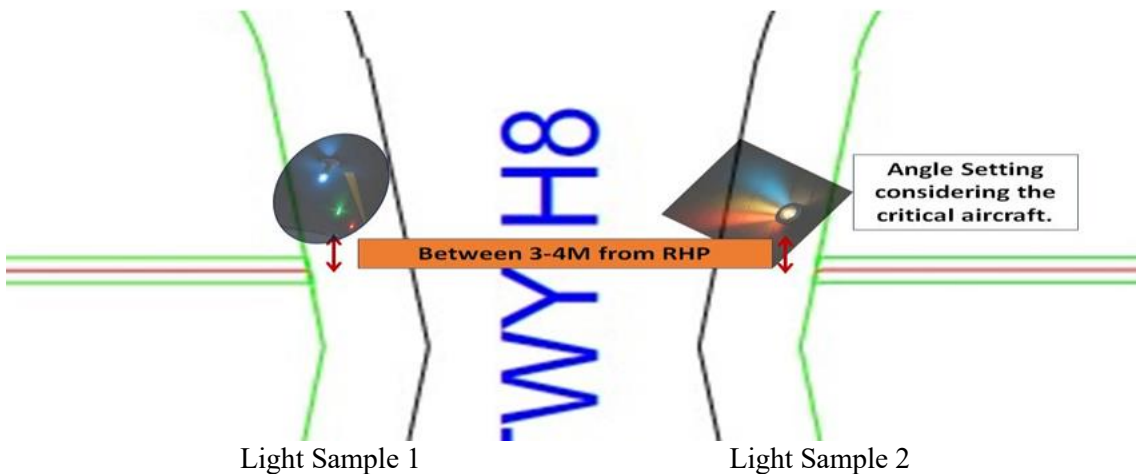
- **Flush or Mounted LED Lighting:** Installation of combination of blue, yellow and red LED lights at shoulder zones to indicate proximity to the RHP.
- **Sequential Illumination Patterns:** Dynamic lighting sequences to guide aircraft precisely to the optimal holding line, improving alignment accuracy.



Light Sample 1



Light Sample 2



- Concept for Lighting are displayed as Light Sample 1 and Light Sample 2, which can be installed on shoulders for optimizing the available distance for positioning before RHP.

- Considering the ‘B’ values from Table 1 Aircraft Characteristics, the ITOHPI Light to be placed between 3-4 m from RHP.
- Light Sample 1 is a combination of three lights, where first light being same as TWY Edge light, second can be either green or yellow and last light to be Red.
- Similarly, for Light Sample 2, an inset light flushing coverage on ground with an angular coverage considering the ‘E & F’ values from Table 1 Aircraft Characteristics.

Sign

- Considering the day and night requirements, following sign is proposed to increase the conspicuity and convenience of pilot community. This sign can be of similar size of runway designation sign placed at distance of 7 m from the RHP.



Pilot Awareness

- **Chart Integration:** Inclusion of intersection hold point coordinates in Jeppesen and other aeronautical charts to support pre-flight planning.
- **Electronic Flight Bag (EFB) Integration:** Incorporation of visual guidance cues into EFB systems to assist pilots during taxi and hold phases.

Expected Benefits

2.12 The implementation of the Intersection Take Off Holding Position Indicator (ITOHPI) system offers several operational and safety advantages:

- **Improved Wingtip Clearance Awareness:** Enhances the Pilot-in-Command’s (PIC) ability to accurately assess lateral clearance during intersection alignment, reducing the risk of wingtip conflicts.
- **Reduced Air Traffic Controller Workload:** Provides clear and intuitive visual cues, minimizing the need for repeated verbal instructions and enhancing controller efficiency.

- **Optimized Runway Utilization:** Supports efficient runway occupancy and throughput without compromising safety margins.
- **Compliance with ICAO Safety Objectives:** Aligns with ICAO’s strategic goals for runway incursion prevention and strengthens the implementation of Aerodrome Safety Management Systems (SMS).

Compliance & Regulatory Consideration

2.13 The proposed Intersection Take Off Holding Position Indicator (ITOHPI) system is designed in alignment with the following international and national regulatory frameworks:

- ICAO Annex 14 – Volume I (Aerodrome Design and Operations)
- DGCA CAR 4BI - AERODROME DESIGN AND OPERATIONS
- ICAO Doc 9981 – PANS-Aerodromes
- Safety Management Systems (ICAO Annex 19)

2.14 This concept may be recommended as a best Practice and holds potential for future consideration within ICAO Standards and Recommended Practices (SARPs).

Conclusion

2.15 As air traffic volumes continue to grow, the need to optimize intersection take-off procedures becomes increasingly critical for high-capacity airports. This study presents a practical and innovative solution to a complex safety challenge at KIAB and applicable to all major 4E and 4F airports. The proposed holding guidance system effectively addresses spatial and visual limitations faced by pilots, while contributing to broader global initiatives aimed at enhancing the safety, efficiency, and intelligence of runway operations.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note the information contained in this paper;
- b) discuss any relevant matters as appropriate;
- c) conduct a pilot trial of the ITOHPI system at selected intersection points;
- d) submit the operational results to ICAO APAC Office for regional review and respective states for review;
- e) explore adaptation and scalability at other Code 4 aerodromes with similar layouts; and
- f) based on acceptance, recommend changes to ICAO SARPS.

Intersection Take Off Holding Position Indicator - Concept

Presented By : Bangalore International Airport Limited, India

Background

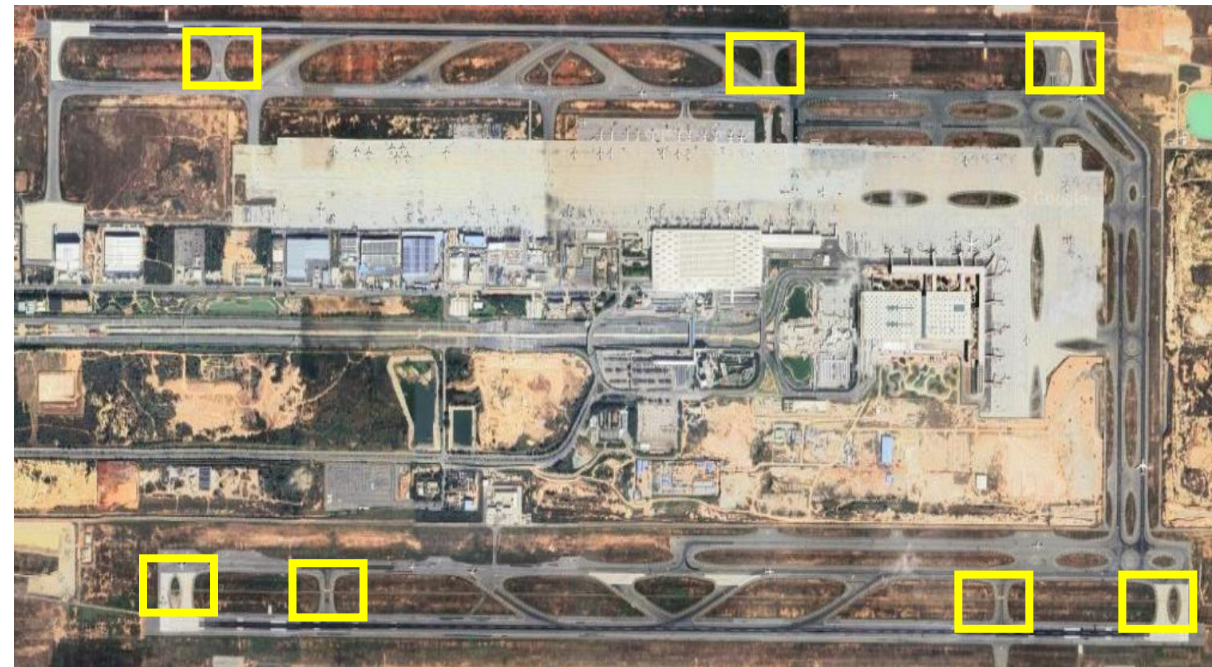
- A presentation on introduction of Intersection Take Off Holding Position Indicator Concept was presented by India (Kempegowda International Airport, Bengaluru) in the **Ninth Meeting of Aerodrome Operations and Planning Sub-Group (AOP/SG/9) at Bangkok, Thailand from 30 June to 4 July 2025**. The paper was widely accepted by the APAC & FAA members, and it was directed at the meeting **to present in the next Asia/Pacific Aerodrome Design and Operations Task Force (AP-ADO/TF) meeting, considering the requirement for further technical analysis.**

Introduction

- Intersection take-offs are a routine operational choice for many airports.
- Tool for capacity enhancement – Enhance throughput.
- Limited lateral separation between center lines of runway and parallel taxiway
- Potential wingtip/tail tip collision risks.

BLR AIP for Intersection

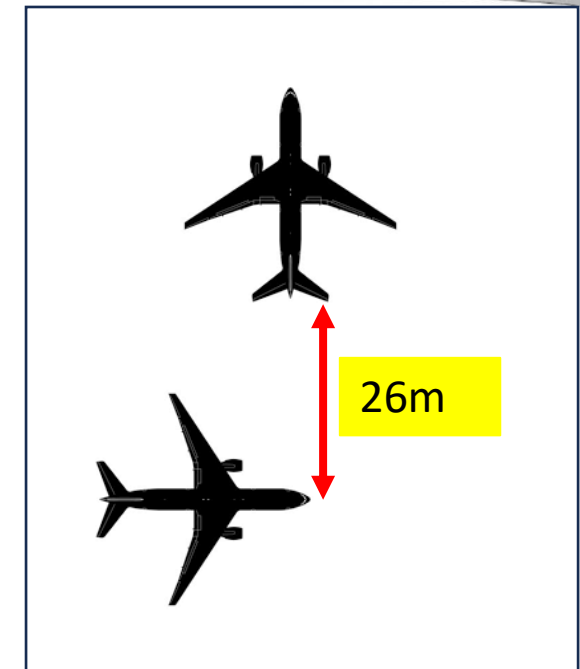
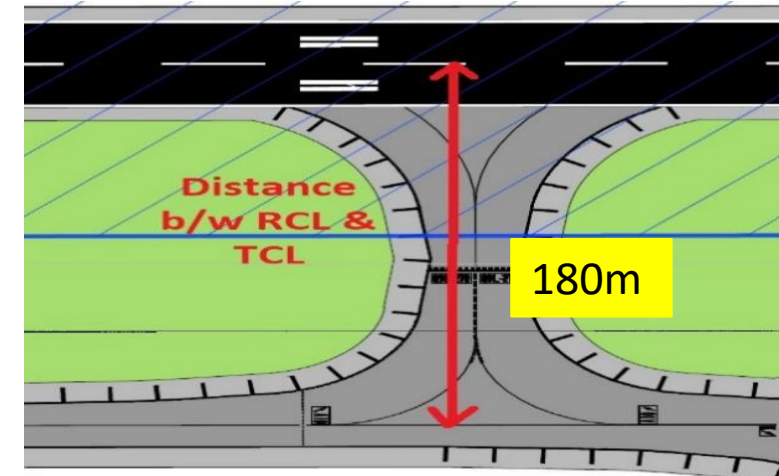
- KIAB – RCL to TCL – 190M & RHP 107.5M from RWY & 82.5M from TCL (A2 Type 2.1M width)
- No aircraft to cross behind Code D/E/F at RHP
- No Code D/E/F can cross behind Code C at RHP
- Only Code C can cross a Code C at RHP.



Problem Statement

Table 3-1. Taxiway minimum separation distances

Code Letter	Distance between taxiway centre line and runway centre line (metres)								Taxiway centre line to taxiway centre line (metres)	Taxiway other than aircraft stand taxilane, centre line to object (metres)	Aircraft stand taxiway centre line to aircraft stand taxilane centre line (metre)	Aircraft stand taxilane centre line to object (metres)
	Instrument runways Code number				Non-instrument runways Code number							
	1	2	3	4	1	2	3	4				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	77.5	77.5	-	-	37.5	47.5	-	-	23	15.5	19.5	12
B	82	82	152	-	42	52	87	-	32	20	28.5	16.5
C	88	88	158	158	48	58	93	93	44	26	40.5	22.5
D	-	-	166	166	-	-	101	101	63	37	59.5	33.5
E			172 5	172.5	-	-	107. 5	107.5	76	43.5	72.5	40
F			180	180	-	-	115	115	91	51	87.5	47.5



Note 2: The distances in columns (2) to (9) **do not guarantee sufficient clearance behind a holding aeroplane to permit the passing of another aeroplane** on a parallel taxiway. Sufficient clearances may be ensured in such cases. See the ICAO Aerodrome Design Manual, Part 2.

Present Scenario

Distance RCL to RHP - **100m (code F)**

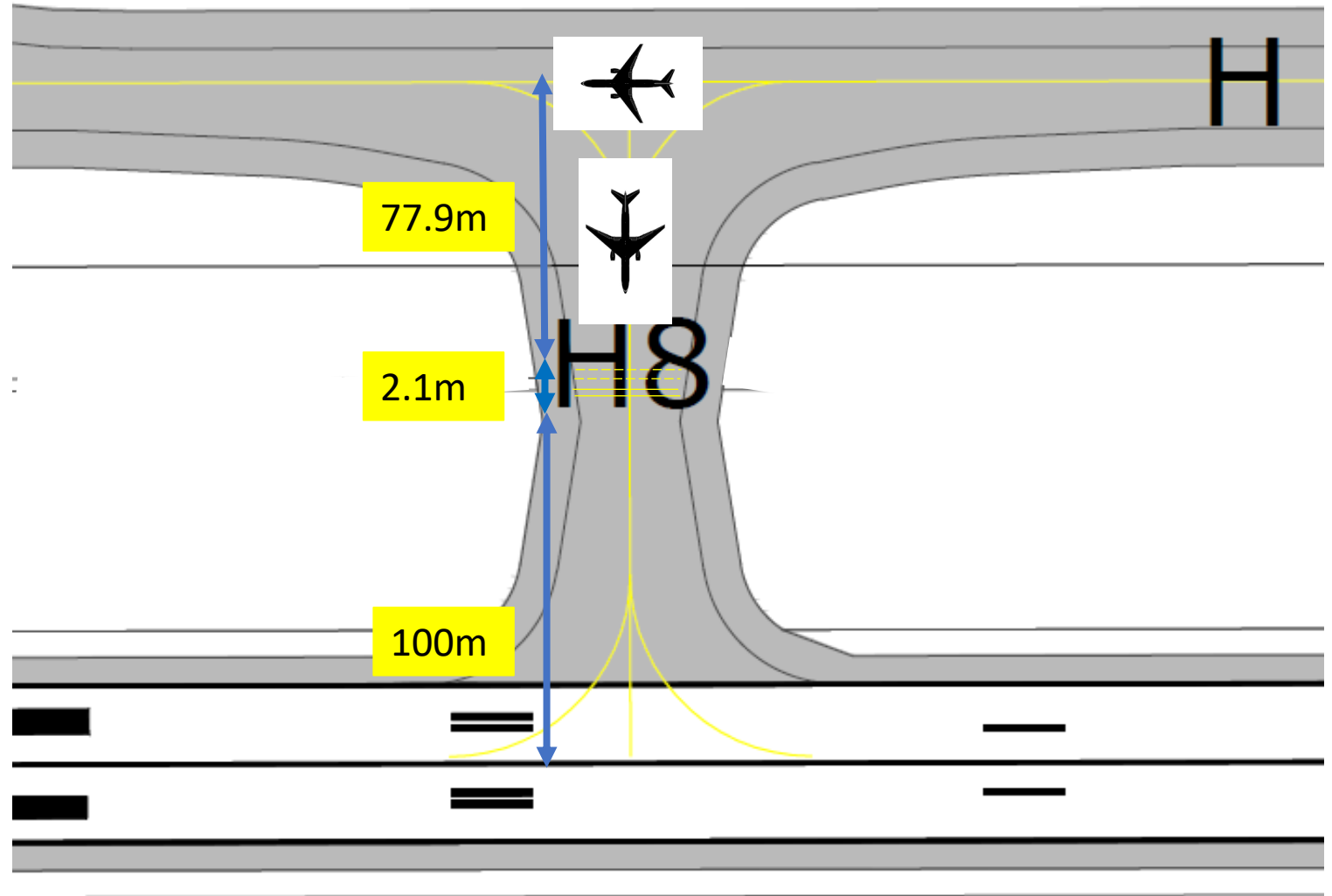
Width of RHP - **2.1m (Type 2)**

Remaining Distance - **77.9m**

Max Code C Length - **44.5m (A321)**

Separation - **26m**

Margin - **7.4m** (Tail Tip to Wing Tip)



Present Scenario



Visual reference limitations (Marking & RGL – Day ; Stop bar & RGL - Night of pilots to align with the RHP and the mindset of pilots - required to see the RHP marking from where they stop to avoid potential runway incursion – Reduces the margin



Methodology

This aeronautical study was conducted using the following approaches:

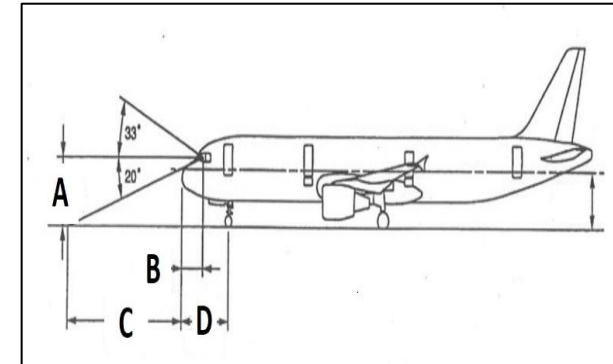
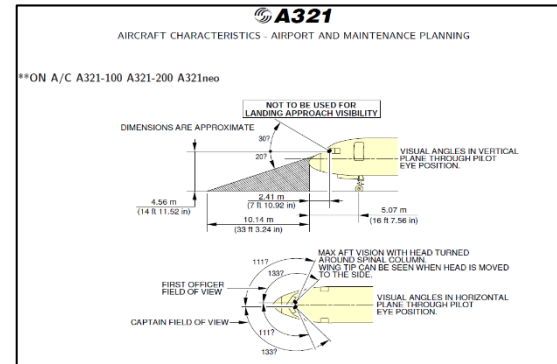
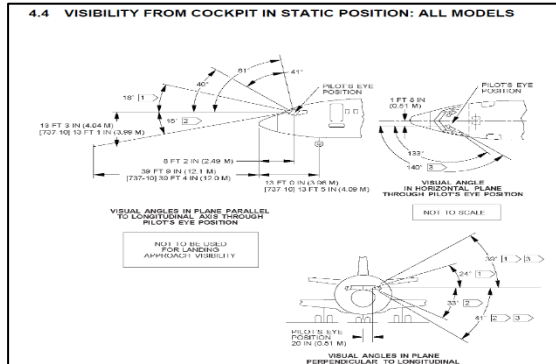
- On-site observations during peak operations
- Consultation with air traffic controllers and airline pilots (Through RST)
- Consideration of ICAO Annex 14 guidance on separation and holding practices
- Aircraft performance data for typical Code C aircraft (e.g., A321, B737, ATR72)
- Line-of-sight (Cockpit cut of angle) analysis from cockpit eye-level positions.

Aircraft Limitations:

The Pilot-in-Command (PIC) experiences restricted visibility during final alignment at the holding position due to aircraft-specific longitudinal down angles (Cockpit cut off angle) with reference to the Pilot's Eye Position:

- Airbus A321/320/319 series: 20°
- Boeing 737 series: 15°
- ATR series: 18°

Analysis



B738/739 – 14.59m

A320/321 – 12.55m

TYPE	LENGTH (M)	B (M)	C (M)	Length + C (M)
A321	44.5	2.41	10.14	54.64
A320	37.6	2.40 5	10.14	47.74
B737-8-200	42.11	2.49	12.1	54.21
B737-8	39.47	2.49	11.46	50.93
ATR 72	27.166	2.18	5.17	32.336
ATR 42	22.670	2.18	5.976	28.646

Code Letter	RWY Code 3/4 (Remaining Distance – A321 Effective Length – RHP width)
C	68 – 54.64 - 2.1 = 11.26
D	76 – 54.64 - 2.1 = 19.26
E	82.5 – 54.64 - 2.1 = 25.76
F	80 – 54.64 - 2.1 = 23.26

Analysis

Table 2: Minimum Separation Distances b/w RWY Centre Line & TWY Centre Line
(All Dimensions in Meter)

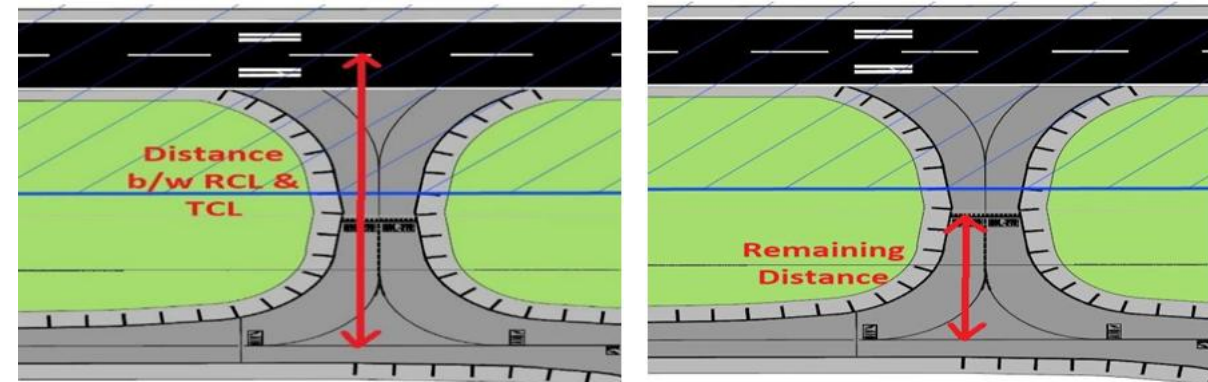
Code Letter	RWY Code 1/2	RWY Code 3/4
A	77.5	
B	82	152
C	88	158
D		166
E		172.5
F		180

Table 4: Remaining Separation Distances from RHP to TCL
(All Dimensions in Meter)

Code Letter	RWY Code 1	RWY Code 2	RWY Code 3	RWY Code 4
A	17.5			
B		22	62	62
C		28	68	68
D				76
E				82.5
F				80

Table 3: Minimum Separation Distance b/w RWY Centre Line and RWY Holding Position
(All Dimensions in Meter)

Type of RWY	RWY Code 1/2	RWY Code 3/4
Non-Instrument	30/40	75
Non-Precision Approach (Non-PA)	40	75
PA CAT 1	60	90
PA CAT 2		90
Code F		100
Take Off	30/40	75



Analysis

- Data from Table 3 computed with the effective length (Actual Length + C) of Airbus 321 i.e. **54.64 m**.
- Considering the visual limitations of PIC & width of Pattern A2 type RHP which is 2.1 m maximum remaining distance available behind the tail.

Code Letter	RWY Code 3/4 (Remaining Distance – A321 Effective Length – RHP width)
C	$68 - 54.64 - 2.1 = 11.26$
D	$76 - 54.64 - 2.1 = 19.26$
E	$82.5 - 54.64 - 2.1 = 25.76$
F	$80 - 54.64 - 2.1 = \underline{23.26}$

- Clearance is insufficient to prevent wingtip overlap with aircraft on the adjacent taxiway.
- Distance Remaining - **5.26 m** {Requirement is **8 m** (18 m $\frac{1}{2}$ wingspan + 8 m separation = **26 m**)}
- Simultaneous operations involving a Code C aircraft holding for intersection take-off and another Code C aircraft taxiing parallel pose a **significant risk of wingtip collision**.
- Taxiing an aircraft on a parallel taxiway behind an aircraft holding is possible - both types of aircraft are **Code C and below**, when the aircraft holding on RHP is **positioned as close as possible without considering the cockpit cut of angle**.

Safety Risk

- Presence of an aircraft on the adjacent taxiway during intersection hold can result in near misses or loss of separation.
- Existing painted markings provide situational awareness towards front only as the markings are towards front of the aircraft.
- Existing Stop bar lights / Runway Guard Lights provide situational awareness towards front under low visibility conditions as they are aligned with RHP markings.

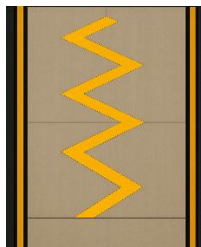
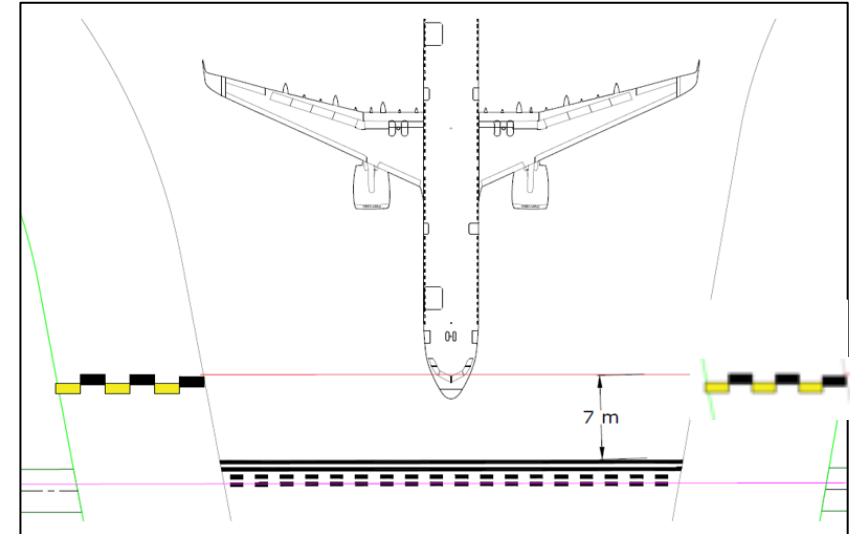


RHP Marking on a Code F Taxiway



B737 When held on RHP – Sidewise view

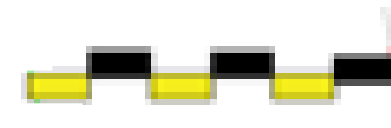
Proposal (Markings)



Sample -1



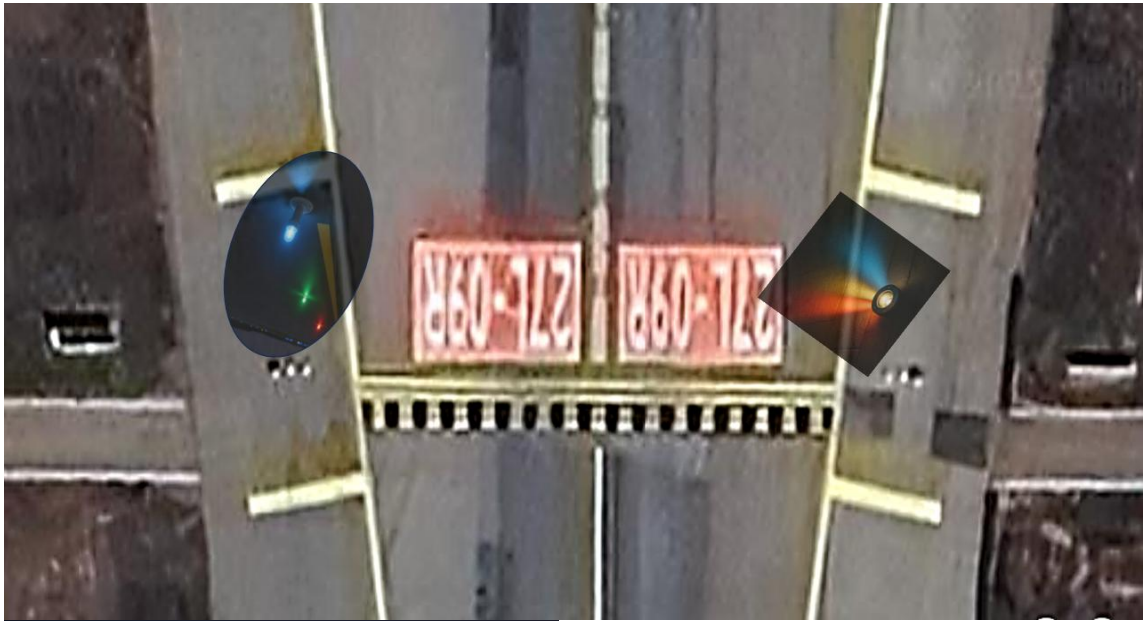
Sample -2



Sample -3

- Considering 'B' Value – ITOHPI marking to be placed between 3-4m from RHP
- Size of marking – 2-4 or 7-10m as appropriate.

Proposal (Lights & Sign)



Sample -1



Sample -2



Sample -1

- Considering 'B' Value – ITOHPI light to be placed between 3-4m from RHP

Advantages

Intersection Take-Off Holding Position Indicator (ITOHPI)

- **Improved Wingtip Clearance Awareness:** Enhances the Pilot-in-Command's ability to accurately assess lateral clearance, reducing the risk of wingtip conflicts.
- **Reduced Air Traffic Controller Workload:** Provides clear and intuitive visual cues, minimizing the need for repeated verbal instructions and enhancing controller efficiency.
- **Optimized Runway Utilization:** Supports efficient runway occupancy and throughput without compromising safety margins.
- **Compliance with ICAO Safety Objectives:** Aligns with ICAO's strategic goals for runway incursion prevention and strengthens the implementation of Aerodrome Safety Management Systems (SMS).

Conclusion

- Note the information contained in this paper;
- Discuss any relevant matters as appropriate;
- Conduct a pilot trial of the ITOHPI system at selected intersection points;
- Submit the operational results to ICAO APAC Office for regional review and respective states for review;
- Explore adaptation and scalability at other Code 4 aerodromes with similar layouts; and
- Based on acceptance, recommend changes to ICAO SARPS.

THANK YOU

Bangalore International Airport Limited