Analysis of 2NM Separation for Minimal Pair Arrivals

Investigating the relationship between separation minima and runway occupancy time

Alan R. Groskreutz

SESAR Innovation Days

Dec 2, 2015

Overview

- Introduction
- Proposed Minimal-Pair separation reduction
- Dependency on Runway Occupancy Time
- Operational Recommendations
- Conclusions

Introduction

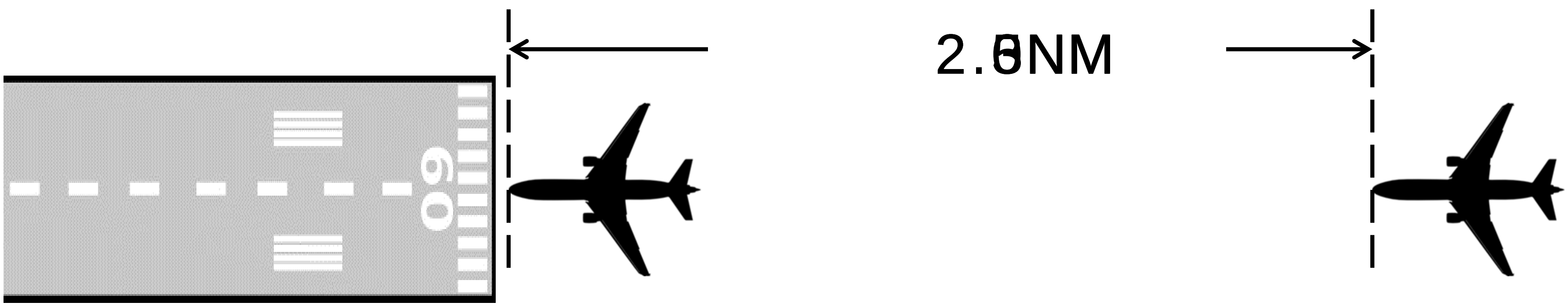
- Objective
  - Increase arrival capacity through reduced separation minima
  - RECAT-EU is focused on wake turbulence separations
  - This research focused on reducing the Minimal-Pair separations

Arrivals			Follower					
			J	H		M		L
			A	B	C	D	E	F
Leader	J	A	3.0	4.0	5.0	5.0	6.0	8.0
	H	B	SM	3.0	4.0	4.0	5.0	7.0
		C	SM	SM	3.0	3.0	4.0	6.0
	M	D	SM	SM	SM	2.5	2.5	5.0
		E	SM	SM	SM	SM	2.5	4.0
	L	F	SM	SM	SM	SM	SM	3.0

Introduction

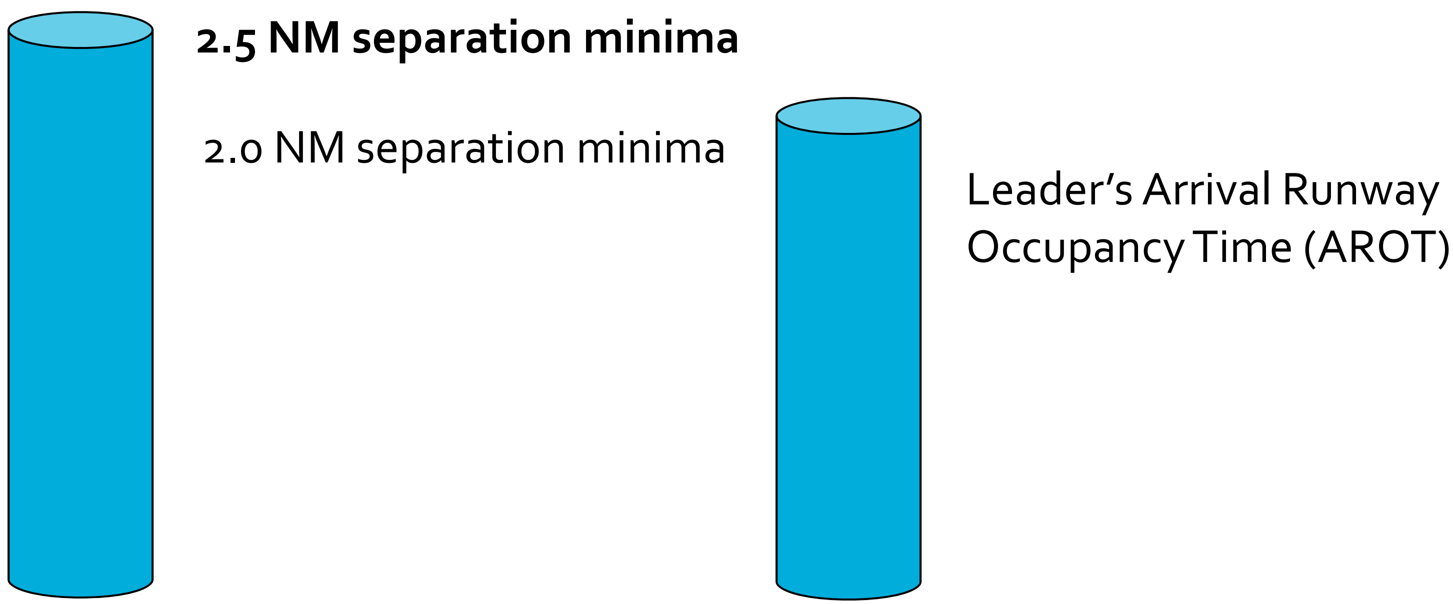
- Standard ICAO MP arrival separation – 3NM
- In specific conditions and equipment – 2.5NM
- Research to reduce to 2NM

  with Required Surveillance Performance conditions



Introduction

- Proposed reduction can change the “long pole in the tent” of arrival capacity.



Problem definition

- How big of a problem is the interdependency?
  - It Depends
    - Traffic mix
    - Exit location
    - Exit type
- Ran two independent simulations to see effects
  - 1) PICAP simulation
  - 2) Theoretical simulation

Traffic Mix

A (J)	B (H)	C (C)	D (M)	E (S)	F (L)
A388 A124	A332 A333 A342 A343 A345 A346 AN22 B744 B748 B772 B773 B77L B77W B788 B789 IL96	A306 A30B A310 B703 B752 B753 B762 B763 B764 B783 C135 DC10 DC85 IL76 L101 MD11 TU22 TU95 C17	A318 A319 A320 A321 AN12 B737 B738 B739 C130 IL18 MD81 MD82 MD83 MD87 MD88 MD90 T204 TU16 B722 A400	AN32 AT43 AT45 AT72 B462 (RJ85) B712 B732 B733 B734 B735 CL30 CL60 CRJ1 CRJ2 CRJ7 CRJ9 DC93 DH8D E135	FA10 FA20 D328 E120 BE40 BE45 H25B JS32 JS41 LJ35 LJ60 SF34 P180 C650 C525 C180 C152 C421 C172 BE20

Aircraft type per category

CATEGORY	Scenario 50%	Scenario 70%	Scenario 80%
Super Heavy (A)	5%	2%	0%
Upper Heavy (B)	10%	8%	5%
Lower Heavy (C)	30%	20%	15%
Upper Medium +Lower Medium (D+E)	50%	70%	80%
Light (F)	5%	0%	0%

Category mix per scenario

PICAP Simulation definition

- Three types of AROT used
  - **Unfavorable AROTs** - real values, based on current operational statistic times at ENAIRE airports
  - **Favourable AROTs** - real values, based on current operational statistic times at ENAIRE airports
  - **Optimal AROTs** - predicted values, based on future AROT reduction techniques implemented

PICAP Simulation definition

AIRCRAFT CATEGORY	Optimal		Favourable		Unfavourable	
	mean (s)	*s*	*mean (s)*	*s*	*mean (s)*	*s*
A	60	2.3	69	3	81	1.7
B	55	1.8	65	2.8	79	2.9
C	45	4.7	48	3.4	58	3.4
D	38	3.6	45	2.8	55	5
E	38	2	45	3.1	50	4.8
F	40	2.7	45	5	50	3

Distribution of the AROT values

Distribution of the independent variables

Scenario	Separation Minima (NM)	% of traffic in groups D+E (M)	ROT used (sec)
Reference (0)	2.5	50%	Unfavourable
Run #1	2.0	50%	Unfavourable
Run #2	2.0	70%	Unfavourable
Run #3	2.0	80%	Unfavourable
Run #4	2.0	50%	Favourable
Run #5	2.0	70%	Favourable
Run #6	2.0	80%	Favourable
Run #7	2.0	50%	Optimal
Run #8	2.0	70%	Optimal
Run #9	2.0	80%	Optimal

Theoretical Simulation definitions

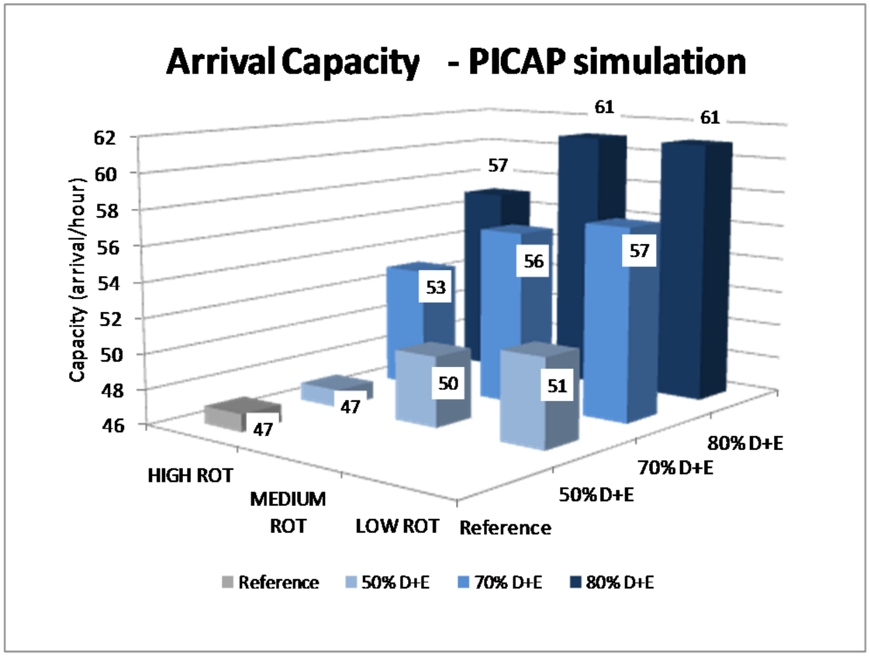
- Differences from PICAP sim
  - The theoretical study uses the lead aircraft's AROT value to design a more ideal scenario where there is no double runway occupancy.
  - Arrival separations were based on time using BADA arrival peformance values
  - AROT values were set as averages for all categories

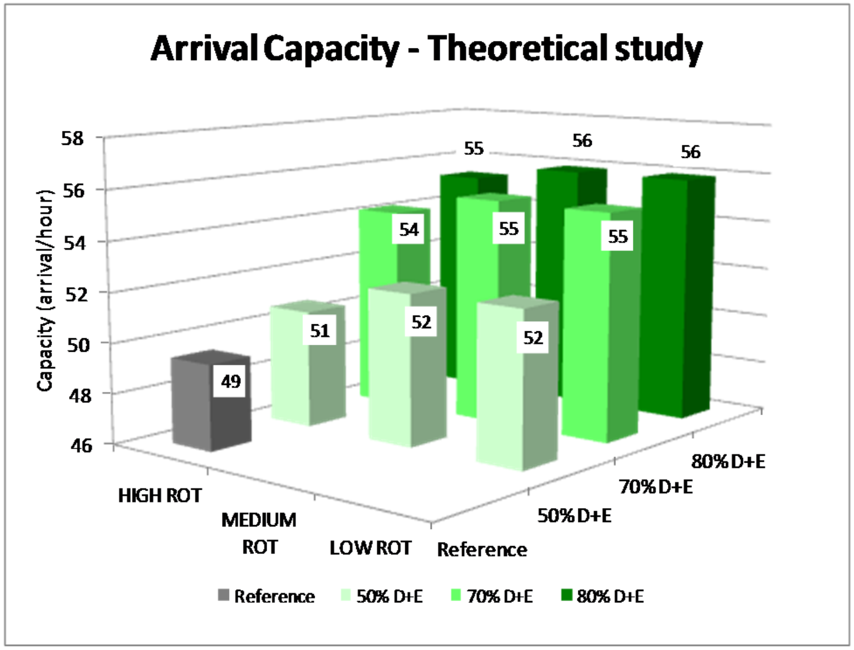
	AROT values(s)		
AIRCRAFT CATEGORY	***Optimal***	***Favourable***	***Unfavourable***
All Categories	40	45	55

  - These values are an approximated weighted mean, taking into account predominant categories (D, E) and others that are residual (A, F)

Results

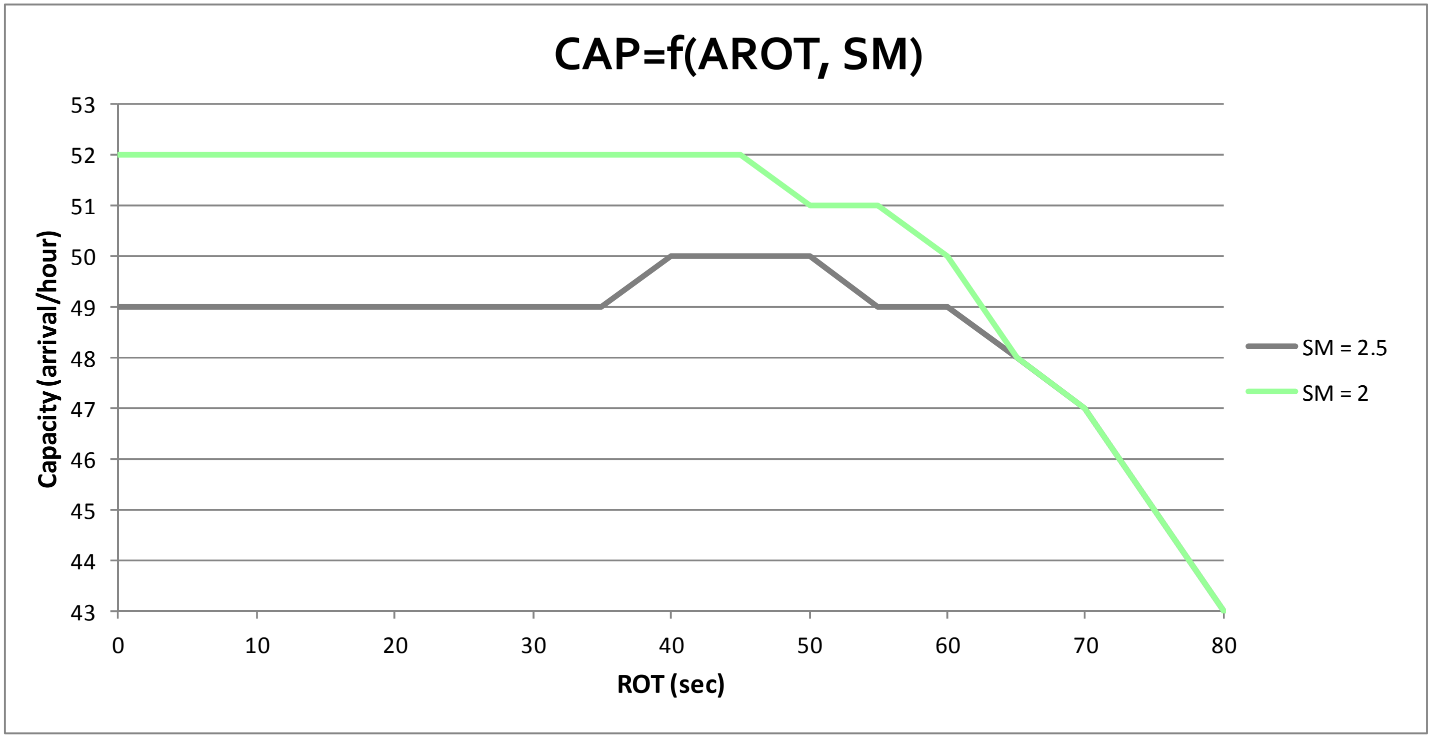
- Results show 6% - 30% capacity improvement
  - depending on the scenarios compared





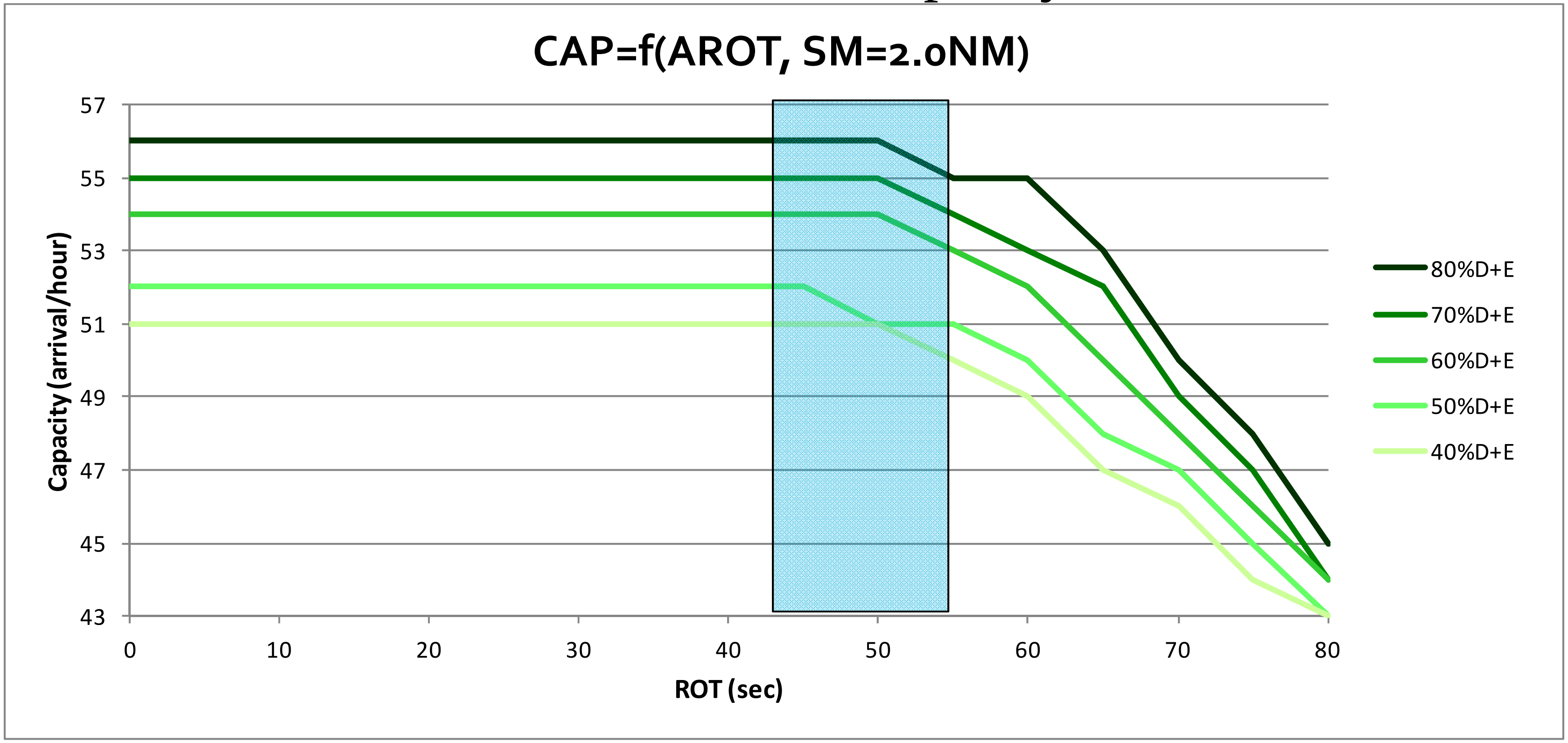
Results

- Capacity vs AROT and SM *(50% D+E)*



Results

Influence of Aircraft Fleet Mix on Capacity

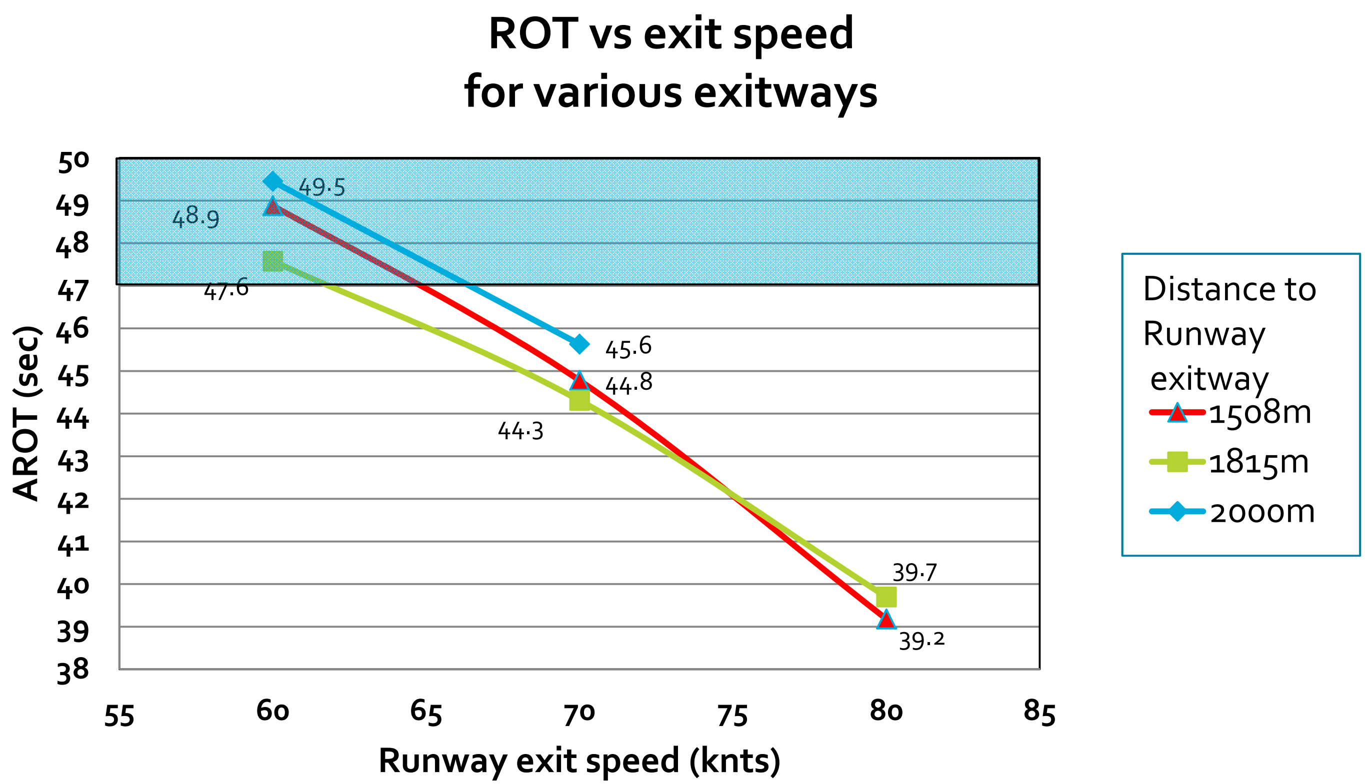


Results

- CAPACITY STABILISATION VS AROT LIMITS

AROT limit (seconds)	CAPACITY (arrival/hour)				
	80%D+E	***70%D+E***	***60%D+E***	***50%D+E***	***40%D+E***
45	56	55	54	52	51
46	56	55	54	52	51
47	56	55	54	52	51
48	56	55	54	52	**51**
49	56	55	54	**52**	50
50	56	55	**54**	51	50
51	56	55	53	51	50
52	**56**	**55**	53	51	50
53	55	54	53	51	50
54	55	54	53	51	50
55	55	54	53	51	50

Results



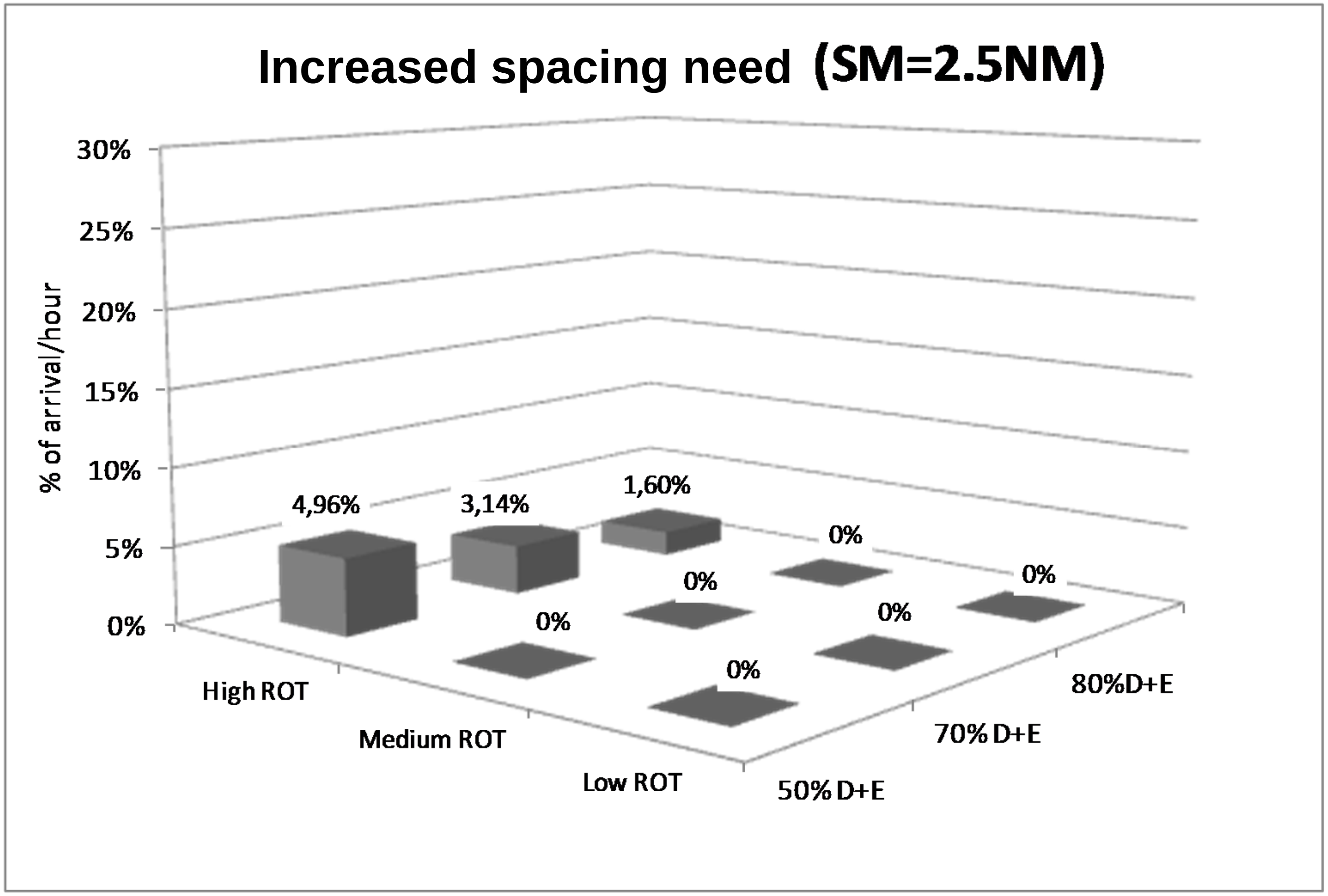
Taken from - S.H. Goldthorpe, Sensitivity of Runway Occupancy Time to various Rollout and Turnoff Factors, June 1997

AROT reduction methods

- Vacate runway at high speed, turnoff at high speed.
  - 737-800 Ryanair pilots have been authorized by Boeing to take high speed exits up to 70 knts. Others felt more comfortable at +-20 knts.
- ATC have the ability to give conditional landing clearance, so crew on final approach may proceed visualizing the departing traffic.
  - If the controller is pushing with emphatic clearances, and phrases such as "plan first available exit", "expedite to the next high speed", etc. then the flight crews will pick up on this
- Lack of touchdown zone predictability can limit runway exit – (ROT predictability). A factor in this uncertainty is flare ballooning.

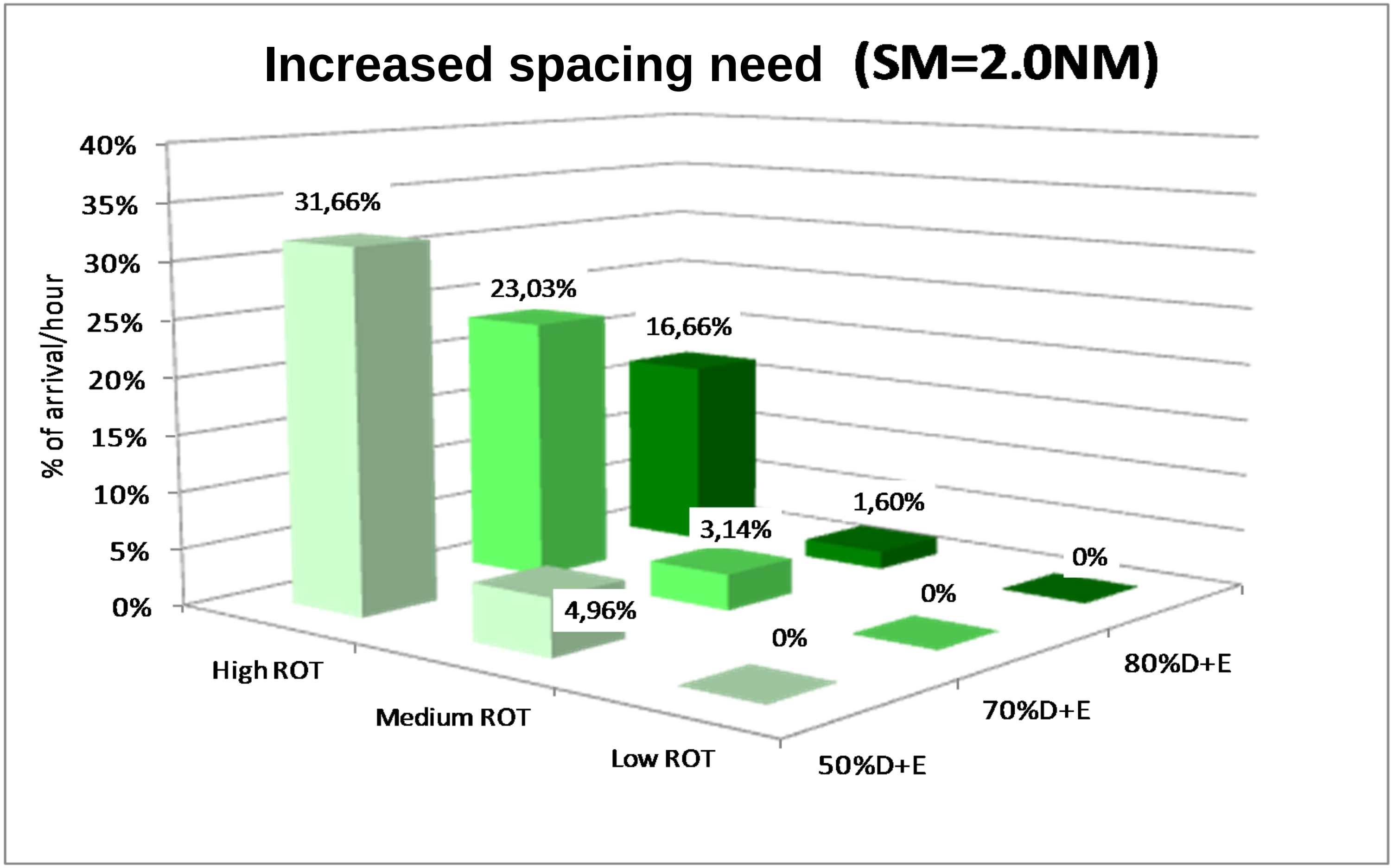
Safety

- Probability of need to increase spacing with SM=2.5NM



Safety

- Probability of need to increase spacing with SM=2.0NM



Conclusions

- The concept helps increase arrival runway capacity between 6% and 30%.
- Gains more sensitive to traffic mix that AROT
- ROT can be effectively reduced through use of procedural controls *(increasing runway exit speed, advice to expedite runway exit) or* possible future use of Enhanced Braking Systems

Conclusions

- Reducing AROT more than necessary does not positively influence the separation reduction capacity gains.

- Both the PICAP and Theoretical study show that there is an increased risk that a go-around might occur with the reduction of the minimal-pair separations

Recomendations for Future Investigation

- Go-around reasons should be consolidated, since they may be ordered by ATC or decided by the Flight Crew in command.
- ATC control spacing must be included in order to dynamically adapt the minimal-pair arrivals between 2.0NM and 2.5NM, depending upon the standard AROT of the leader. The clearance to land spacing will need to take into account:
  - The prevailing glide slope wind condition that will be experienced by the follower aircraft over this distance

Recomendations for Future Investigation

- Transition to the same glideslope such that 1,000ft vertical separation cannot be utilised during the transition.

- The transition from the intermediate approach 3NM MRS to the reduced 2NM MRS needs to be considered with respect to the benefits validation;

Recomendations for Future Investigation

- Separations from RECAT EU project combined with SM=2.0NM must be improved using ECTRL Pair-wise separations.

- The reduced 2NM MRS has application to wake pairs D-D, D-E, E-E when TBS is applied in moderate and strong headwind conditions.
  - This will also be the case for the Static Pairwise Separation (S-PWS) wake pairs B-B and C-C.


Questions are coming