Civil Aviation Department

The Government of the Hong Kong Special Administrative Region

Development of Tactical Arrival Sequencing

"From Eyeball to Integrated AMAN"

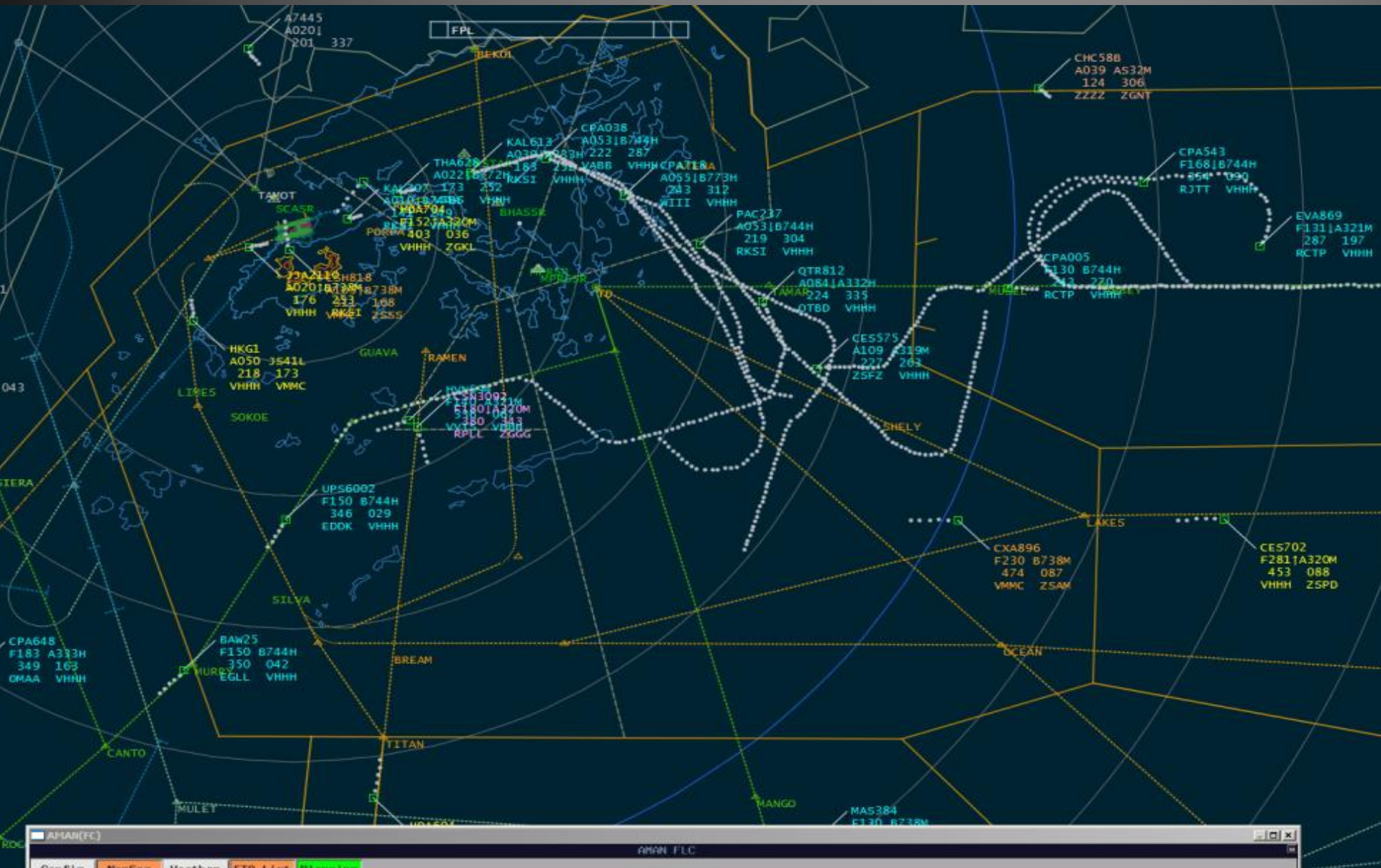
Introduction

- The need for tactical arrival sequencing
- Setting up the basics
  - Inter-arrival spacing
  - Standard time intervals
  - Effects of wind
- Setting the sequence and communicating to ATC Sectors
  - Sequencing horizon
  - Compression in the sequence
- Advanced tools
  - Standalone AMAN
  - Fully Integrated AMAN
- Hong Kong case study

No tactical arrival flow?

- Delay generally left to Approach controller to absorb through aggressive vectoring/late speed control
- Inefficient from a/c operating perspective
- Lack of predictability for pilots ► reduced confidence for controller ►reduced movement rate
- May lead to unstable approach and subsequent MAP
- High R/T loading for ATC and aircrew

No/incorrect arrival flow



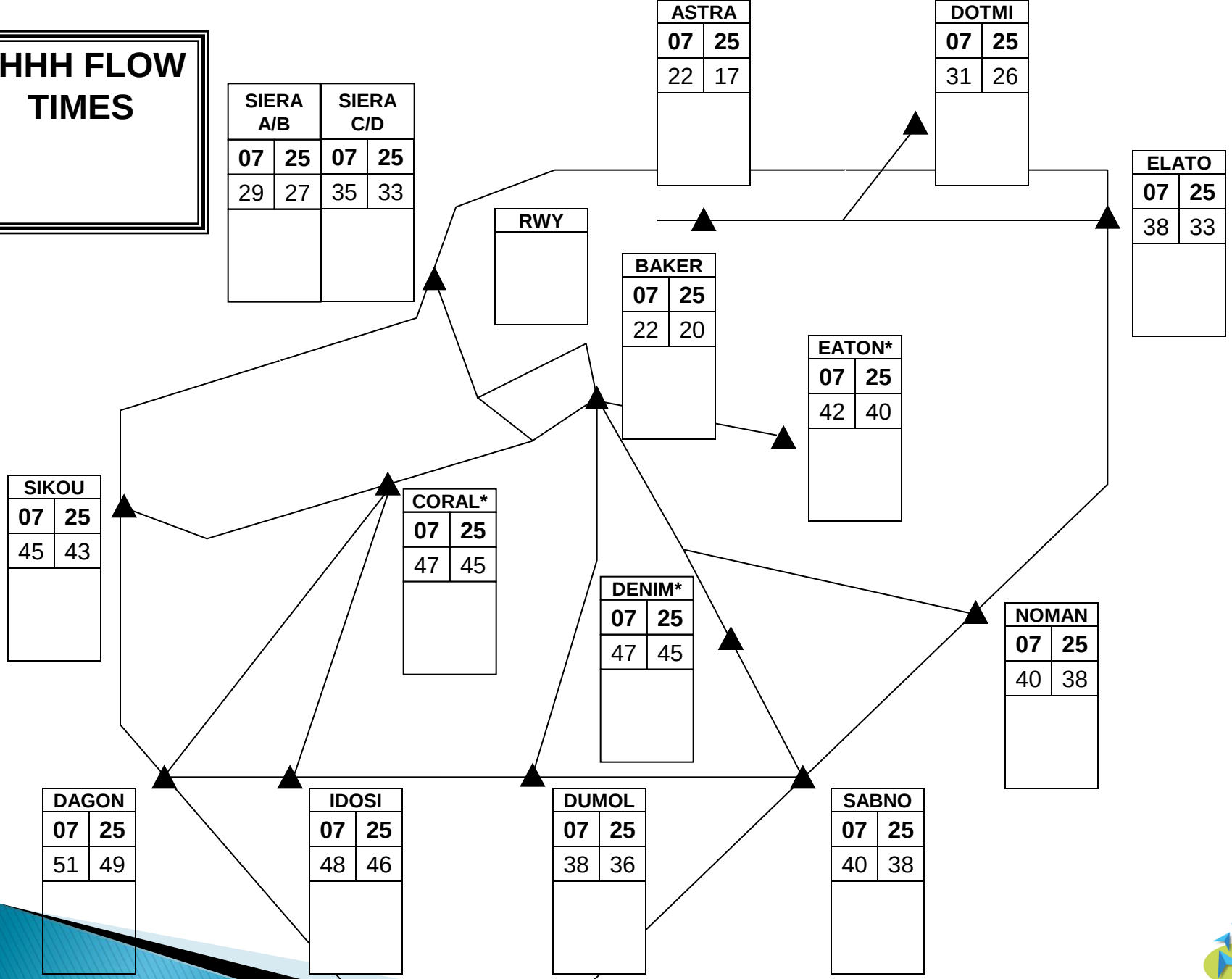
Setting up the basics

- What average final spacing is required?
  - Segregated or mixed-mode ops?
  - Cat II/III ops?
  - Other operational reasons?
- What hourly arrival rate will that achieve based on aerodrome conditions? i.e. what will the landing interval (time) be?
  - Rule of thumb – 25 secs per mile for the last 5 miles in still air
  - Strong headwind on final can cause a significant increase in landing interval (every 5 kts may cause a loss of 1 arrival per hour)

Setting up the basics (2)

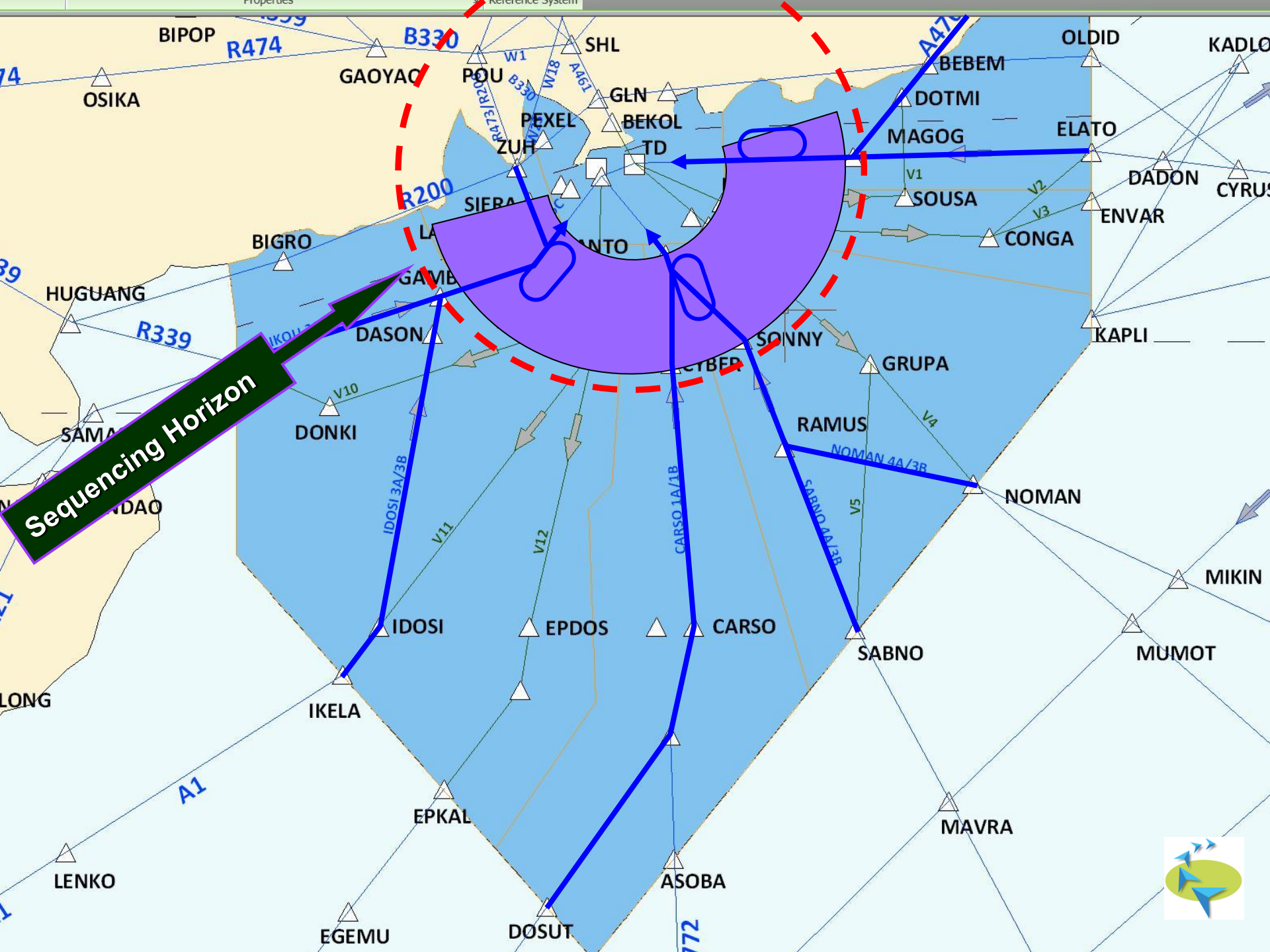
- Standard time intervals and wind
  - Determine nil-wind time intervals to touchdown from appropriate arrival fixes, including holding stacks
  - Determine the effects of wind on standard times
    - Rule of thumb: Each additional 20kt headwind adds approx 1 minute from TOD

VHHH FLOW TIMES



Setting the Sequence

- Decide the sequencing “horizon”
  - Ideally, as far as possible but prior to TOD point highly desirable
  - Should encompass all aircraft with untouched landing times determined i.e. don’t set the sequence too early, while there is still uncertainty about a large % of aircraft


Sequencing Horizon
BIPOP
R474
B330
SHL
GAOYAO
POU
W1
W18
A461
GLN
BEBEM
OLDID
KADLO
OSIKA
DOTMI
PEXEL
BEKOL
ZUH
TD
MAGOG
ELATO
R200
SIERA
V1
SOUSA
V2
V3
DADON
CYRUS
ENVAR
CONGA
BIGRO
HUGUANG
R339
DASON
SONNY
KAPLI
GRUPA
V10
DONKI
RAMUS
V4
NOMAN 4A/3B
NOMAN
IDOSI 3A/3B
V11
V12
CARSO 1A/1B
SABNO 4A/3B
V5
MIKIN
IDOSI
EPDOS
CARSO
SABNO
MUMOT
IKELA
A1
EPKAL
MAVRA
LENKO
ASOBA
EGEMU
DOSUT

Conveying the Sequence

- Simple miles-in-trail may be specified for long periods of operation in less busy environments
- In busier situations, gate times/stack departure times can be annotated on flight strips for controller reference- high workload for FLC
- Passing verbal flow instructions often impossible in complex environment
- Electronic AMAN displays can portray sequence pattern as well as continuously updated times if HMI is adapted correctly
- Fully integrated AMAN information can be displayed directly in the data block

“Compression”

- The need for compression in a continuous sequence
- Managing the compression safely
  - Published speed limit points
  - Airspace structure to match profile

Compression

- Determination of average final spacing in terms of time (HK~105 seconds)
- Subsequent spacing between consecutive flights should equate to this time regardless where measured
- Speed limit points and IAS should match procedure hand-off requirements between Sectors

ACDS SCDS SMGCS CAM DOC MAP MESG AD FPL

Mpic Mcen ROT LDL HIST RBL PTL FPL SP Filter A-LBL ROT

FPL

DOTMI

HDA643
F263|A321M
468 236
ZSNB VHHH

CXA381
F236 B738M
417 268
ZSAM VHHH

[1]
74.56(254.56)
18.17 Nm

MAGOG

CPA469
F399|B772H
489 268
RCTP VHHH

HDA831
F110 A333H
340 268
ZSPD VHHH

BMAZ
F121|F21HM
330 269
RKPC VHHH

CES721
F110 A333H
317 268
ZSSS VHHH

HDA453
F204|A320M
445 268
RCKH VHHH

LAKES

SOUSA

OCEAN

V2

V3

MANGO

BETTY

KATE

BAKER

SONNY

CPA710
F234|B773H
412 360
WSSS VHHH

AMAN(FC)

AMAN FLC

Config NonSeq Weather ETO List Planning

S-07L-HT 07L:4.3 07R:6.0 25L:5.9 25R:4.0 07L/07R:3.5 25L/25R:3.5 AVG DLY: OVR / 0 REN / 0 Normal

07L	CQH8921	DOS	11
07L	CES501	DOT +1	06
07L	CAL680	CAR	04
07L	PAL318	MNG +1	02
07L	EVA867	ELA +1	00
07L	CPA567	ELS +1	58
07L	THA600	SIK -1	56
07L	CPA469	ELS	49
07L	HDA643	DOT	45
07L	CXA381	DOT	43

07L	HDA701	SRA +1	09
07L	CPA700	SIK -1	07
07L	THA600	SIK -1	45

07L	CAL680	CAR	47
07L	PAL318	MNG +1	44

SIERA ETO

Show All

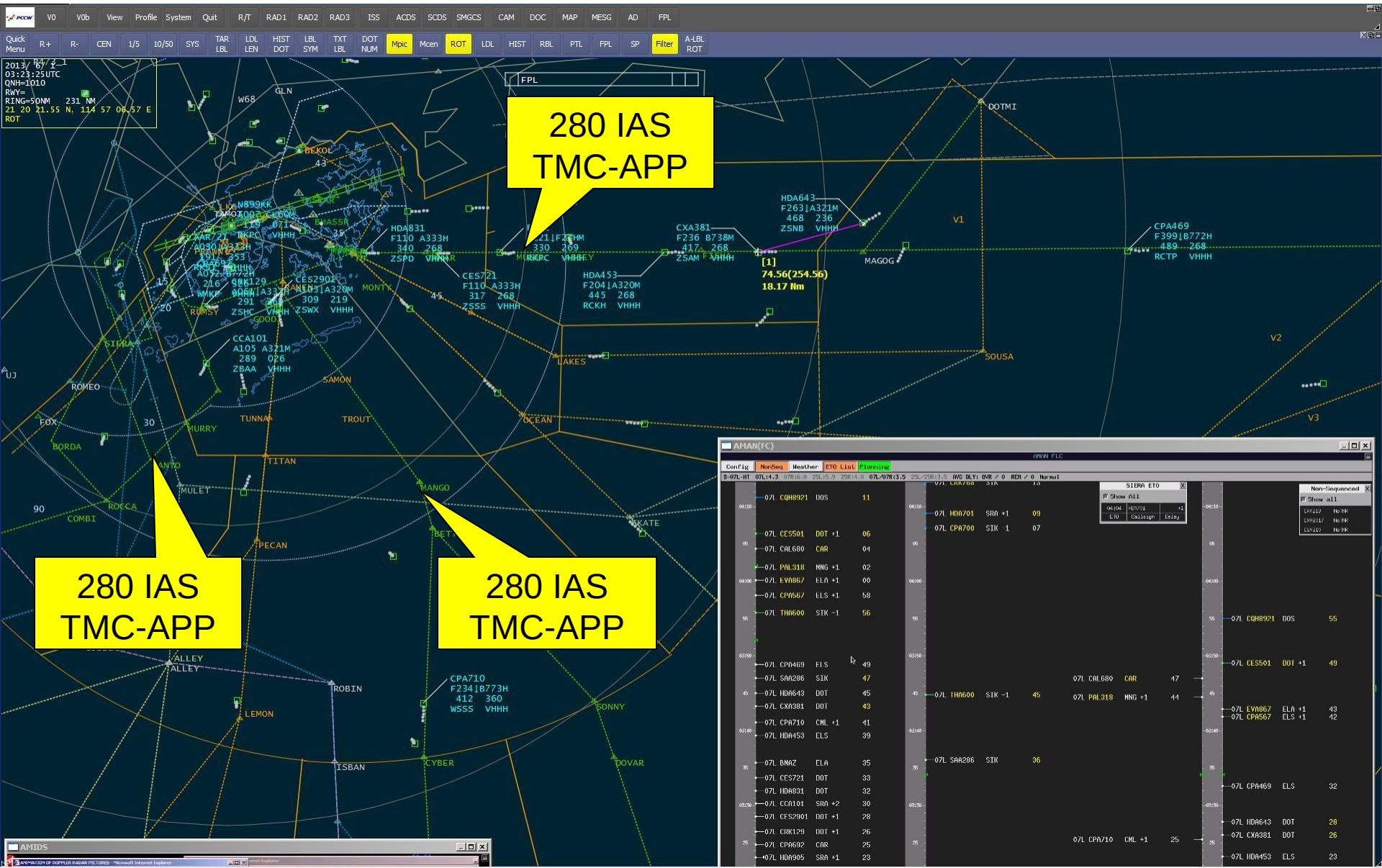
ETO	Callsign	Delay
04:04	HDA701	+1

Non-Sequ

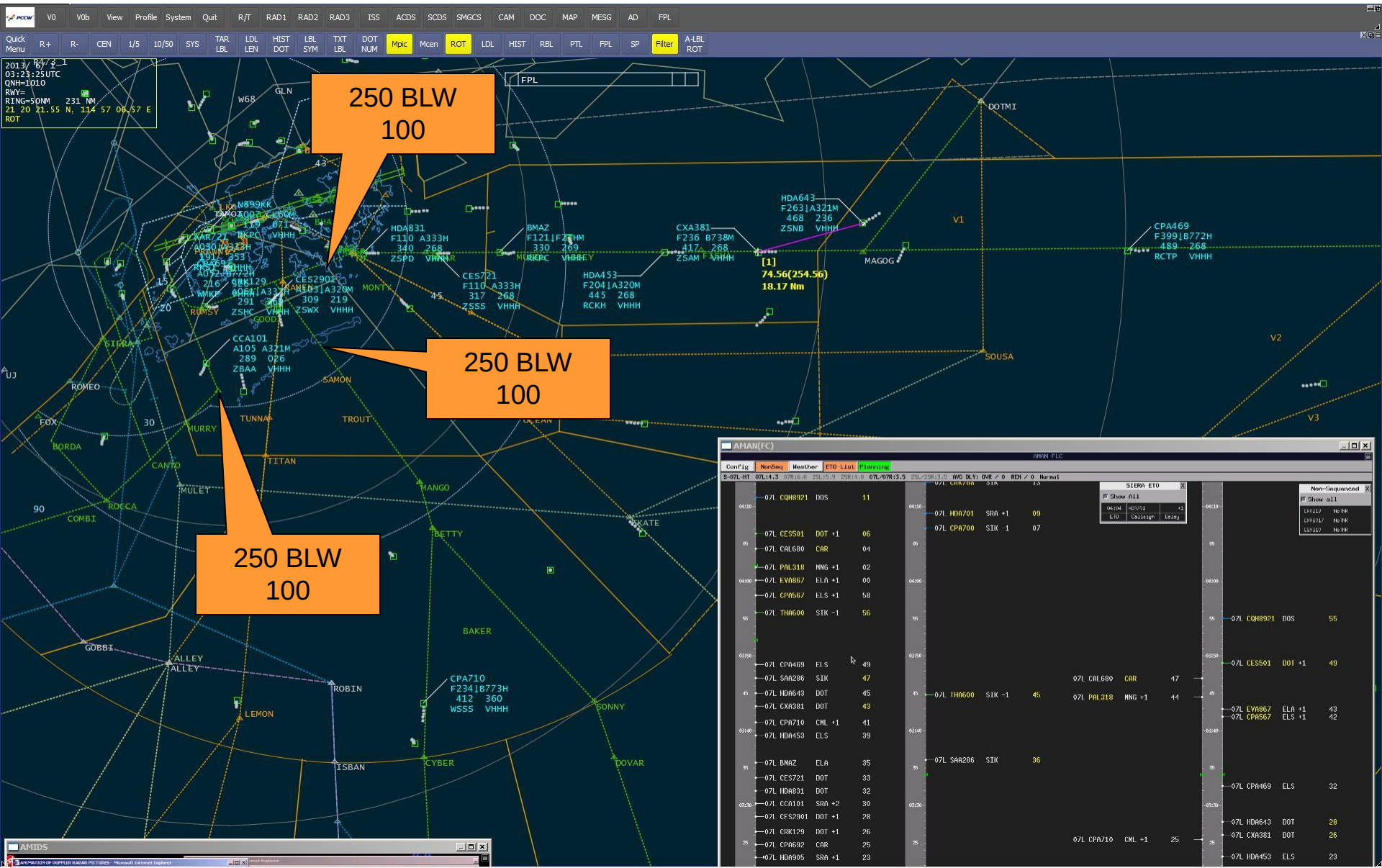
Show all

07L	CQH8921	DOS	55
07L	CES501	DOT +1	49
07L	EVA867	ELA +1	43
07L	CPA567	ELS +1	42

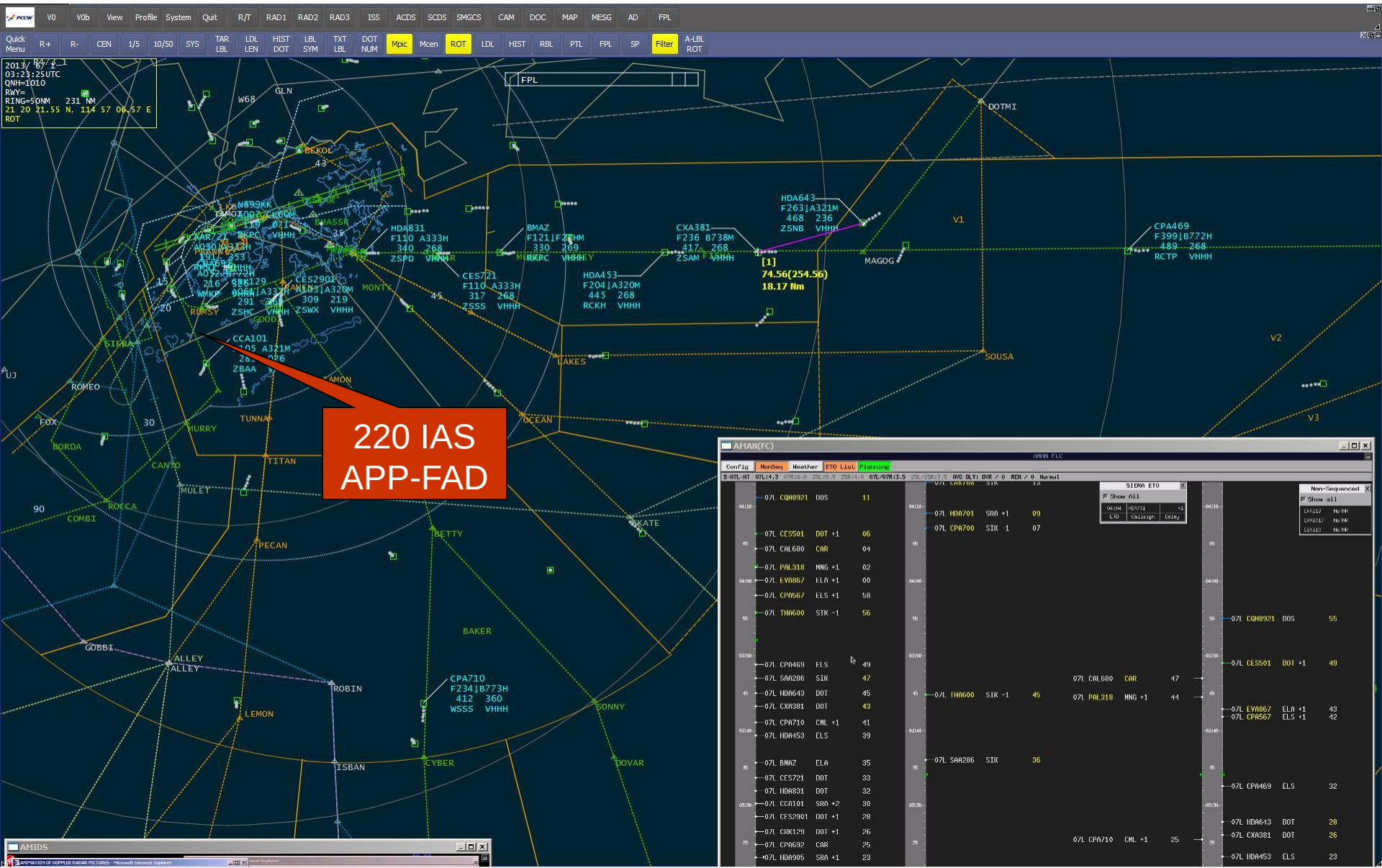
Speed limit points– APP “gate”



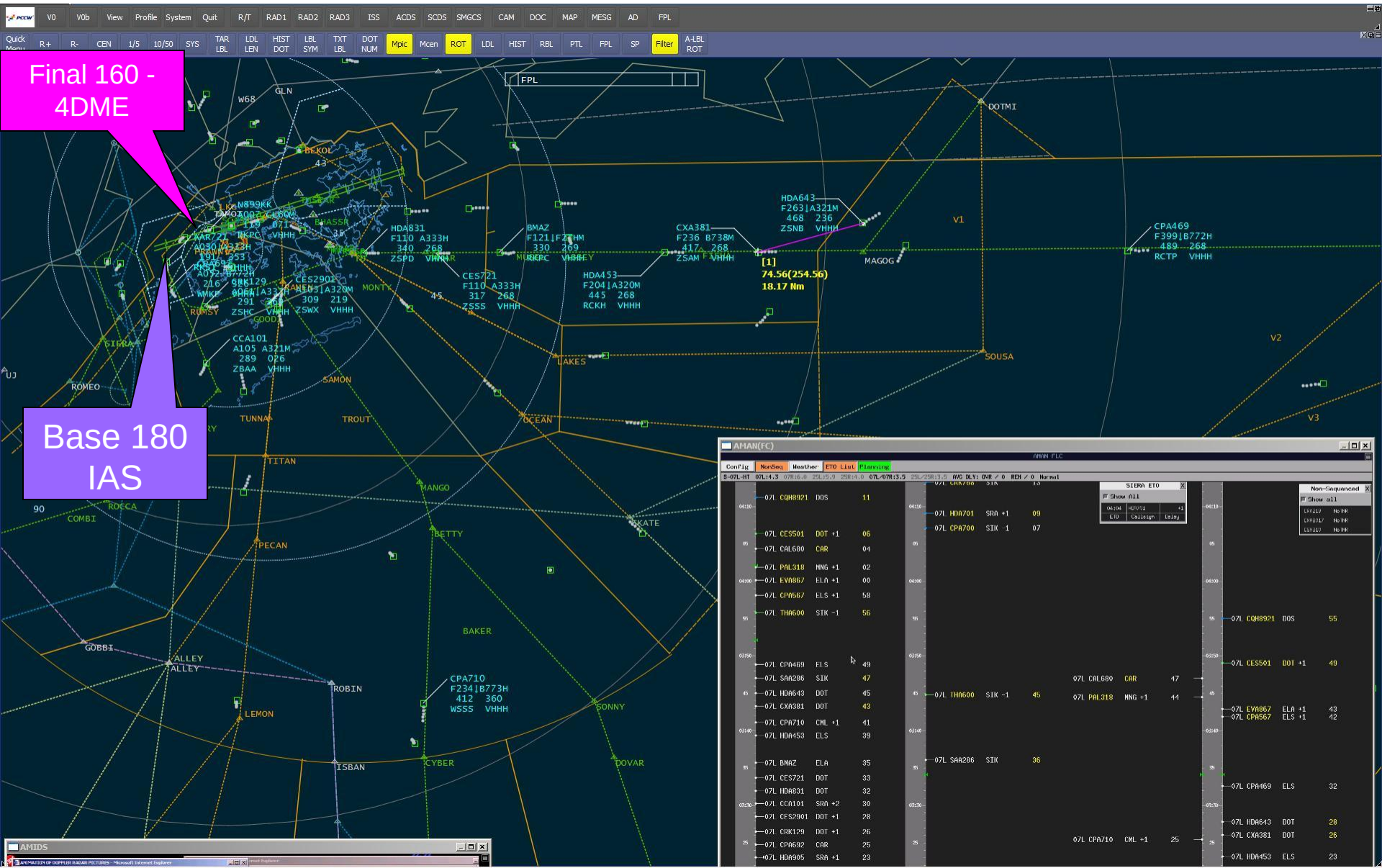
Speed limit points– 250BLW100



Speed limit points– APP –FAD



Speed limit points– IF & FAP



RAD1 RAD2 RAD3 ISS ACDS SCDS SMGCS CAM DOC MAP MESG AD FPL

HIST DOT | LBL SYM | TXT LBL | DOT NUM | Mpic | Mcen | ROT | LDL | HIST | RBL | PTL | FPL | SP | Filter | A-LBL ROT

FPL

BEKOL
43
TMSTAR
BHASSR
35
MBRBR
HDA453
F110|A320M
357 268
RCKH VHHH
CXA381
F117|B738M
342 267
ZSAM VHHH
HDA643
F135|A321M
364 267
ZSNB VHHH
TAMAR
[1]
90.03(270.03)
12.77 Nm
MUSEL
ABBEY
FISHA
CPA469
F241|B772H
439 267
RCTP VHHH
MAGOG
RAMEN
MONTY
BMAZ
A084|F2THM
300 248
RKPC VHHH
B9630
F191|C680M
351 115
ZZZZ VHHH
SAMON
TROUT
OCEAN
CPA710
F121|B773H
329 322
WSSS VHHH
TITAN
MANGO
BETTY
CAN

AMAN(FC)

AMAN FLC

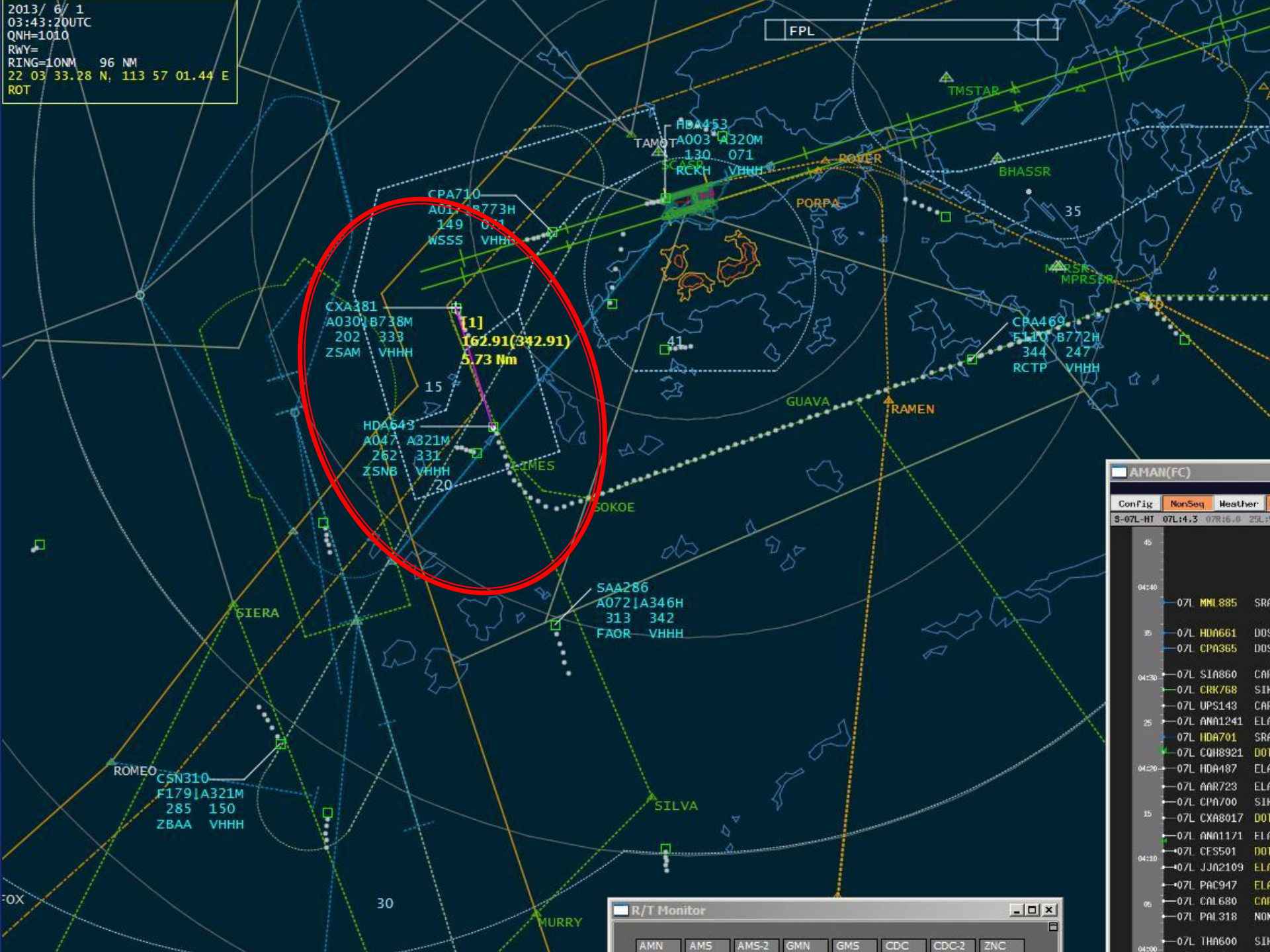
Config | NonSeq | Weather | ETO List | Planning

S-07L-HT 07L:4.3 07R:6.0 25L:5.9 25R:4.0 07L/07R:3.5 25L/25R:3.5 AVG DLY: OVR / 1 REN / 1 Normal

07L	CPA365	DOS -1		33
07L	CRK768	SIK		24
07L	HDA701	SRA +2		22
07L	AAR723	ELA +7	A01	20
07L	CQH8921	DOT +6		18
07L	CXA8017	DOT +8	A57	16
07L	CPA700	SIK +6		14
07L	ANA1171	ELA +6		12
07L	PAC947	ELA +5		11
07L	CES501	DOT +4		09
07L	JJA2109	ELA +1		07
07L	CAL680	CAR +1		05
07L	PAL318	MNG +2		03
07L	THA600	SIK +1		01
07L	EVA867	ELA +1		59

07L	MML885	SRA	27
07L	CRK768	SIK	13
07L	HDA701	SRA +2	11
07L	CPA700	SIK +6	03


CSN310
F208|A321M
427 196
ZBAA VHHH
HDA453
A027|A320M
223 006
RCKH VHHH
LKC
TAMOT
SCASR
TMSTAR
BHASSR
35
CES721
A005 A333H
131 071
VHHH
PRAWN
BMAZ
A016
161 070
RKPC
41
HDA643
A101|A321M
319 248
ZSNB VHHH
CPA469
F116|B772
359 268
RCTP
TAMAR
CXA381
A077|B738M
263 237
ZSAM VHHH
RAMEN
MONTY
15
45
20
RUMBY
[1]
62.34(242.34)
8.42 Nm
CPA710
A055|B773H
312 296
WSSS VHHH
SIERA
SAMON
TUNNA
TROUT
30
MURRY
SAA286
F160|A346H
348 044
FAOR VHHH
CANTO
TITAN
AMAN(FC)
Config
NonSeq
Weather
ETO
07L MML885 SRA
07L HDA661 DOS +1
07L CPA365 DOS -1
07L CRK768 SIK +3
07L UPS143 CAR +2
07L HDA701 SRA +4
07L CQH8921 DOT +3
07L HDA487 ELA +2
07L AAR723 ELA +5
07L CXA8017 DOT +6
07L CPA700 SIK +6
07L ANA1171 ELA +5
07L CES501 DOT +5
07L JJA2109 ELA +3
07L PAC947 ELA +1
07L CAL680 CAR +2
07L PAL318 NOM +1
07L THA600 SIK +1
07L EVA867 ELA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QNH=1010
RWY=
RING=10NM 96 NM
22 03 33.28 N, 113 57 01.44 E
ROT
FPL
TMSTAR
BHASSR
MPRSSR
ROVER
PORPA
TAMOT
HDA453
A003 A320M
130 071
RCKH VHHH
CPA710
A013 B773H
149 071
WSSS VHHH
CXA381
A030 B738M
202 333
ZSAM VHHH
[1]
162.91(342.91)
5.73 Nm
HDA643
A047 A321M
262 331
ZSNB VHHH
CPA469
F110 B772H
344 247
RCTP VHHH
GUAVA
RAMEN
SOKOE
SAA286
A072 A346H
313 342
FAOR VHHH
SIERA
ROMEO
CSN310
F179 A321M
285 150
ZBAA VHHH
SILVA
MURRY
35
41
15
20
30
AMAN(FC)
Config
NonSeq
Weather
R/T Monitor
AMN
AMS
AMS-2
GMN
GMS
CDC
CDC-2
ZNC

View Profile System Quit R/T RAD1 RAD2 RAD3 ISS ACDS SCDS SMGCS CAM DOC MAP MESG AD FPL

CEN 1/5 10/50 SYS TAR LBL LDL LEN HIST DOT LBL SYM TXT LBL DOT NUM Mpic Mcen ROT LDL HIST RBL PTL FPL SP Filter A-LBL ROT

38 03.20 E

FPL

TMSTAR

ATENA

ROTER

BHASSR

PORPA

35

HDA643
A022 A321M
181 073
ZSNB VHHH

CXA
A010 B738M
151 070
ZSAM VHHH

[1]
252.54(72.54)
4.02 Nm

SAA286
A030 A346H
231 339
FAOR VHHH

41

15

GUAVA

RAMEN

CPA469
A057 B772H
290 269
ACTP VHHH

TIMES

20

SOKOE

SIERA

AMAN(FC)

Config NonSeq Weather ETO List

S-07L-HT 07L:4.3 07R:6.0 25L:5.9 25R:4.0

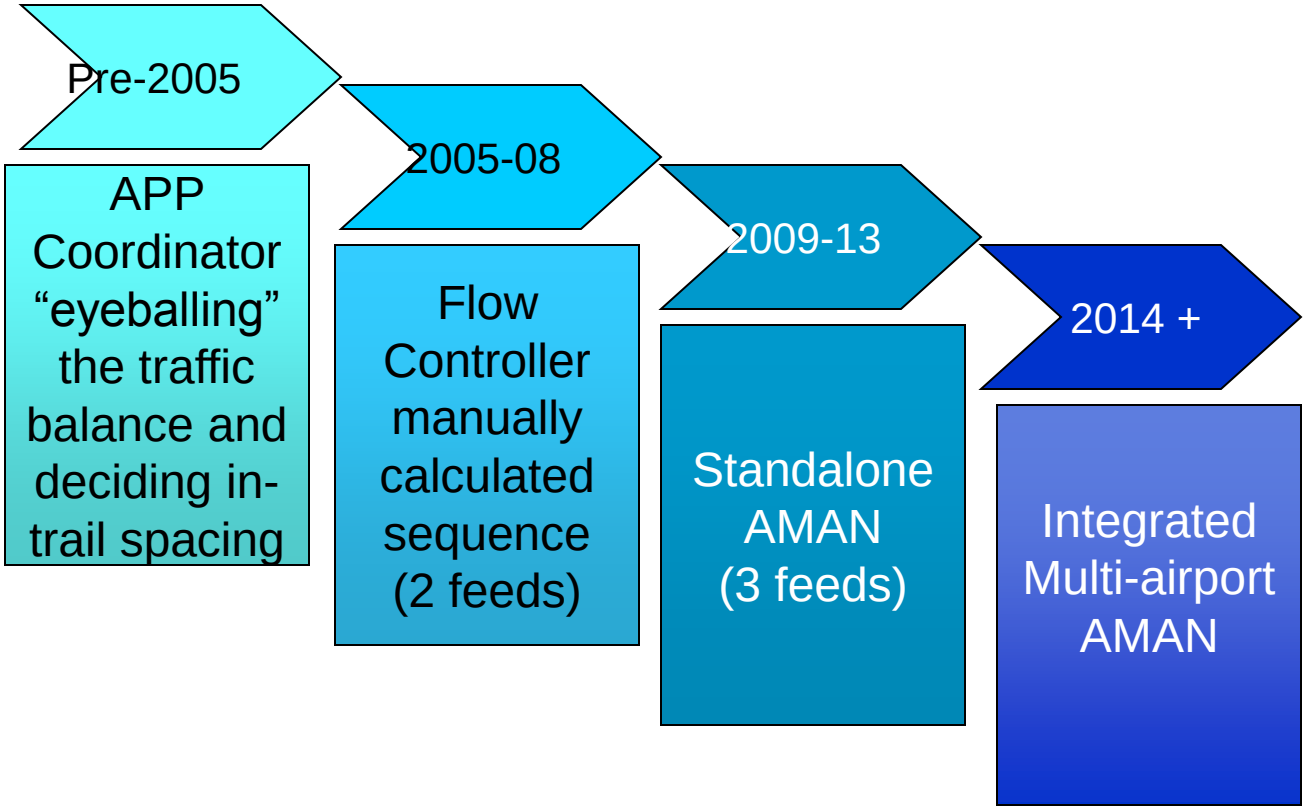
07L CPA250 SRA

07L MNL885 SRA +2
07L HDA661 DOT +4
07L CPA365 DOT +2
07L KAL613 ELA +6
07L SIA860 CAR +5
07L CAL909 ELA +5
07L CPA503 ELA +6
07L CRK768 SIK +4
07L UPS143 CAR +3
07L ANA1241 ELA +3
07L CQH8921 DOT +3
07L HDA701 SRA +2

Case Study

- Development of Tactical Arrival Flow Control in Hong Kong

HK Tactical Flow Timeline



Pre-2005

- APP COO: Amongst other duties, determine the arrival demand from 2 “gates” into the APP sector, and pass to Terminal controllers in the form of Miles-in-trail e.g. 20/20, 15/30 etc
- No tools provided apart from Situation Display and “Mk I eyeball”
- Overall level of delay was not determined and no holding stack departure times (rarely needed) were calculated
- By 2005, traffic demand began to exceed capacity on a regular basis causing a significant level of unspecified delay

“Eyeballing the sequence”

- Simple to apply in low-moderate traffic
- Use of in-trail spacing from multiple feeds prone to either wastage or oversupply on occasion
- Needs constant updating as traffic distribution varies
- Difficult to judge in strong wind conditions-almost unbelievable difference sometimes

2005-08

- Dedicated Flow Controller (FLC) position implemented
- “Untouched landing times” determined for each flight to finalize a landing order
- Target Landing times assigned to each flight and delay determined. Holding advisory given to Terminal controller if delay > 6 minutes
- Simple tools, starting with “Flow Times” sheet, then landing time software introduced to assist with the calculation. FLC used paper strips
- 2-minute sequence (ie 30 arrivals per hour) used to simplify calculation
- First-come-first-served basis only

FLOW Tool-ULTs & OCTs

UTC 03:33:37

RUNWAY 07

OK

VIEW WIND ZONES

RESET DEFAULTS

DOTMI 31 04:05

MELON 20 03:54

ASTRA 22 03:56

SIERA

2A 29 04:03

2C 35 04:09

ELATO 38 04:12

MAGOG 26 04:00

MANGO 17 03:51

HOLDING MODE

NORMAL

CONTINGENCY

SIKOU 45 04:19

BAKER 22 03:56

NOMAN 40 04:14

DAGON 51 04:25

IDOSI 48 04:22

DUMOL 38 04:12

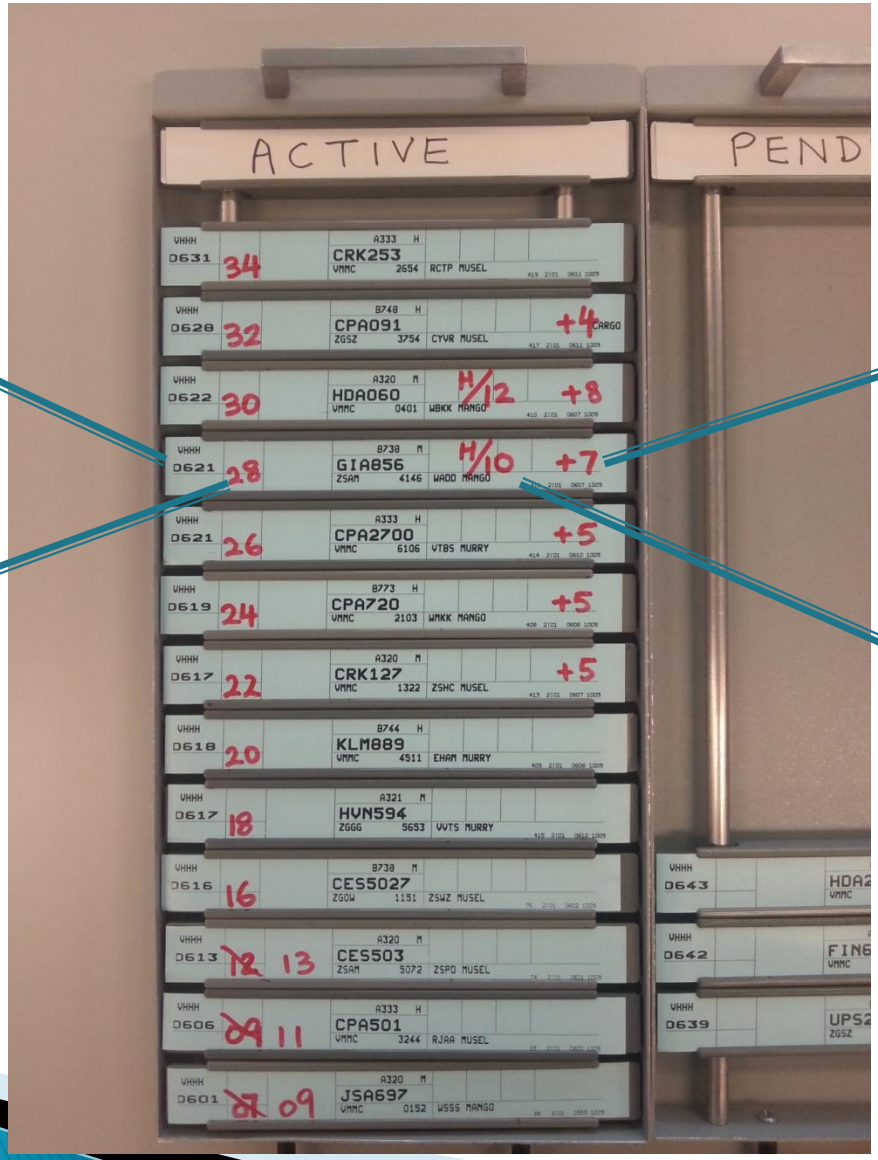
SABNO 40 04:14

ELT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
ASTRA	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
BAKER	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37

Manual Flow Methodology

Untouched landing time

Target landing time



Delay=Target landing time-Untouched landing time

Delay >6 Hold OCT

2009-present

- Stand-alone AMAN implemented
- 3 feeds to APP
- Optimized sequence to produce minimum overall delay (not necessarily FCFS)
- Arrival "gate" times displayed at Terminal controller working positions
- Initially interpreted to in-trail spacing by FLC
- Now TMCs follow times as displayed without coordination- tolerance ±1 minute
- Standalone AMAN still "guessing" what track adjustments are being made

Arrival Manager (AMAN)

- AMAN is a *Decision Support Tool*
- The system performs tasks that a Manual Flow Controller would do with paper strips within predefined parameters
  - Same limitations as Manual flow wrt sequencing horizon- AMAN cannot create a final sequence if it cannot see the aircraft on radar and determine the landing time
    - FIR entry points with short arrival times
    - Nearby Airports can be pre-sequenced to "reserve' a slot e.g. ZGOW, ZGSZ

AMAN FLC

Config | NonSeq | Weather | ETO List | Planning

S-07L 07L:4.5 07R:4.5 25L:5.9 25R:4.0 07L/07R:3.5 25L/25R:3.5 AVG DLY: OVR / 5 REM / 2 Normal

RWYALL

05:20	07L JAL29	ELA	+15 A00	19
	07L CPA250	SRA	+14 C05	17
15	07L MAS72	CAR	+12 B56	14
	07L HVN592	SRA	+10 C01	13
	07L CES501	DOT	+9 A52	11
05:10	07L CCA111	SRA	+9 C57	09
	07L HDA831	DOT	+8 A48	07
05	07L CCA709	SRA	+10 C53	05
	07L CPA509	ELA	+6	03
	07L CPA533	ELA	+4	01
05:00	07L HDA871	DOT	+4	59
	07L CCA713	SRA	+5	57
55	07L CES721	DOT	+3	55
	07L ACA015	SRA	+4	54
	07L AXM1652	CAR	+2	52
	07L CPA700	SIK	+4	50
	RWY STRATEGY	S-07L-HT		
04:50	07L RWY SPACING	4.6		
	07L CPA091	ELS	-1	48
	07L CPA475	ELS		46
45	07L CXA8017	DOT	-1	44
	07L ANA1241	ELA	-1	42
04:40	07L THA629	ELA	-2	40
	07L HDA433	ELS	-2	38
	07L CPA417	ELS	-2	36
35	07L CPA503	ELA	-1	33
	07L KAL613	ELA	-1	31
04:30	07L MDA1821	ELS		29
	07L CAL909	ELS		27
25	07L HDA487	ELA	--	25
	07L JJA2109	ELA		24
	07L HDA6662	BET		22

HURRY

05:20	07L ELY075	SRA	+15 C18	19
15	07L CPA740	SRA	+17 C10	12
05:10	07L CPA250	SRA	+14 C05	06
05	07L HVN592	SRA	+10 C01	02
05:00	07L CCA111	SRA	+9 C57	58
55	07L CCA709	SRA	+10 C53	54
04:50	07L CCA713	SRA	+5	47
45	07L ACA015	SRA	+4	43
04:40	07L CPA700	SIK	+4	39
35	07L AXM1652	CAR	+2	35
04:30				
25				

SIERA ETO

Show All

ETO	Callsign	Delay
05:04	CPA347	0
05:04	HDA296	0
05:00	ELY075	0
04:50	CPA740	0
04:48	HVN592	0
04:48	CPA250	0
04:45	CCA111	0
04:40	CCA709	0
04:37	CCA713	+5
04:35	ACA015	+4

07L MAS72 CAR +12 B56 57

Non-Sequenced

Show all

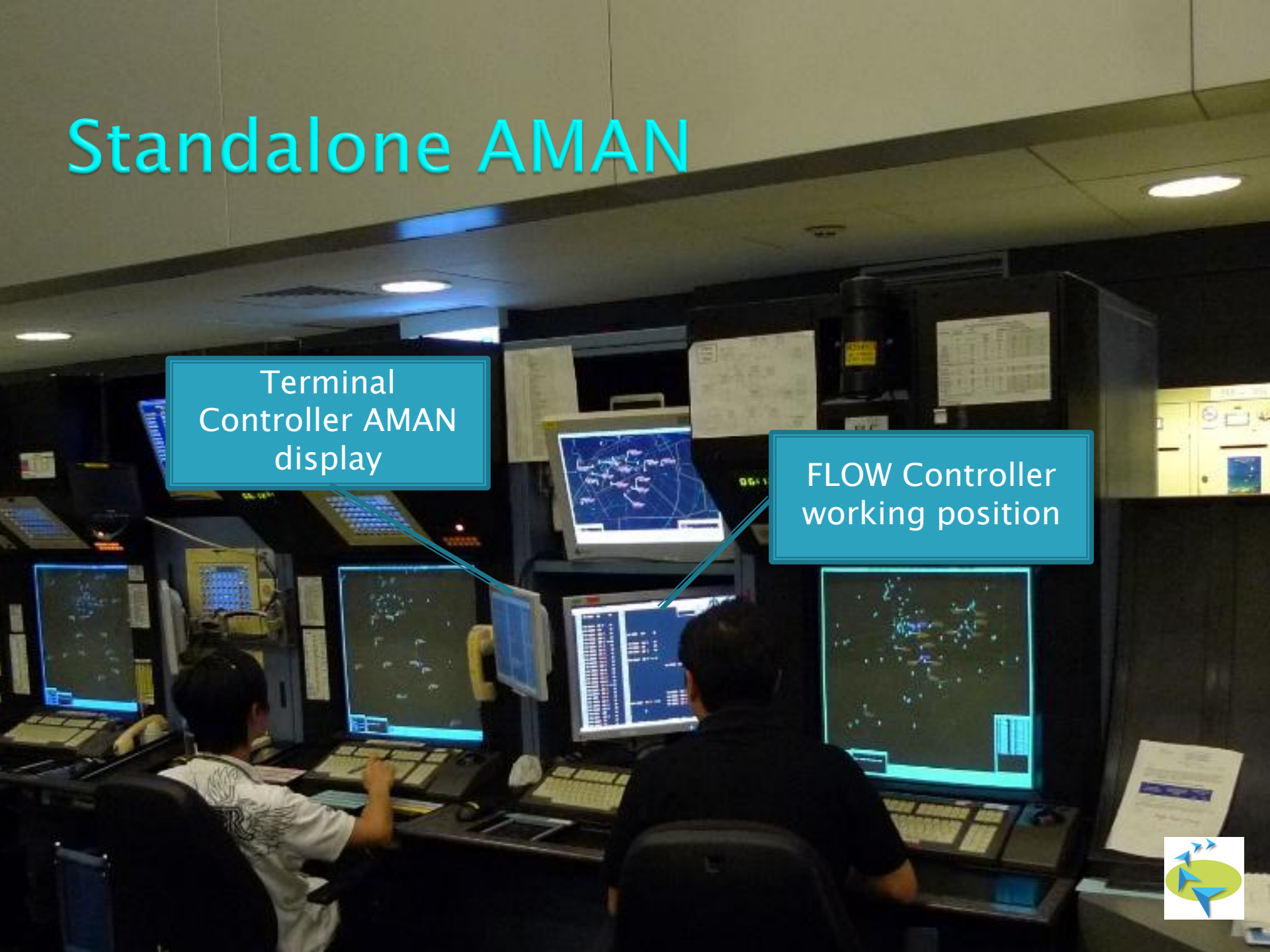
CSZ9041	NoTNR
CQH8921	NoTNR
HDA651	NoTNR

MANGO MUSEL

05:20	07L HDA627	DOT		
15	07L CPA365	DOT	+19 A09	11
05:10	07L HDA661	DOT	+20 A07	09
	07L HDA619	DOT	+19 A06	07
05	07L CES701	DOT	+16 A02	03
	07L JAL29	ELA	+15 A00	01
05:00				
55	07L CES501	DOT	+9 A52	54
04:50	07L HDA831	DOT	+8 A48	50
45	07L CPA509	ELA	+6	46
	07L CPA533	ELA	+4	44
	07L HDA871	DOT	+4	42
04:40	07L CES721	DOT	+3	38
35				
	07L CPA091	ELS	-1	32
04:30	07L CPA475	ELS		30
	07L CXA8017	DOT	-1	27
	07L ANA1241	ELA	-1	26
25	07L THA629	ELA	-2	23
	07L HDA433	ELS	-2	22

SSR FPL MET 04 23

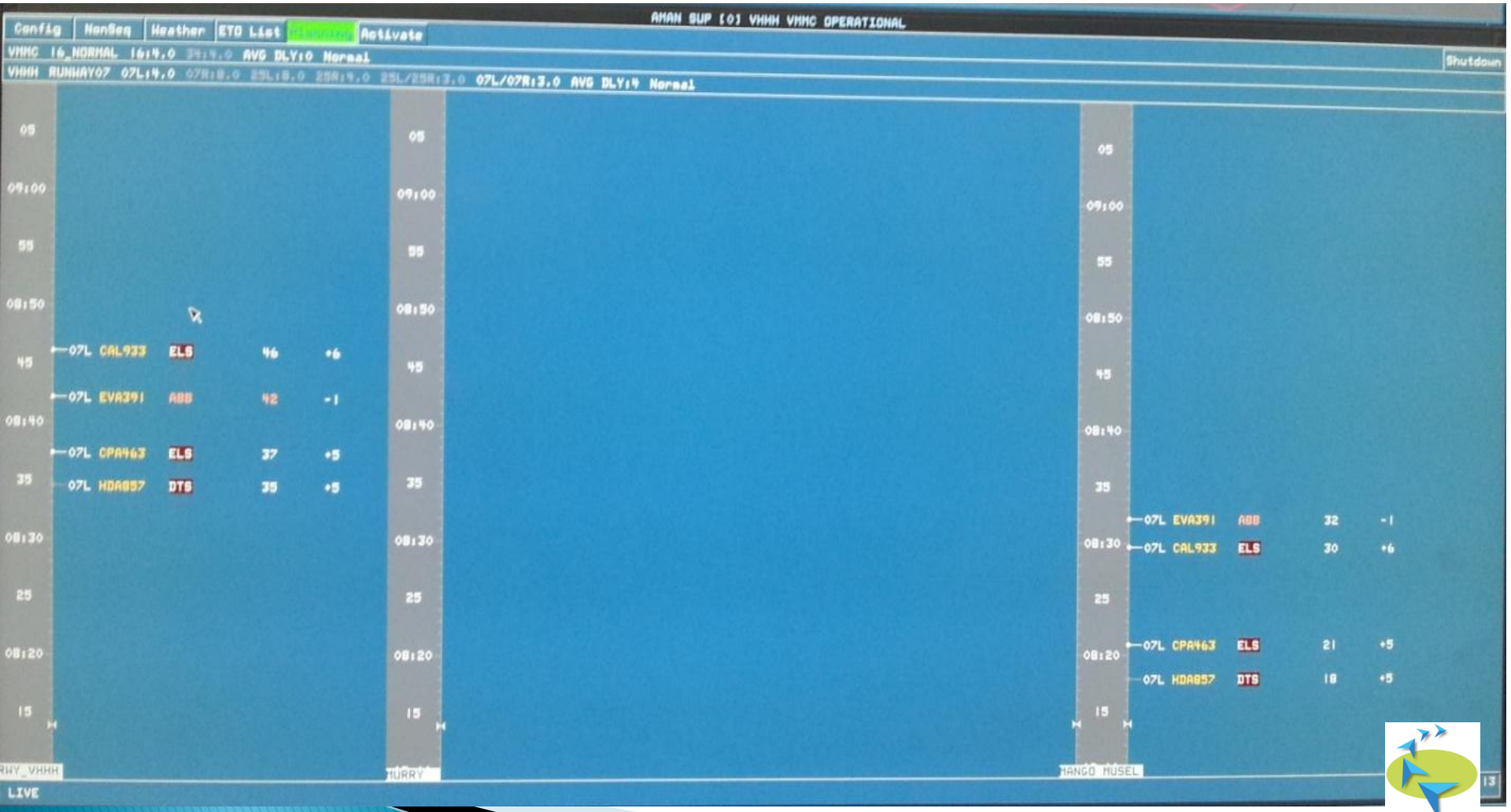
Standalone AMAN



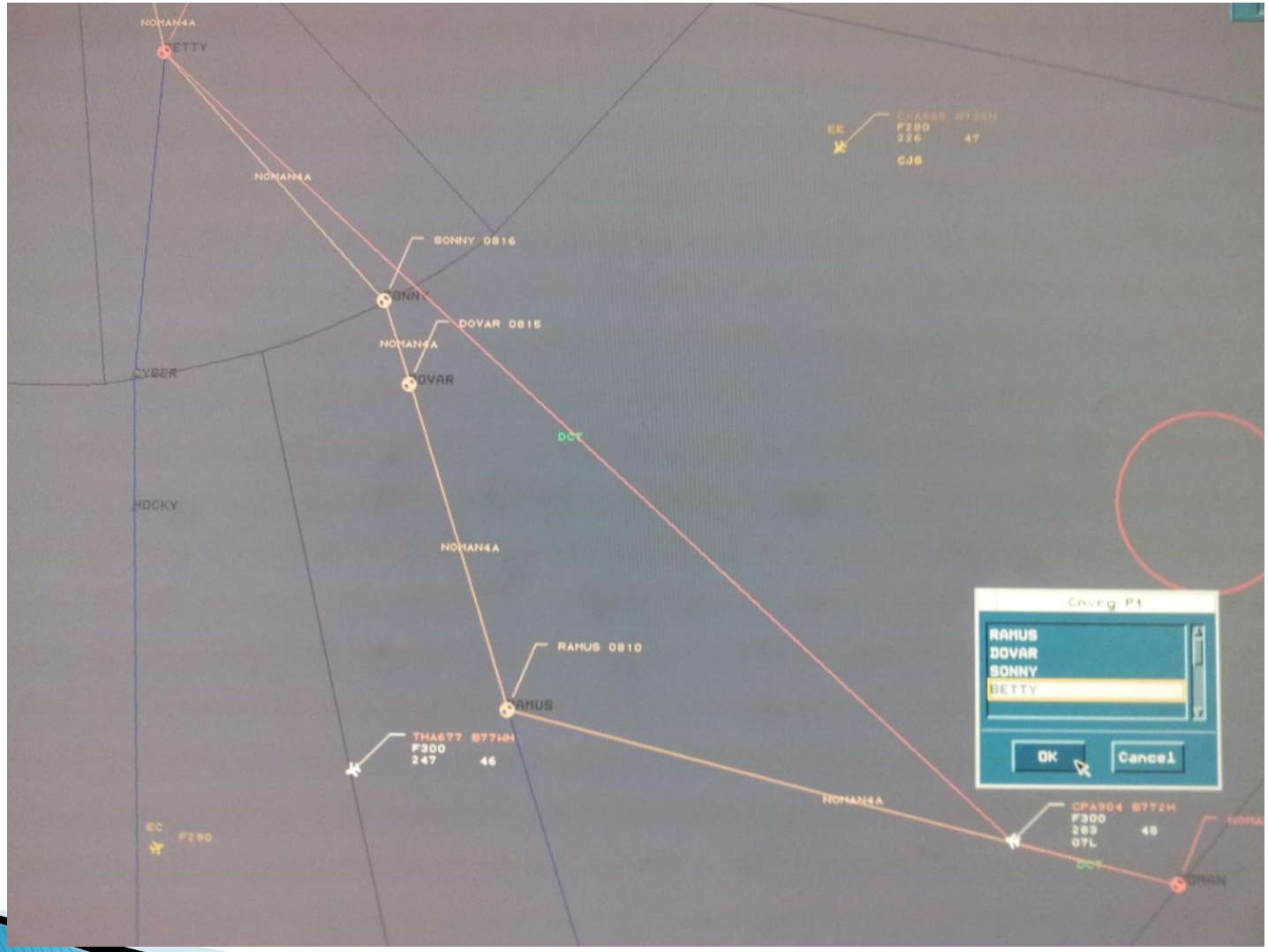
2014 +

- AMAN fully integrated with new ATMS
- Sharing trajectory information with FDPS
- AMAN information integrated into Aircraft Datablock to maintain heads-up operation

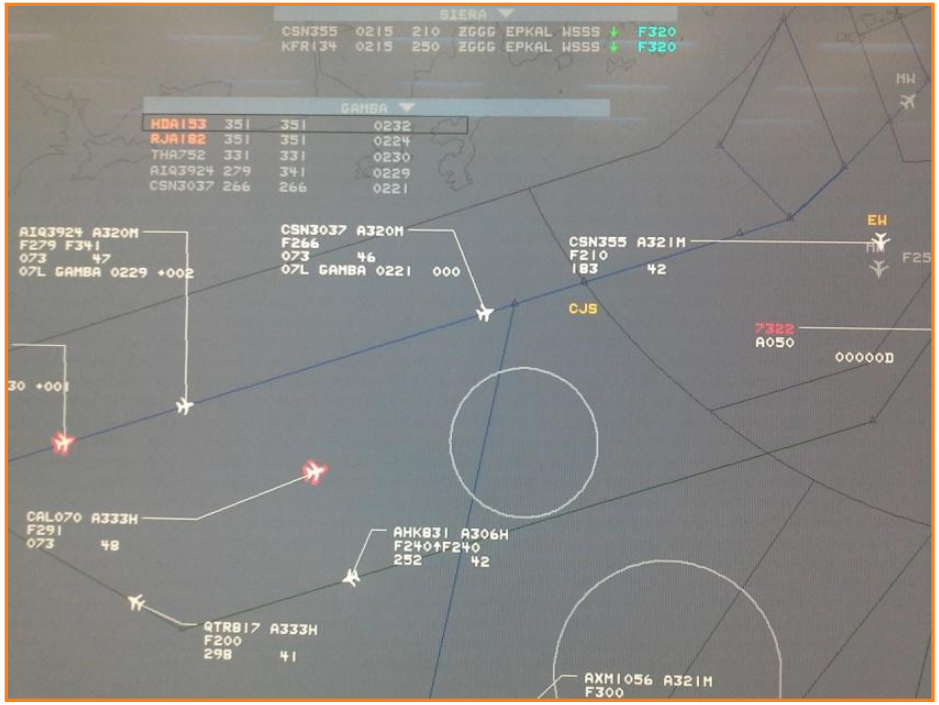
Integrated AMAN

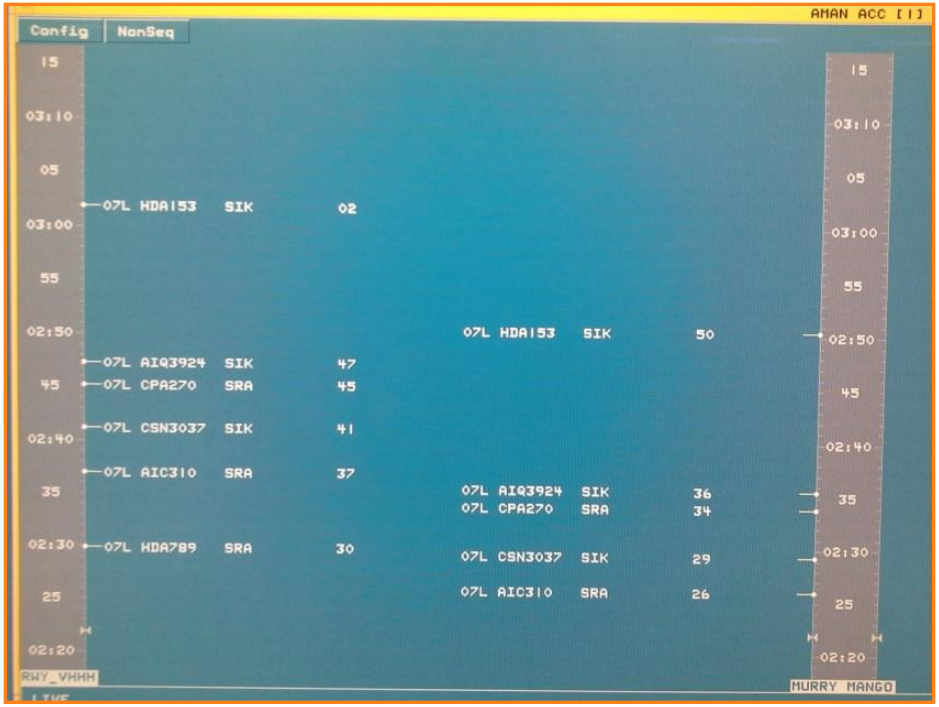


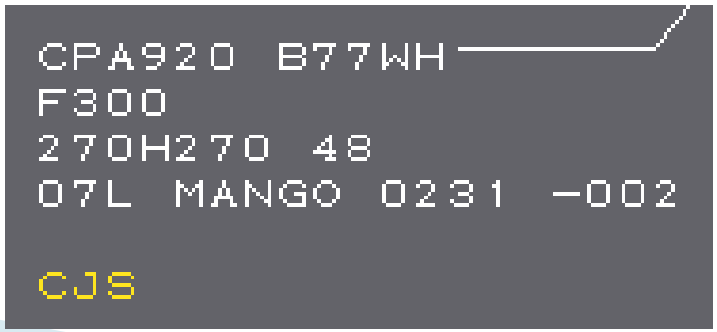
Sharing Trajectory with FDPS



AT3 and Integrated AMAN







Civil Aviation Department

The Government of the Hong Kong Special Administrative Region

Thank you

Peter Chadwick
Senior Operations Officer
Air Traffic Management Division
pmchadwick@cad.gov.hk