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Agenda Item 5: Air Traffic Flow Management (ATFM) in the SAM Region

METHODOLOGY ADOPTED BY BRAZIL TO CALCULATE THE CONTROL CAPACITY OF ACC OF BRAZILIAN FIR

(Presented by CGNA- Brazilian Air Navigation Management Center)

Summary

This working paper has the objective of presenting to ICAO the methodology adopted by Brazil to calculate the sectors of control of ACC Brasília, Curitiba, Recife and Amazônico of Brazilian FIR.

Reference:

ICA 100-30- ATC personnel planning and work timetable, Airspace Control Department (DECEA). Rio de Janeiro, 2007.

ICAO strategic objectives	A: *Safety* D: *Efficiency*

1 Background

1.1 As mentioned in SAM/IG/2, DECEA adopts a methodology to determine the capacity of APP and ACC sectors which makes possible to obtain a reference value for the sector's capacity. It consists in obtaining a value, calculated through a mathematical formula, whose basic data are extracted from a research carried out by a group at the ATC unity, considering a moment of heavy activity, when the controller's actions and his availability, at that moment, to control the traffic of the control sector are observed and timed. When an estimated capacity is being successfully applied to the sector at issue, that phase is not necessary.

2 Discussion

2.1 CAPACITY INVESTIGATION THROUGH MATHMATICAL FORMULA

2.1.1 The term ATC capacity reflects the capacity of the ATC system or of any of its subsystems, or operational positions, to provide the aircraft the services foreseen within the regular activities of these unities.

2.1.2 In Brazil, the capacity of ACCs is calculated by observing the capacity of their sectors which are analytically obtained, according to the methodology established in the ICA 100-30, ATC personnel planning (DECEA, 2007). In this way, the model used in Brazil can be classified as mesoscopic (where some additional detail is taking into consideration) and analytical (through mathematical formulas).

2.1.3 Nowadays, the calculated value can be understood as the maximum number of aircraft that can be simultaneously controlled by each operational position (ATCO), so providing the capacity carried out by the ATC unity. It is worthy to emphasize that DECEA has been working on new concepts which, in the future, will consider that value as a reference to be adjusted according to operational judgment.

2.1.4 According to the current model, the controller's work load is the summation of the time spent on each of the following tasks:

a) communications (transmission/reception);
b) manual activities (filling out strips) and coordination; and
c) traffic planning and distribution.

2.1.5 The Brazilian methodology applies the concept of the controller's **"availability factor"** (ϕ), which is defined as the percentage of time available for the ATCO to plan the aircraft separation procedures.

2.1.6 This availability factor is found, usually, between a minimum value of 40% of the ATCO time, for no radar control, and 60% for radar (ICA 100-30). Efforts shall be focused on increasing ϕ and the only way to achieve this goal is by applying measures which reduce the controller's engagement with the activities mentioned in 1 and 2.

2.1.7 This factor ϕ can present a bigger percentage when the Man / Machine Interface – MMI is enhanced.

2.1.8 In Brazil, the number of aircraft that can be simultaneously controlled by a controller (N), within the sector at issue, is calculated through the following formula (ICA 100-30):

$$\mathbf{N = \phi \cdot \delta \cdot (\eta \cdot \tau_m \cdot \nu_m)^{-1}} \qquad \mathbf{(1)}$$

2.1.9 In the formula (1), the ATC capacity is inverse or direct function of some factors (ICA 100-30), as follows:

- **Factores directly proportional to the ATC capacity:**
  - ϕ : factor of controller availability, defined as the percentage of time available to plan the aircraft separation procedures;
  - δ : average distance flown by aircraft in the sector, which is function of the pathways and route or terminal established for each sector;

- **Factors inversally proportional to the ATC capacity:**
  - η : number of communication for each aircraft in the sector, which must be restricted to the necessary minimum for the understanding between pilot and controller. That number can be minimized by issuing a full clearance with the necessary anticipation to allow the flight planning;

τ_m : average length of time of each message. This factor can be minimized by transmitting messages in an objective way, avoiding long explanations which are detrimental as far as the understanding between pilot and controller is concerned; and

ν_m : average speed of the aircraft in the sector.

2.1.10 Replacing δ y νm by the average flight time spend by the aircraft crossing the sector (T), that formula can be replaced by a simpler version:

$$\mathbf{N = \phi \cdot T \cdot (\eta \cdot \tau_m)^{-1}} \qquad \mathbf{(2)}$$

2.1.11 The values of the factors ϕ, T, η and τm are collected empirically, following the standardized procedures.

2.1.12 As an example, we can consider T= 12 minutes, τm = 9 seconds, ϕ = 60%, η= 6, which results in a number of simultaneous aircraft N = 8 per controller in the referred sector. In other words, in this sector and under these conditions, a controller would control 8 aircraft simultaneously.

2.1.13 Several factors are constantly influencing number N. Factors directly related, for instance, sector size or route modification. Thus, every time a significant change is notice, it is necessary an update of the determined value. Besides, it is important that the data gathering be very expressive, in order to dilute the provisional stochastic deviations and to represent trustworthy values to the ATC unity.

2.1.14 In ideal conditions, data research shall be conducted when there is a heavy air traffic activity, for this reason to choose the ideal season is a factor to be considered, once it has a direct influence in final results.

2.2 GENERAL PROCEDURES PERFORMED:

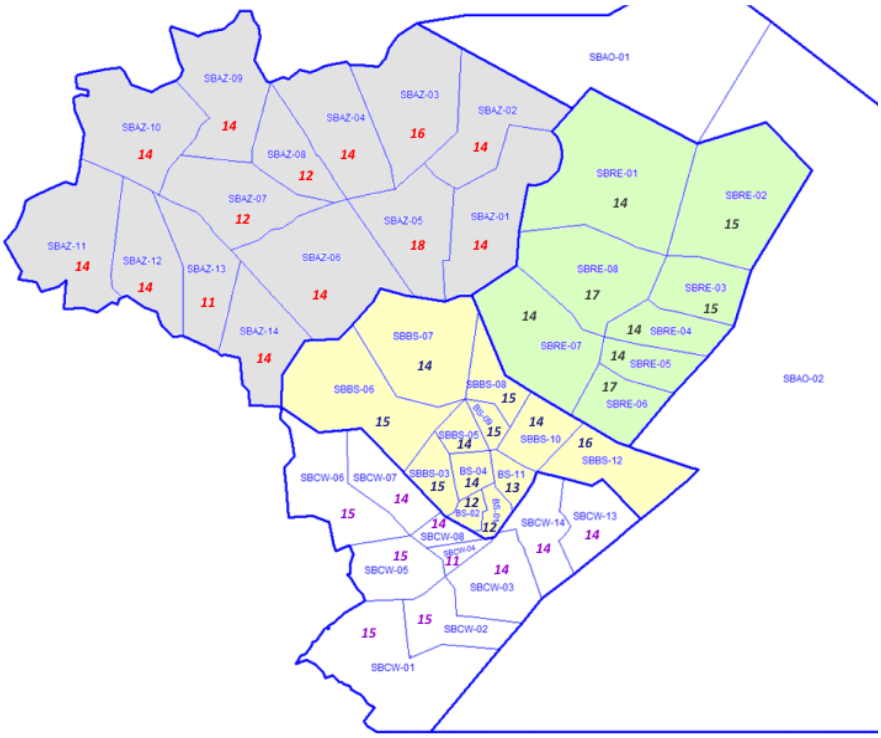
2.2.1 Brazil has calculated the capacities of all sectors, isolated and combined. After performed the calculus of sector, considerations are been made taking account an analysis of main trajectories of air traffic flow, also the complexity of each sector and the adjacent sector capacity adjustment.

2.2.2 The factor of controller availability (ϕ) is taking “in loco” in ATC, when air traffic controller is performing its job and it is variable, being it as big as there is assistant to perform its tasks of coordination and fill “strips”. However, in some cases Brazil adopted the minimum availability factor allowed for radar control, 60%, according to the document and this limit was used to the calculus of capacity.

2.2.3 Brazil used to collect all data “in loco” by measuring with chronometer the time spent by ATCO on his duties as communicating with aircrafts on sector. Nowadays, it was used the tapes recording of ATC communication to obtain some parameter of formulae. This provides some advantages since one can rewind the tape to check out some details that was misunderstood.

2.2.4 The obtainment of the samples which were used for the calculations were taken from the recorded tapes on the period from at least a week and it was the minimum to fulfil the statistics requirements.

2.2.5 Due to the characteristics constant of formulae, the aircraft crossing the sector (T) is the strongest factor and it tends to compromise the capacity ranging to values too high, beyond of a comfortable situation to the ATCO's. For this reason, Brazil, in these cases, considered a maximum of 16 minutes sector as aircraft crossing the sector (T).



The figure 1- shows the capacity of all sectors of Brazilian FIR.

2.2.6 The item 2.3 below shows an example of calculation according to methodology applied.

2.3 CALCULATION OF SECTORS 09 AND 10 COMBINED OF ACC CURITIBA

2.3.1 The sectors 09 and 10 combined is an important sector in the context of Brazilian air traffic flow. It manages all flights that are routed to Galeão international airport coming from North and Northeast, the second most import Brazilian international airport, besides the Santos Dumont a high volume regional airport.

Figure 2- sectors 09 and 10 of ACC Curitiba.

2.4 PROCEDURES PERFORMED

2.4.1 The calculus of sectors 09 and 10 took in consideration the ICA 100-30, ATC Personnel Planning, issued on January 17, 2008 and also the report 11/CGNA/2009, issued on August 28, 2009. The first instructs how to execute the research and collect data above mentioned and the last orients about the statistics parameters of samples.

2.4.2 According to this document the minimum availability factor for radar control is 60% and this limit was used in the case to the calculus of capacity.

2.4.3 The obtainment of the samples which were used for the calculations were taken from the recorded tapes on the period from May 25 until May 29, from 22:58 until 23:25 UTC.

2.4.4 When evaluating the sectors capacity, Brazil looks for consider the consistency respect to overall statistic patterns.

2.4.5 The definition of the air traffic controllers' quantity, the minimum number of aircraft (contacts) is described on the report n. 11/CGNA/2009, on August 28, 2009, appendix A. On this report, the minimum number of air traffic controllers that were taken into account was 09 air traffic controllers and the minimum number of observations for the average time of communication (τ_m) was 30 observations for each air traffic controller and for the average number of communication (η) was 39 observations for each air traffic controller.

2.4.6 The average length of time of each message was 14,5 seconds, as a result of the average of the medium values provided on appendix B.

APPENDIX B

OBSERVED SECTOR	09/10 CWACC	DATE : 25 MAY 2009
OBSERVED ATCO	ATCO 1	

AVERAGE TIME OF COMMUNICATION IN THE SECTOR

TIME TRA/REC(s) ACFT	1	2	3	4	5	6	7	8	9	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	
TAM8002									29								32																							2
TAM3827				5																																			1
TAM3505					46																							48											2
GLO1604						10	13																																2
SAA223		23																																					1
TAM3752																6																							1
GLO1577												8																											1
WEB6796	4			48																																			2
GLO1844								10																															1
TAM3135									28	34									32																				3
TAM3152													35																										1
ARG1256														22							23																		2
N3PG															37													50											2
PPARG																		20							41														2
TAM3897																							51																1
GLO1735																					49				28														2
GLO1588																						9																	1
GLO1893																								53															1
GLO1601																													43										1
GLO1819																														24									1

AVERAGE TIME OF COMMUNICATION FOR EACH AIRCRAFT 15,6

Table 1- example of partial average length of time of each message for each aircraft(τ_m)

2.4.7 The average number of communications of each aircraft in the sector was 02 communications, as a result of the average of the medium values provided on appendix C.

APPENDIX C

DATE :	25/26/27/28/29 MAY 2009
OBSERVED SECTOR	SECT. 9/10
OBSERVATION TIME	

LENGTH OF TIME OF EACH COMMUNICATION OF THE AIRCRAFT (TRANS./RECEP.)sec in AIR TRAFFIC CONTROLLER

AIRCRAFT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	2	4	2	2	3	2	3	3	1							
2	1	1	2	3	4	4	6	2	3							
3	2	6	1	5	1	4	5	2	4							
4	2	1	1	2	1	3	2	3	3							
5	1	1	2	5	1	1	3	2	1							
6	1	2	2	4	1	1	2	4	2							
7	1	2	2	4	6	1	1	4	2							
8	2	1	3	1	2	2	1	1	1							
9	1	1	5	1	2	1	1	1	2							
10	3	1	1	1	3	3	1	2	3							
11	1	1	1	1	3	2	1	1	3							
12	2	2	1	1	2	1	1	2	1							
13	2	2	1		1	1	2	1	1							
14	2	3	2			1	1	1	1							
15	1	2	2			2		1	1							
16	2	1	1			1			1							
17	1		1													
18	1															
19	1															
20	1															
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28																
29																
30																
ARITHMETIC MEAN BY ATCO	1,5	1,9	1,8	2,5	2,3	1,9	2,1	2,0	1,9							
THE AVERAGE NUMBER OF COMMUNICATION WITH EACH AIRCRAFT IN THE SECTOR	2,0															

Table 2- example of average number of communication for each aircraft (η)

2.4.8 The time of permanence in the sector was the result of the harmonic medium of the flights that circulate in 09 and 10 sectors, extracted from SYNCROMAX, tool used to manage ATFM data, and the value for the mentioned situation was 15,1min.

2.4.9 Appendix D represents the formula of ICA 100-30 and the calculation of the capacity for the 09/10 sectors when joined.

APPENDIX D

DATE :	25/26/27/28/29 MAY 2009
OBSERVED SECTOR	SECT. 9/10
OBSERVATION TIME	
MAXIMUM SIMULTANEOUS VALUE OF AIRCRAFT IN THE OBSERVED SECTOR	
N	

Applied value for	f =	60 %
Average Time of flight in the sector	T =	15,1 min
Average length of each message	tm	14,5 sag
Average number of communication of each aircraft in the sector	n	2

$$N = \frac{f \times T}{tm \times n}$$

$$N = 18,7$$

2.4.10 Brazil adopts 80% of the ATC capacity found in the calculations, rounding it up in order to make possible a minor probability of causing delays in case of situations which may occur a demand peak. In this way, the value that must be updated in the operations manual of the ATC unity and also used when controlling is 16 simultaneous aircraft, with a possibility of reaching 19 simultaneous aircraft for a short period of time.

2.4.11 The table 4 pictures the capacities of all sector of Brazilian FIR, isolated and combined.

3 Action suggested

3.1 The meeting is invited to:

a) Analyze the information presented in the Information Paper.

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FIR-RE

ISOLATED SECTORS

RE1	RE2	RE3	RE4	RE5	RE6	RE7	RE8
12	12	15	14	14	15	15	14

COMBINED SECTORS

RE1/2	RE3/4	RE5/6	RE7/8	RE2/3/4	RE1/2/8
12	12	14	14	12	14

RE5/6/7	RE6/7/8	RE1/2/3/4	RE5/6/7/8
14	14	12	14

RE3/4/5	RE3/4/8
12	14

FIR-AZ

ISOLATED SECTORS

AZ1	AZ2	AZ3	AZ4	AZ5	AZ6	AZ7	AZ8
14	14	13	11	11	11	10	10

AZ9	AZ10	AZ11	AZ12	AZ13	AZ14
11	11	11	12	9	11

COMBINED SECTORS

AZ1/2	AZ1/2/3/4	AZ1/2/5	AZ3/4	AZ6/7/8/9/10
11	13	14	13	10

AZ2/3/4	AZ3/4/5	AZ6/7	AZ6/7/8	AZ6/8
13	14	11	11	11

AZ8/9/10	AZ9/10	AZ11/12	AZ13/14
11	11	11	11

AZ11/12/13/14	AZ7/9/10	AZ7/8/9/10	AZ1/2/3/4/5
11	11	11	14

FIR-CW

ISOLATED SECTORS

CW1	CW2	CW3	CW4	CW5	CW6	CW7	CW8
12	12	11	9	12	12	11	11

CW9	CW10
11	11

COMBINED SECTORS

CW1/5	CW6/7	CW4/8	CW9/10	CW2/3	CW4/5	CW5/6	CW7/8
12	12	11	11	12	12	12	11

CW1/2/5	CW6/7/8	CW5/6/7	CW4/5/8
12	12	12	12

CW5/6/7/8	CW4/6/7/8	CW1/2/3	CW4/7/8
12	12	12	12

FIR-BS

ISOLATED SECTORS

BS1	BS2	BS3	BS4	BS5	BS6	BS7	BS8
12	12	15	14	14	15	15	14

BS9	BS10	BS11	BS12
14	14	13	16

COMBINED SECTORS

BS1/2	BS3/4	BS1/4	BS2/3	BS1/2/3/4	BS5/6	BS5/9
12	15	14	14	15	15	14

BS6/7	BS7/8	BS8/9	BS7/8/9	BS5/7/8/9
15	15	14	15	15

BS10/11	BS10/12	BS10/11/12	
14	16	16	