Australia Indonesia Partnership

Kemitraan Australia Indonesia

BALI AIRPORT DEVELOPMENT DIAGNOSTIC REPORT ON NGURAH RAI AIRPORT CAPACITY

FINAL REPORT




INDONESIA INFRASTRUCTURE INITIATIVE

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March 2011

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A Draft Final version of this report, dated 3 January, 2011, was presented to IndII and DGCA in Jakarta on 25 January, 2011. The ensuing comments are included in Chapter 10 with the reflections of the authors. A number of minor errors have been corrected. A major error concerned the separation of aircraft on approach, discussed in Section 6.1.2.

All photos in this report are taken by the Team.

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ACRONYMS

ADS	Automatic dependent surveillance
AIP	Aeronautical information publication
AP1	PT Angkasa Pura 1
APU	Auxiliary Power Unit
ATC	Air traffic control
ATCO	Air traffic control operator
ATIS	Aerodrome Terminal Information Service
ATS	Air traffic services
CDA	Continuous descent approach
CNS	Communications, navigation and surveillance
CPL	Commercial Pilot License
CTR	Control zone
DG	Director General
DGCA	Directorate General of Civil Aviation
DME	Distance measuring equipment
EIA	Environmental Impact Assessment
FMS	Flight management system
GATCO	Guild of Air Traffic Controllers
GNSS	Global navigation satellite system
GP	Glide Path
GPS	Global positioning system
GPU	Ground Power Unit
HIRO	High Intensity Runway Operations
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ILS	Instrument landing system
IndII	Indonesia Infrastructure Initiative
LLZ	Localiser
MM	Middle Marker
MoT	Ministry of Transport
MTOW	Maximum Take-off Weight
NDB	Non-directional beacon
OM	Outer Marker
PAPI	Precision Approach Path Indicator
PCN	Pavement Classification Number
PSR	Primary surveillance radar
RESA	Runway End Safety Area
RET	Rapid Exit Taxiway
SARPs	Standards and Recommended Practices
SEA	Strategic Environmental Assessment
SID	Standard instrument departure
SSR	Secondary surveillance radar
STAR	Standard instrument arrival
TMA	Terminal control area

VHF	Very High Frequency
VOR	VHF Omni-directional Range

CHAPTER 1: GUIDELINES UNDER CURRENT GOVERNMENT REGULATION

The Republic of Indonesia is a huge archipelagic country in South-East Asia spreading more than 5,000 kilometres from west to east and more than 1,800 kilometres from north to south. With around 17,000 islands, out of which about 6,000 have resident population, Indonesia is dependent on a well-functioning air transport system to a much higher degree than most other countries.

1.1 BACKGROUND

The "aviation-intensity" of Indonesia is much higher than it would have been, had the nation been formed by one contiguous landmass, where surface transport would have played a much more salient role. Managing civil aviation under such circumstances is an extremely complicated task. The route network must be much more fine-meshed and the major prerequisite of the network is a huge number of airports, each one of which constitutes a management task of its own. Several projects have dealt with airport and Air Traffic Management (ATM) since the 1990s. In most cases, and as could be expected, airport and route load is dominated by domestic traffic. The most remarkable exception to this rule is Ngurah Rai Airport on the island of Bali, directly to the east of Java. Ngurah Rai is dominated by incoming tourists as Bali is the unrivalled tourist magnet of Indonesia, receiving one-third of all foreign tourists.

The overall goal of this project is stated in its terms of reference: "to identify the most appropriate future actions required to improve national and international air transportation to and from Bali". However, aviation – and transport in general – has no value of its own. The demand for transport is entirely derived from other activities which in the case of Ngurah Rai are dominated by incoming tourism. Understanding the nature of air traffic demand, and its probable development in the future, is a necessary prerequisite in order to determine which improvements should be undertaken, put on hold, or shelved.

1.2 MAJOR FINDINGS

In general, airport capacity has turned out not to be a major problem. Current runway capacity should be around 35 movements per hour, which is around 20–30 percent higher than present peak utilisation and far above the published capacity of 23 movements. There are good possibilities to increase the capacity beyond 35 at modest investment costs. An additional nine movements per hour can probably be obtained through improved efficiency in Air Traffic Service (ATS) routines, additional rapid exits, and departure sequencing pads, bringing total capacity to about 44.

In addition, various managerial tools like restructured charges have a major potential to increase off-peak capacity utilisation.

The only imminent problem found in the study is the traffic situation on the road serving the airport. Frequent breakdowns occur due to a lack of public transport, forcing departing passengers to leave for the airport with an excessive time margin. Road construction will not be sufficient; traffic management is required. A rapid improvement in the share of public transport can be brought about by simply increasing parking and access fees. The increase should be substantial and rapid, but announced well in advance to give the hotels and other stakeholders time to adapt their traffic policy.

At present, there is a substantial overload at the small domestic terminal but this problem is addressed by a construction project to be commenced shortly and to be completed in 2013.

The general environmental situation at the airport appears satisfactory, with room for marginal improvements regarding use of aircraft auxiliary power units, treatment of solid waste and sewerage. However, compared with nearby areas of southern Bali, the airport is so superior in terms of environmental performance that it could be used as a showcase.

Existing traffic forecasts hint at a passenger volume of 25–32 million in 2025, most of which being tourists. With minor improvements, the airport can handle at least 25 million. How-ever, it is the firm opinion of the Team that Bali Island cannot possibly accommodate such a volume and that the increase will level off far below 25 million passengers.

As regards major construction projects, the new terminal is urgently required while there is no need for a runway extension. A second runway cannot be located within the existing airport area if it is to be of any use in terms of capacity, as it must be separated by at least 1,035 metres from the existing runway. The land required for a meaningful location, north of the terminals, cannot be acquired. It is, however, possible to handle future traffic on a single runway.

Summing up, the long-run capacity of Bali’s Ngurah Rai Airport is surprisingly much higher than could be expected from its single-runway configuration and seemingly limited expansion possibilities. The realisation of this capacity requires not only investments in infrastructure, but also some demand-side measures.

CHAPTER 2: HOW TO READ THIS DOCUMENT

A problem facing all authors of reports on civil aviation infrastructure and operations is to choose a suitable level of previous knowledge required by the reader. If the intended circle of readers is confined to civil aviation professionals, the text will be partly incomprehensible for most other readers, including some decision-makers with a professional skill in areas other than aviation. On the other hand, a more basic or instructive text will be perceived as boring and repetitive by the core aviation professionals.

The compromise chosen in this report is closer to the second alternative, implying that the text contains a lot of facts already known to DGCA and Angkasa Pura professionals. Readers from these categories may skip, or only skim, the following sections:

3.1 Airport obstacles

3.2 Airspace, procedures and landing aids

3.3 Runway, taxiways and aprons

3.4 Landside access and road communication

3.5 Passenger terminals, except

- 3.5.3 International terminal, arrivals

3.9 Environmental performance, except

- 3.9.1 Aircraft noise
- 3.9.4 Waste

All major conclusions, found in Chapter 7, Chapter 8, and Chapter 9 will come out clear anyway.

CHAPTER 3: NGURAH RAI AIRPORT

A detailed review of the current airport is a crucial part of this assignment. The team has collected information from a number of sources including a five-day, high-intensive visit to the airport.

3.1 AIRPORT OBSTACLES

In general, the obstacle situation at Bali airport appears quite good. Both runway ends are close to open sea areas and no major obstacles interfere with the conical or horizontal surfaces. The strip, 3,120 metres long and extending 150 metres on each side of the runway centreline, should be free from obstacles. This requirement is fulfilled, barring a small grove in the northwest part of the strip. The grove should be removed, but if this is not possible¸ obstacle lighting in accordance with the International Civil Aviation Organization (ICAO) Annex 14 should be installed. As long as the grove still exists, data should be published in the Air Information Publication (AIP). Other obstacles on the strip are technical equipment necessary for the airport operations. This equipment should be fitted with obstacle lighting in accordance with ICAO Annex 14.

To keep track of the obstacle situation and to preserve the present favourable situation a recommendation is to perform obstacle measurements and inspections on a regular basis. Inspections, performed visually from the ground, should be repeated at least once a year while obstacle measurement, which is an airborne inspection, should be carried out every second or third year.

3.2 AIRSPACE, PROCEDURES AND LANDING AIDS

Bali Control Zone (CTR) adjoins the CTR of nearby Mataram Airport. A large number of standard instrument arrival and departure routes (STAR and SID) connect the airport with nearby air routes. Traffic surveillance is performed by secondary surveillance radar (SSR) with a backup primary surveillance radar (PSR). Declared coverage of these are 150 and 70 nautical miles (NM), respectively. Route navigation is based on a Very High Frequency (VHF) omni-directional radio range (VOR) combined with a range-finder (distance measuring equipment or DME) and a non-directional beacon (NDB).

Landing on runway 09 (i.e. eastwards) is guided by a procedure using VOR and DME. Ideal performance of such a procedure (a "non-precision approach") is to guide the aircraft to a height of 250 feet above the runway. In this case, the minimum height is 454 feet to allow for some obstacles. In case of VOR or DME malfunction, a backup procedure based on the NDB is available with the same performance. Runway 09 has no approach lights as the threshold is far out in the sea but a precision approach path indicator (PAPI) is installed.

Runway 27 is equipped with a full instrument landing system (ILS) comprising standard localiser (LLZ) and glide-path (GP) components. The primary landing procedure is based on ILS and DME. Ideal performance in this case ("a precision approach") is a height of 200 feet and the actual procedure is only marginally inferior with a declared performance of 233 feet. In case of GP malfunction, the procedure turns into an LLZ-based non-precision one with a performance of 348 feet. In case of complete ILS failure, a VOR-DME procedure is available with a performance of 358 feet. Runway 27 has no NDB-based procedure and the NDB is not a component of the ILS/DME and VOR/DME procedures. A vertical radio beacon (middle marker, MM) alerts the pilot at a distance of approximately 1,500 metres from the threshold. There are no outer markers (OM) as these would be located in the sea. Approach lighting system is installed as a high-intensity, 900-metre centreline, Barette-type. The final aid is a PAPI. Threshold lights, runway edge lights, and runway end lights are installed on both runways.

3.3 RUNWAY, TAXIWAYS AND APRONS

The current runway is 3,000 metres long and 45 metres wide with the ICAO designation 09-27, meaning that it is oriented in an east-west direction. Aerodrome reference height is 14 feet above sea level. The runway is paved and supplied with 7.5-metre-wide shoulders on each side to fulfil code 4 E from ICAO Annex 14. This means that the runway can handle aircraft up to code F size or Airbus A 380. At each end, there is a 60-metre stopway followed by a runway end safety area (RESA) of 90 by 90 metres, giving aircraft aborting takeoff an extra braking margin. After the RESA, there is open sea at the western end and a narrow strip of land followed by the sea at the eastern end. The strip is 300 by 3,120 metres (including stopways, but not RESA).

The strength of the runway area equals code 83 FCXT from ICAO Annex 14, meaning that the heaviest of present-day aircraft can be accommodated.

Taxiway N7P is parallel to the runway, connecting the apron area with each runway end via connections N7 in the western end and N1 in the eastern end. In addition, there are another five connections, N2 to N6, N4 and N5 being rapid exit taxiways (RET) allowing aircraft to vacate the runway at high speed, which will reduce runway occupancy time. All taxiways meet ICAO requirements for aircraft size up to Boeing 747, seating 428 passengers in its Garuda Indonesia version.

Figure 1: Western part of apron with aircraft bridges

Rolling aircraft is heading for takeoff on runway 09.

The entire apron area comprises approximately 215,000m^2. Within this area there are four sub-areas, designated Apron A to D depending on location, type of traffic allowed, and aircraft service capability. The whole apron system is built on concrete and has a bearing strength (Pavement Classification Number or PCN) accommodating all existing passenger aircraft. At Apron A, positioned far to the west, there are 18 remote parking positions for code C aircraft (e.g. Boeing 737, Airbus 320 and similar). These positions are used for domestic flights only. Apron B area, directly west of apron A, comprises four remote parking positions for aircraft sizes up to code E or B747. Alternatively, the area can offer five positions for aircraft code D (B767, A300 and similar). The apron is used for both domestic and international flights.

Figure 2: Eastern part of apron

Apron C comprises five bridge-connected positions for aircraft code E and seven remote positions for aircraft code C. The area can alternatively be used for three code C and two code D aircraft. All positions can be used for both domestic and international flights. Finally, the Apron D area, west of the terminal building, comprises three bridge-connected positions for aircraft code E.

Table 1: Apron capacity

Apron	Stands code E (up to B747)	Stands code D (up to B767, A300 etc.)	Stands code C (up to B737, A320 etc.)	Total stands
A	-	-	18	18
B	(4)	5	-	5 (4)
C	5 (5)	(2)	7 (3)	12 (10)
D	3	-	-	3
Sum	**8**	**5**	**25**	**38**

Source: 2006 Master Plan. Figures in brackets indicate alternative parking pattern.

There are five entrances between taxiway N7P and the apron system, but the actual choice depends on the runway in use and available parking positions. The flexibility of the apron is very good, as the five entrances allow ample possibilities to manage the traffic without conflicts or frequent needs for one aircraft to give way for another.

3.4 LANDSIDE ACCESS AND ROAD COMMUNICATION

Road access to the airport is bit stretched in so far, as there is only one road, which is quite narrow and passing through a densely populated area. At the airport perimeter, four tollgates issue access tickets, predominantly through automatic ticket printers. After a sharp right turn, all vehicles pass through a security bridge, amply staffed while apparently no vehicles are actually stopped and checked. The security bridge is followed by a road leading to a huge number of parking positions and continuing to the domestic and international terminals.

Figure 3: Airport entry tollgate

The area closest to the international terminal has a separate lane with eight painted bus positions. Each position will accommodate a 10-metre bus but the entire lane has not been in use for some time and has been blocked with concrete barriers, allegedly for security reasons.

Figure 4: Unused bus parking spot

Exit from the airport is arranged through another set of four tollgates where parking fees are collected.

Taxi lanes for dropping off passengers are arranged alongside the terminal. The taxi service for arriving passengers is located in special areas of the car parking area. For the moment, there seems to be no capacity shortage. There are approximately 500 parking places for cars including those dedicated for taxi cars. The total area is at least 50,000m^2 out of which roughly 10,000m^2 is reserved for motorbikes. The area is stretched along the south side of the terminal and is easily accessible from the entrance road.

3.5 PASSENGER TERMINALS

At present, two separate buildings are in use for international and domestic passengers. The international terminal has a total area of 63,400m2 while the domestic terminal comprises 10,500m^2. Within the frames of this project it is not possible to evaluate all characteristics of terminal capacity at length, but an overview providing a fair hint of the capacity has been produced. For this purpose, the International Air Transport Association (IATA) standard values for passenger service levels have been used. These values, ranging from A to F, represent the perceived passenger comfort level where A represents “Excellent” and F “System breakdown”. Service level C can be regarded as a good level which many airports aim at, with varying degrees of success.

The method uses available floor space as the main indicator for comfort level and this is also critical for the capacity. Using experience from similar airports, the team has taken into account the standard of working routines, flow patterns etc.

Table 2: IATA terminal service levels

Square metre per occupant						
Service level	A	B	C	D	E	F
Label	Excellent	High	Good	Adequate	Inadequate	Unacceptable
Security queue, pre-check-in	1.8	162	1.4	1.2	1.0	<1.0
Check-in queue	1.8	1.6	1.4	1.2	1.0	<1.0
Documentation control	1.4	1.2	1.0	0.8	0.6	<0.6
Baggage reclaim	2.0	1.8	1.6	1.4	1.2	<1.2

Level F is leading to system breakdown.
Source: IATA Airport Reference Manual. Figures adapted to local conditions.

3.5.1 Domestic terminal

A project to rebuild both terminals is just about to start, pending some final approvals. A completely new international terminal will be constructed. Furthermore, the current international terminal will be converted into the domestic terminal while the current domestic terminal will be demolished. The project schedule aims at having both terminals operational in early 2013. Due to this project, the capacity of the current domestic terminal is of minor interest and a deeper evaluation has not been performed. However, a hint of the capacity is found in the fact that almost all domestic passengers travelling with Garuda Indonesia pass through the international terminal on arrival. This is a clear indication of the inadequate capacity of the existing domestic terminal.

3.5.2 International terminal, departures

Passengers enter the international terminal through automatic sliding doors, followed by four security lines with one common “snake” queue. The queuing area is roughly 12 by 30 metres or 360m^2, allowing some 320 passengers to queue at service level C above. Some additional area is available, for example around pillars in the hall, mainly serving as an area for passengers preparing for the security check. Although not a queuing area, this will raise the capacity of the hall since it provides space for more passengers in the hall.

At the **security check**, hand baggage, hold baggage, and passengers are checked by arc metal detectors for the passengers and screening machines for the baggage. At station number one, as seen to the left from the passenger’s point of view, there is also a state-of-the-art body scanner. Estimated average process time in the security control process is 20–30 seconds, measured for a number of passengers. This gives an average throughput of 120–180 passengers per hour, or 480–720 passengers through all four security lines.

From the security control, passengers enter the **check-in area** in the back end. There is a short walk to the check-in hall and the flow is logical with no constraints or crossing flows. Visibility toward the check-in area is good, giving passengers guidance of where to go. The check-in area is divided into a western part and an eastern part. The western part comprises 22 check-in counters in a 50-metre row and the eastern part has 40 counters in an approximately 90-metre-long row. The queue areas behind the counters are approximately 20–22 metres long, going all the way parallel with the counters, meaning that there are some 1,000 m^2 available in the western part and some 1,800m^2 in the eastern part. Common “snake” queues are used, meaning that there is roughly room for 700 and 1,250 queuing passengers at standard level C, respectively. After check-in, passengers reach the departure floor, one level up, via a staircase or an escalator in the rear end of the check-in hall.

Check-in time is normally around two to three minutes per charter passenger, i.e. an hourly capacity of approximately 20–30 passengers per counter. With a common check-in, where all passengers, regardless of airline, can use all counters, the total capacity of the check-in counters would be some 1,200–1,800 passengers per hour if all counters were in use simultaneously.

The logistic flows of the terminal appear reasonably good. Entrance to the check-in hall is in the western part and there is good accessibility to the check-in queue area from the shopping street along the commercial areas in the rear end of the terminal. However, after check-in, passengers must move back through the check-in queue to reach the staircase/escalator to the departure floor. At peak hours, this will create problems with the flow but it should be possible to handle with dedicated walking areas through the queue area. Special aids for disabled passengers have not been found.

Large **commercial areas** are located in the rear end of the check-in area and parallel with the check-in counters. These services can be used without conflicts with passengers checking in. Commercial areas are also found on the departure floor.

After check-in, passengers move one step up via escalator or staircase. **Document control** is performed at 11 positions with approximately 10–12 metres of queue to each. This process is fast, around 20 seconds per passenger, and there are no problems in handling the passengers coming up via the staircase/escalator. The overall capacity with all lines open is in the range of 1,800 passengers per hour, matching the capacity of the check-in counters

Following the document control is the **second security control**, the purpose of which is somewhat unclear, as the same check has already been performed prior to check-in. The check is done via double lines with a maximum queuing length of 10 metres. Equipment used is screening machines for the hand luggage and arc metal detectors for the passenger control. The estimated process time at this position is 15–20 seconds per passenger giving a total capacity of 360–480 passengers per hour. Compared to capacities above, this is an obvious bottleneck. A better solution is to move this second check to the first one, thereby increasing capacity.

No drawings of the areas have been found and the Team has not had the possibility to measure the different areas in the hall. The current capacity is, therefore, difficult to state, but the Team has a feeling there is “quite a lot of space” and that no major constraints exist. Although not being able to present any figures for the capacity, the operations manager at the airport confirmed this impression.

Separate **baggage handling** systems are used for each of the two rows of check-in counters. Each system consists of a conveyor passing behind the counters, collecting bags that are fed to the subsequent conveyors in the system. The bags are transported to the loading positions where they end up on carousels before they are distributed to the correct baggage trolley. No automatic screening is carried out during transportation.

The belt speed in the system is 0.5 metres per second, meaning that 1,800 metres of band are transported each hour. The real capacity of the system depends on how densely it is possible to load the bags but, realistically, it should be possible to put at least one bag every second metre. This indicates a real capacity in excess of 900 bags per hour at each check-in row, giving a total capacity of at least 1,800 bags per hour.

3.5.3 International terminal, arrivals

The arrival flow at an airport is normally less complex and less critical to efficient terminal operations than the departure flow. At Ngurah Rai Airport, three main processes compose the arrival flow: passport control, customs clearance, and baggage reclaim. Passport control is a reasonably easily performed check and the available areas seem to be adequate. Although not having all data about the current arrival passport control, the Team strongly believes there are no major problems with the process.

Baggage reclaim is the next process. Once again, no detailed data over the areas are available and, once again, the feeling is that there is a lot of space in the baggage reclaim hall for the waiting passengers. Baggage is delivered by five carousels, each one exposing some 40 metres of belt to the passengers. In total, there are approximately 200 metres of exposed belt for the passengers. Based on the assumption that four to five passengers can be handled per metre of belt there is capacity of 800–1,000 passengers per hour if the average stay-time for each passenger is one hour. A more realistic stay-time is 30 minutes, meaning that the capacity of the baggage reclaim is in the range of 1,600–2,000 delivered bags per hour. This is valid for the exposed belt length of the carousels, but it has not been checked with respect to available floor space. The opinion of the Team is that available floor space is not a bottleneck.

The final process in the arrival flow is the customs control. This process is stated as "no problem" and the Team has found no contradictory indications. The passenger flow appears to be logical and the available areas seem adequate. In addition, the process is reasonably fast and simple and the customs personnel can choose which passengers to investigate. Therefore, the conclusion is that no major capacity problems occur during customs control.

Table 3: Estimated capacity, international passenger terminal

Departure	Dimension	IATA Std area for level C	Capacity per hour	Notes
Pre-check in security control	Queue area≈360m^2	1.0m^2	480–720 pax	4 control lines
Check-in hall	≈2,800m^2	1.4m^2	≈1,950 pax	1 hour stay 30 min stay = double capacity
Check-in counters	-	-	≈1,200–1,800 pax	62 check-in counters
Check-in machines	-	-	-	Not in use

Departure	Dimension	IATA Std area for level C	Capacity per hour	Notes
Stairs/escalators to upper level	-	-		1 staircase, 1 escalator
Document control, departure	Queue area≈120m^2	1.0m^2	≈ 1,800 pax	11 queues, each 10–12 metres long
Baggage handling system	-	-	≈2 x 900 bags	
Arrival				
Passport control	-	-	-	No data available
Baggage reclaim		1.6m^2		
Exposed conveyor length	5 carousels 250 m total	-	1,000–1,250 pax	1 hour stay 30 min stay = double capacity
Customs	-	-	-	No data available

3.6 AIRPORT OPERATIONS

In this project, airport operations have been reviewed from three different angles:

- Ground handling and catering
- Fuelling
- Airport rescue and fire-fighting, hangars and airport maintenance.

3.6.1 Ground handling and catering

Ground handling of aircraft and passengers is performed via five sub-contractors:

- PT Gapura Angkasa

- PT Jasa Angkasa Semesta
- PT Prathita Titian Nusantara
- PT Aero Bali Dirgantara and
- PT Sari Rahayu Bimantara

Total area available on airside for the service is 24,500m^2. During the Team's visit to Ngurah Rai Airport the impression was that there is a lot of space for ground support equipment and that no capacity constraints have been identified in this area. However, the airport management made the comment that five different handling agents are somewhat too many for the available space, as all agents tend to bring their own equipment and vehicles. The Team recognises this problem – having five handling agents is rare even for airports handling twice the traffic of Ngurah Rai's. While the number of agents in all probability cannot be reduced, it seems possible to restrict the total amount of equipment brought onto the apron, thereby forcing some cooperation.

Catering facilities are placed directly north of apron A and west of the fire station. The area for the service is split between two buildings comprising 5,720m^2 and 3,040m^2 respectively. The total available catering area is 8,760m^2. The capacity in terms of plates per year is stated to be 3,650,000. This number seems quite low compared with other international airports of similar size where heuristics for the capacity hint approximately 700 plates per year and square metre. This indicates a capacity of more than 6 million plates per year within the current facilities as attainable.

In what way the catering demand will develop in the future is highly dependent on the airlines. Some airlines normally cater even for the return flight at their home base, which reduces the required areas at the destination airport. If this is a widespread behaviour, the areas at Ngurah Rai Airport will be sufficient for many years to come. Conversely, if there is an increasing demand for catering in line with traffic growth, there are possibilities to meet the new requirements within the existing facilities.

3.6.2 Fuelling

Fuel is delivered from the company Pertamina, open 24 hours a day. This company is also in charge of the fuelling process which means that its personnel perform all aircraft refuelling. Refuelling trucks are mostly used for this purpose, but there is also a hydrant system, which apparently only serves parking position number 13. The total storage volume at the airport exceeds 20,000m3. This amount is divided between two tanks holding 6,481 and 13,528m3 respectively. No capacity constraints have been found in this aspect and the storage is expected to suffice for a long time.

If necessary, the refuelling capacity can be increased by additional trucks and/or by an extension of the hydrant system. The latter should be preferred in the long run due to a high share of large aircraft holding large fuel volumes. A Boeing 747-400 has a total fuel capacity of up to 216m^3. A hydrant system is more efficient in terms of refuelling time. The hydrant system is also a safer solution thanks to the reduced number of cars on the apron. Fuel storage capacity can easily be increased through additional tanks, should the need occur.

3.6.3 Airport rescue and fire-fighting, hangars and airport maintenance

The fire station is situated directly north of apron D with easy access to the apron system, taxiways and runway. Reaching each threshold within the stipulated maximum time of 180 seconds from alert is reported to be no problem. The rescue and fire-fighting service is performed with the airport's own personnel and the main equipment is three Panther fire-fighting trucks. In addition, there is some older equipment available. The service fulfils all requirements for airports category 9, allowing aircraft sizes up to Boeing 747.

No hangars for airliners exist at the airport today.

Maintenance of the airport area is performed by sub-contractors as well as own personnel. Main services include rubber removal from touchdown zones; painting of day-markings; maintenance of electrical fittings; wildlife hazard control; grass mowing on strips; maintenance of drainage systems etc.

3.7 CARGO TERMINAL

In 2009, the airport handled 65,000 tons of cargo in total. The domestic share was 22,500 tons, out of which 16,000 were inbound for Bali and 6,500 outbound. International cargo constitutes the remaining 42,500 tons, where 14,000 were inbound and 28,500 were exported. All cargo is carried in the belly of passenger aircraft. There are no dedicated freighter airlines serving the airport although some parcel forwarders have done so previously. The present cargo terminal and facilities are situated north of apron D and comprise 3,708m^2 for international cargo and 2,578m^2 for domestic. These premises are sufficient for the current cargo handling and will be improved in connection with the new terminal building project.

3.8 GROUND TRANSPORT

Ground transport of passengers and cargo is not a responsibility of the airport operator. At airports handling traffic volumes of the size found at Ngurah Rai, one would expect a wide variety of public bus services. Considering the fact that Bali is very densely populated, one would expect even rail transport in spite of comparatively short distances. Surprisingly, the only public transport available is a few small buses, operated not by the local community but by the hotels. Passengers use either their own cars or motorbikes or take a taxi, in the latter case often creating two vehicle movements per passenger. The result, of course, is that the access road is frequently clogged and huge areas within the airport are occupied for parking, even though many passengers are incoming tourists without a car.

This situation is not sustainable but the Team found no actual plans for improvement at the local government. The situation is already untenable and, within a few years, the road congestion will be severe enough to seriously damage not only Ngurah Rai's reputation as an airport, but Bali's name as a tourist destination. As far as the Team can judge, the planned bridge spanning part of Benoa Bay close to the airport will not make much of a difference as the entire Kuta-Denpasar area is very congestion-prone. Fortunately, the airport possesses the means to improve the situation without itself having to engage in public transport, see recommendation 18.

3.9 ENVIRONMENTAL PERFORMANCE

An environmental perspective can be applied on inter alia noise, air pollution, energy production, and the use and management of solid and liquid waste. This section is somewhat superficial as the Team did not find any capacity restrictions in the airport´s present and future environmental situation. The airport prepares an annual environmental report, the latest version of which was promised to the Team but never materialised. In general, the environmental situation of the airport may not be flawless, but it is vastly superior to the conditions in the surrounding area. It is worthwhile exploring whether the airport can be marketed as an environmental role model for Bali Island.

As regards future plans, there are principally two tools for assessing the environmental impact of projects and plans. While the Environmental Impact Assessment (EIA) deals with the effects of certain public or private projects on the environment, the Strategic Environmental Assessment (SEA) deals with the effects of plans and programmes on the environment. The EIA and SEA are potentially powerful tools for managing the environmental, health and social impact of individual projects or development plans, but they are efficient only when linked to regulatory permits and licenses and legally enforceable.

3.9.1 Aircraft noise

Sound is generated by many different sources and can be perceived as a disturbance, i.e. noise, by humans in many different circumstances. Environmental noise is the sound generated by human activities (road, rail, sea and air traffic, industry, recreation, construction etc.) when perceived in the domestic environment (e.g. in and near the home, in public parks, schools and hospitals).

Environmental noise has several effects on humans, but as to whether a person experiences such effects is strongly dependent on the individual sensitivity to noise.

The most important effect, in terms of number of affected people, is “annoyance”, which can be determined from structured field surveys. Annoyance is strongly connected with specific effects such as the necessity to close windows in order to avoid sleep disturbance or interference with communication, television, radio or music. A number of serious medical effects such as high blood pressure, mental stress, heart attacks and hearing damage, concern a smaller part of the population. Furthermore, there are negative effects on the learning capabilities of children. It is evident that people who report noise-induced annoyance experience a deteriorated quality of life.

Internationally, L_{den} and L_{max} are two noise decibel indicators used in noise legislation, noise mapping and urban planning. The object of environmental noise legislation is to protect the public against unwanted noise in the domestic environment caused by e.g. air traffic. L_{den} and L_{max} are defined by the International Standard Organization (ISO). L_{den} is the day-evening-night level in decibels, which is the indicator for annoyance used for large airports with night traffic. L_{max} is the noise indicator in decibels and describes the maximum noise produced by an aircraft passage, which is often related to complaints.

As regards aircraft noise, there have been continuous improvements over the past decades. The first jet airliners were powered by pure turbojet or low-bypass engines and were extremely noisy even compared to noisy piston-engine predecessors. Engine noise has been reduced to such an extent that airframe noise has emerged as a major problem, in particular in a landing configuration where engine power is low while slats, flaps, airbrakes and landing gear disturb the airflow. Improved takeoff performance enables a steeper climb, making the noise footprint shorter but wider. This particular line of development is not favourable for Ngurah Rai, where a long and narrow noise footprint is preferable, as such a shape will have a larger proportion striking the open sea. The footprint shape is impressionable by the airport through the introduction of noise abatement takeoff procedures, possibly including restrictions on applied climb power. Whether such procedures are justified is beyond the knowledge of the Team.

Noise from aircraft on the ground originates in engines on idle or low power during taxi and the use of auxiliary power units (APU) when on the apron. The first problem is very hard to address by other means than reducing queues, which is motivated also for other reasons. An APU is a small turbine (producing at best a few hundred kW) built into the aircraft to supply electricity and heating/cooling when engines are off. It is fuelled from the aircraft’s own tanks. APUs tend to be surprisingly noisy in relation to their limited output and a dozen aircraft using APUs on the apron creates a major noise problem and causes a far from insignificant air quality problem. Both problems can be remedied by supplying electricity and conditioned air at the aircraft stands. For remote stands, electricity should be supplied through mobile ground power units (GPU). The use of APU should be prohibited at stands offering both electricity and conditioned air services but may have to be accepted at remote stands on hot days when cooling is required.

3.9.2 Drainage

Surface water drainage is particularly important for aircraft operations, as standing water on the runway decreases the friction value, increases braking distances, and jeopardises safe takeoff and landing. Drainage systems around the runway include side ditches, open channels, and culverts. Drainage water flows are channelled to the sea without any previous treatment.

The potentially most negative environmental impact caused by drainage to the recipient lies in the event of an accident with a large discharge of fuel or oil. Fuel and oil are toxic and persistent water and soil pollutants, and the drainage system appears to lack contention facilities for pollutants. There is a risk that pollutants may reach the sea, and after percolating into the soil it may reach the groundwater.

3.9.3 Energy and waste

It is obvious that energy use at an island airport close to the equator will be dominated by cooling and lighting and, in all probability; there is scope for improvement in both. As the present situation will be history in 2011, when the terminal construction and upgrading project starts, there is no point neither in going through current energy use nor suggesting improvements. Such a study should await completion of the new terminals.

Waste is generated from many different activities at an airport, e.g. catering activities, construction of airport facilities, ground handling of aircraft waste, etc. Due to the lack of the promised environmental report, the Team has no clear picture of the present waste management. It is, however, obvious that sorting and reclamation of solid waste can be improved. For sewage, there is local processing plant at the airport. Such a local solution appears expensive and possibly inefficient in the long run. A connection to a public sewerage system with an efficient treatment plant should be a better solution, once the imminent need for such a system has been satisfied.

3.9.4 Continuous descent (“green”) approaches

The most fuel-saving flight from cruising altitude to landing is to make an uninterrupted descent, using the aircraft’s potential and kinetic energy with a minimum of engine power. Such a continuous descent approach track (CDA) is marketed as “green”, due to reduced fuel consumption and thereby also reduced emissions, although the actual savings tend to be exaggerated. A CDA can easily be computed and displayed to the pilot by modern airliners’ flight management systems (FMS) and, in most cases, CDA can be applied at low-traffic airports. At high-traffic airports, the ATS frequently needs to adjust approaching aircraft positions relative to other aircraft by interrupting descent with one or more horizontal flight segments. This will increase the total fuel consumption. The application of CDA in high-traffic situations requires continuous access to aircraft speed and position, with a precision that cannot be offered by radar. Such information is provided by the global navigation satellite system found in all airliners and, with the emerging automatic dependent surveillance system (ADS), it is transmitted to the ATS. This is a necessary, though not sufficient, condition for the application of CDA. Sophisticated computation is required to allow several aircraft making simultaneous CDAs, as in the end they must be sufficiently spaced on final approach. Trials have been made at several airports. It appears to the Team that the relatively undisturbed airspace around the joint control zone of Ngurah Rai and Mataram offers a suitable area for introducing and testing CDA in Indonesia.

3.9.5 Alternative fuels

All jet and turboprop airliners all over the world use roughly the same fuel, based on kerosene or naphtha. In Europe, it is labelled JET A1, in the United States and other places JET A, and in China Jet Fuel 3. These differ mainly in their sulphur content which is 200, 700 and 2,000 grams per ton, respectively. Its density is 0.8 kilogram per litre and the energy content is 9.6 kWh per litre. The fuel is not a chemical compound and hence it has no chemical formula. It is, however, a hydrocarbon with an "average molecule" roughly composed of nine carbon atoms and 20 hydrogen atoms, C_9H_{20}. Stoichiometric calculations, analysing the fuel's combustion process, reveal that 1 kilogram of fuel will leave 3.1 kilograms of carbon dioxide (CO_2) and 1.4 kilograms of water vapour (H_2O) as residuals. The much higher weight of the residuals is due to their oxygen atoms, taken from the air.

Water vapour is normally harmless but turns into a greenhouse gas when emitted in the stratosphere, where jet aircraft cruise when on long-haul services. However, the major problem of today is carbon dioxide. Alternative fuels address this problem either by reducing the proportion of carbon in the fuel or by replacing fossil carbon with biological, based on biomass (plants, algae, forestry remains). In this case, the CO_2 emissions will not be a net addition to the biosphere as the plants have taken their carbon contents from the air in the photosynthesis process. While in theory an appealing solution, the use of biofuels is restricted by the totally inadequate availability of biomass. This restriction will prevail for the foreseeable future and, in this situation, where biofuels will not come even close to covering the need for surface transport, it is not quite clear why it should be used in aviation where conditions are more complicated.

Not all alternative fuels represent environmental progress. One sidetrack is aviation fuel derived from pit coal or fossil ("natural") gas through conversion via the Fischer-Tropsch conversion process.[1] With coal as the base, total CO_2 emissions of the resulting

[1] This process was developed in fuel-starved wartime Germany and came to big-scale use in South Africa during the decades of blockade.

aircraft fuel will actually increase compared with standard fuel. Based on fossil gas, the main component of which is methane (CH_4), there may be minor advantages. Another sidetrack is hydrogen, the potential of which, incidentally, has been analysed at length in other contexts by members of the Team. Hydrogen will not be available as a commercial fuel in the coming decades and, due to its residuals (water vapour and nitrogen oxides) and general unwieldiness, it is highly unsuitable for aviation.

In general, the airport cannot do very much to promote the use of alternative fuels but the development in this field should be closely monitored.

3.10 LAND UTILISATION

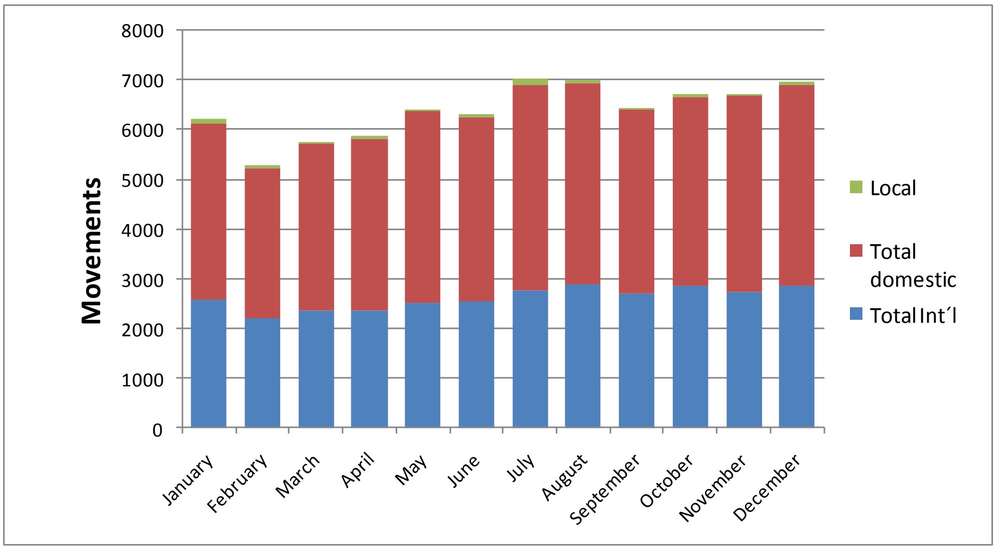
All land inside the aerodrome fencing is government-owned while all land outside is private. While the total airport area is small compared with other airports handling the same traffic volume, it does not appear to be a restricting factor. Fully 51,000m^2 are used for car and motorbike parking and an additional 50,000m^2 for a golf driving range. The latter will be converted to a temporary parking space during construction of the new terminal, after which a multi-storey car park will be opened. Large areas close to the terminal lay waste for alleged security reasons, but this will change with the new terminal. Other areas close to the terminal are occupied for taxi cars and commercial activities. Due to the lack of public ground transport, the taxi area is vastly oversized. In general, land utilisation is not stretched and the available area will be sufficient for the foreseeable future.

Figure 5: Motorbike parking area

3.11 PEAK LOAD PATTERN – MOVEMENTS

In 2009, there were a total of 76,754 aircraft movements and the distribution between domestic, international and local flights was 44,670, 31,325 and 759 respectively. The monthly variation is shown in the following table:

Figure 6: Monthly distribution of movements in 2009



Source: Compiled from data supplied by the airport.

The average load was 6,396 movements per month. In 2009, there was a “low season” from February until April with 88 percent of the average. February was the least congested month with 83 percent, while July, the most congested, had 7,035 movements which is 10 percent above average and 33 percent above February. Domestic and international movements vary, by and large, in the same pattern. The difference is approximately 30–35 percent between high and low months. The Team does not know if 2009 deviates markedly from earlier years, but it seems that “low season” normally occurs February to March.

More important for the operation of the airport is the number of movements per hour. Calculating the peak hour movements for each month with a breakdown into aircraft categories gives the following results:

Table 4: Peak hour movements

Runway	Month/date	Movements	Up to Code C	Code D or E	Peak hour
27	January/04	25	20	5	14-15
27	February/20	19	14	5	14-15

Runway	Month/date	Movements	Up to Code C	Code D or E	Peak hour
27 09	March/12 March/19	21 21	17 15	4 6	13-14 16-17
09	April/3	21	17	4	16-17
09	May/01	30	19	11	08-09
09	June/19	24	20	4	16-17
09	July/11	26	21	5	16-17
09	August/25	24	18	6	16-17
09	September/07	25	23	2	13-14
09	October/04	21	20	1	12-13
09 09 27	November/03 November/15 November/30	22 22 22	18 14 20	4 8 2	13-14 16-17 13-14
09	December/27	24	21	3	13-14

Source: See Figure 6.

These figures are directly derived from the statistics supplied by Ngurah Rai Airport. Top score occurred on 1 May with 30 movements. The Team has no statistics of the second, third or fourth densest hour in May, but it may be possible that the number of movements of these is in the same range. The peak hour in May is far above the peak hour in July, while the total number of movements is 9 percent lower in May. It may be the case that something special occurred on 1 May, 2009 and that the 30-movement hour was a one-time event. Another factor that substantiates this is the time for the peak hour. From March until August, the peak hours occur from 16:00–17:00, with the exception of May when it occurred from 08:00–09:00. The Team has some difficulties in understanding the reason for a traffic schedule that lasts for one month, where the peak time during the day differs completely from the scheduled traffic the months before and after. Normally, the airlines run their business according to one schedule for several months without major changes.

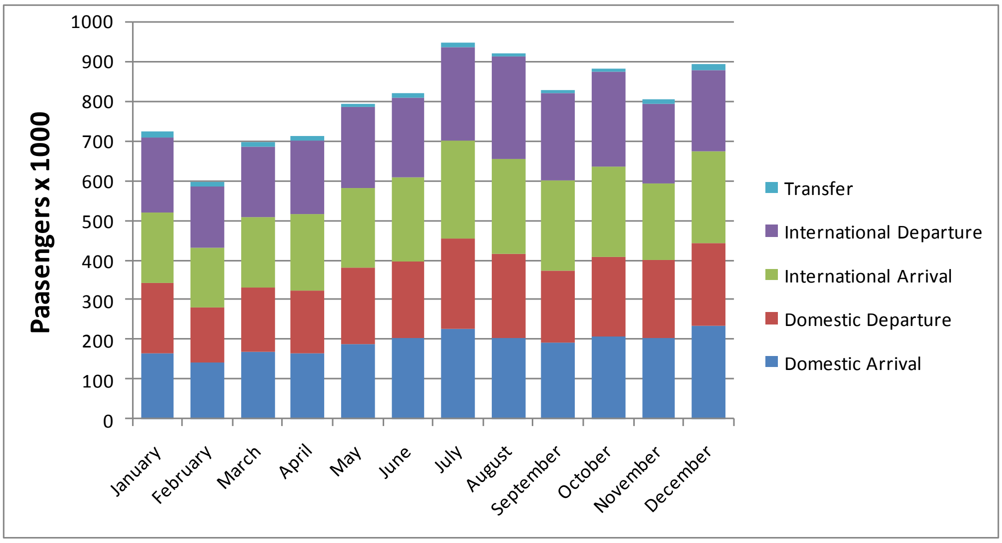
The apron peak load, in terms of occupied stands, is 33. With 38 stands available, and another 10 planned for construction in the near future, there is a good margin before available stands will become a bottleneck.

The load on the terminal from current traffic is a critical factor. Not only does the total amount of passengers affect the terminal, equally important is its distribution over the day. In a situation where a terminal reaches its maximum capacity during some periods of the day, it is still possible to increase traffic as long as it is done during less congested periods.

3.12 PEAK LOAD PATTERN – PASSENGERS

Out of the 9.6 million passengers in 2009, 4.5 million were domestic, fully 4.9 million were international and some 130,000 were transit passengers. Monthly and daily passenger loads in terms of departing international, departing domestic, arriving international and arriving domestic are shown in the table below.

Figure 7: Monthly distribution of passengers in 2009



Source: See Figure 6.

As expected, the monthly distribution of passengers mirrors the distribution of movements but the passenger variation is more pronounced. The average is 826,800. February to April is 81 percent of the average (movements are 88 percent) while July is 14 percent above (movements are 10 percent).

Table 5: Peak day passengers

Month	Peak day/month, domestic				Peak day/month, international			
	Arrival		Departure		Arrival		Departure	
	Date	Number	Date	Number	Date	Number	Date	Number
January	24	7,482	2	10,069	24	8,706	28	8,624
February	13	6,522	15	6,606	23	6,208	1	8,126
March	7	7,861	10	7,348	28	7,603	25	7,345
April	9	7,706	12	8,283	4	7,603	17	7,397
May	20	8,072	24	8,594	1	8,887	1	8,161
June	27	8,524	28	7,906	17	8,042	21	8,174
July	18	9,629	20	9,553	31	9,098	31	9,004
August	14	9,134	17	9,782	5	9,298	17	9,797
September	19	10,260	27	10,833	28	8,788	23	8,731
October	16	8,160	11	8,014	9	9,291	4	9,610
November	20;27	8,058	29	8,732	20	7,217	28	8,192
December	18	9,555	20	8,390	23,26	9,320	23	7,828

Source: See Figure 6.

Taking a look into the variations in number of passengers over the year, it seems to correspond to the variations in number of passengers between each monthly peak day. A fairly clear dip in peak day volumes occurs during February, March and April. In May, traffic starts to increase to a high level, which remains until December/January. A rough estimate is that the number of passengers during the densest peak day is some 40–50 percent higher than the corresponding figures for the least busy peak day.

An interesting observation is that domestic passenger and international passenger volumes do not differ very much. The largest differences are found in April, August, September and October when international traffic exceeds domestic by some 15–20 percent while, on average over the year, the amount of domestic passengers was 92 percent of the international passengers.

Considering the available space in each terminal, this fact deserves a comment. As mentioned before, the international and domestic terminals comprise 63,400m^2 and 10,500m^2 respectively. This means that today almost as many passengers are processed in the domestic terminal as in the international, on a floor area merely 16 percent the size of the international terminal. To understand the reason behind this, it is necessary to take a look into the number of peak hour passengers.

Table 6: Peak hour domestic passengers

Month	Domestic					
	Arrival			Departure		
	Date	Peak hour	Number	Date	Peak hour	Number
January	29	22-23	931	2	13-14	1,531
February	12	17-18	839	1	12-13	739
March	6	16-17	1,049	10	17-18	1,051
April	9	22-23	1,053	12	15-16	1,296
May	15	14-15	1,114	5	08-09	1,245
June	28	16-17	1,179	30	16-17	1,139
July	3	22-23	1,113	20	18-19	1,595
August	15	22-23	1,328	17	18-19	1,315
September	20	17-18	1,281	26	18-19	1,477
October	2	16-17	979	29	18-19	1,131
November	26	17-18	1,066	21	18-19	1,384
December	20	17-18	1,313	10	16-17	1,080

Source: See Figure 6.

Table 7: Peak hour international passengers

Month	International					
	Arrival			Departure		
	Date	Peak hour	Number	Date	Peak hour	Number
January	27	23-24	1,333	31	00-01	1,453
February	16	17-18	990	20	00-01	1,488

Month	International					
	Arrival			Departure		
	Date	Peak hour	Number	Date	Peak hour	Number
March	27	21-22	1,087	22	00-01	1,471
April	10	14-15	2,142	24	00-01	1,391
May	31	06-07	1,622	8	16-17	1,910
June	10	14-15	1,818	15	00-01	1,551
July	15	14-15	1,704	27	00-01	2,033
August	11	14-15	1,774	14	00-01	2,082
September	8	14-15	1,760	23	00-01	1,848
October	17	14-15	1,876	17	00-01	1,613
November	2	14-15	1,165	4	00-01	1,238
December	30	21-22	1,490	21	00-01	1,337

Source: See Figure 6.

These numbers indicate that the average load for international passengers is denser than during domestic operations. Looking at the departure figures, by far the most demanding for the airport, and calculating a mean value over the twelve monthly peak hour values for both domestic and international departures, provides a hint of what is happening in the terminals.

Average peak hour load for domestic passengers is 1,248, with a top in July at 1,595 and a low in February at 739. For international passengers, the average peak hour load is 1,618 with a top in August at 2,082 and a low in November at 1,238. On average, the domestic passenger peak hour had 23 percent less load than the international passenger peak hour although domestic passengers in total are only 15 percent fewer. In addition, during the busiest days in terms of total processed passengers, domestic volume exceeds the international volume, in a much smaller area. The obvious conclusion is that the peak domestic period is wider and lower compared with the international one. Another conclusion already known is that the current domestic terminal must be completely crowded for hours in order to process this amount of passengers.

In the international terminal, 2,082 passengers departed during the peak hour in 2009. It seems to be far too many for some of the processes described in Section 3.5 but, in reality, it may work. The reason is found in the passengers' arrival pattern compared with the aircraft boarding pattern. When boarding starts, almost all passengers are in place at the gate or arrive there within a reasonably short period of time. The boarding process then lasts for some 20 minutes up to an hour until the last passenger enters the aircraft. The actual time depends on several factors, such as the number of passengers, aircraft location (remotely parked or bridge-connected), security pre-boarding or not, etc. When all passengers have boarded, they exert no load on the terminal and can be regarded as departed.

The same passengers have arrived at the airport earlier but that procedure is stretched over a much longer period of time. Normally for a charter flight, the first passengers arrive three to four hours prior to scheduled departure. Remaining passengers arrive during the following two to three hours and, about one hour before departure, almost all passengers have arrived. Provided that the check-in, security control etc. are opened and the passengers choose to use them, airside handling of passengers will be stretched compared with the time spent when boarding. The difference varies with a lot of factors, e.g. passenger type (charter, domestic, business, etc.), departure time, local conditions, etc. A rough estimate is that the number of departing passengers per hour is twice the number of checked-in passengers per hour. This means that the peak load pattern **in the terminal** is not as pronounced as the figures for departing passengers may indicate.

3.13 CONCLUSIONS ON TOTAL AIRPORT CAPACITY

Aircraft capacity is very sharply defined in terms of a number of weight limits, a given number of seats, cargo volume etc. In contrast, airport capacity is a vague concept that cannot be clearly defined and poses few, if any, sharp limits to airport activity. An apron can accommodate only a given number of aircraft at a time, but its *capacity* is determined also by the average occupancy time. In some aspects, the flexibility of the parking positions and the access to the apron also affect the capacity. Most other components of airport capacity are also determined by more than one variable, making every assessment of total airport capacity dependent on a given set of parameters.

In the views of DGCA and AP1, passenger capacity of Ngurah Rai is 17 million per year and cannot be increased beyond this point. Another airport has to be in place to cope with further growth. The calculations behind this figure have not been presented but its foundations have gradually dawned on the Team during the project. Seventeen million appears to be the limit *provided that* the present peak load pattern and aircraft mix remain unchanged. As shown in Section 0, the peak load pattern can be flattened and the aircraft mix can be pushed toward a substantially larger average. The end result is a capacity much higher than 17 million and, in all probability, exceeding even long-term demand.

3.13.1 Movements

As shown in section 3.2, capacity limits in the surrounding airspace pose no major problems, meaning that the first instance where a capacity discussion becomes interesting is the runway. It appears that neither DGCA nor AP1 have performed detailed capacity calculations pinpointing where the restrictions are. This is not as strange as it may sound, as the explanation appears to be that even if the actual capacity is not exactly known, it exceeds present utilisation with a fair margin.

During this project, many different statements on runway capacity have been aired. At Ngurah Rai Airport, the general opinion seems to be that present capacity is 30 movements per hour or slightly less, although many of the technical aids are in place and the ATS routines seem to be reasonably efficient. However, local ATS staff appear to agree that the capacity is 28 movements per hour. The actual limitations behind this relatively small number of movements seem to be somewhat diffuse and the Team does not really understand the background of this opinion. In addition, and for reasons not clearly explained by anyone asked but probably related to safety, only 80 percent of the stated capacity is allowed to be utilised. This means that the allowed number of aircraft movements on the runway is 22 per hour which is half of the theoretical maximum. Still, Table 4 indicates a number of instances where this figure has been exceeded.

Another approach is to make a theoretical calculation. Maximum runway capacity on a single runway configuration is somewhere around 44–45 movements per hour, depending on available technical aids, efficiency of ATC routines etc. and on the aircraft mix. Using accepted general methods from IATA for assessing runway capacity, the following arguments/discussion can be raised:

- A baseline capacity for an aircraft mix comprising less than 20–25 percent heavy jets[2], the full length of parallel taxiways, at least two right-angled exits and Air Traffic Control routines with 5 nautical miles (NM) of radar separation between approaching aircraft is 30 movements per hour. These assumptions are fulfilled at Ngurah Rai Airport with the exception that 8 NM separation is applied, although without notable effect on the capacity, see Section 6.1.2.
- If the presence of infrastructure constraints, for example shorter or no parallel taxiways or ATC constraints in terms of no radar or extended separation between approaching aircraft, the capacity will be further reduced. On the other hand, if there are capacity benefits in terms of ATC routines using reduced approach separation, more than two 90-degree exits, rapid exits (around 30 degrees) allowing aircraft to vacate the runway at higher speed and a departure sequencing pad,[3] the capacity will be increased to a maximum of 44 movements per hour.

[2] Heavy jet in this context means takeoff weight exceeding 130 tons. Due to severe wing-tip vortex, smaller aircraft following the heavy jet require more spacing, which will reduce runway capacity.

[3] A sequencing pad is a part of the taxiway sufficiently wide for one aircraft to overtake another.

The following table summarises the situation at Ngurah Rai relative to the movements per hour baseline capacity:

Table 8: Table 8 Runway capacity estimation

ATC FACTORS Figures pertain to movements per hour	Effect from 30	Situation at Ngurah Rai	Possible increase over 30	Future potential over 35
Approach spacing >5 NM	-16	(8 NM applied)	No effect	
Approach spacing =5 NM	0	Applied		
Approach spacing 3 NM	+5	Not applied, possible in the future		+5
No radar	-20	Radar available		
AIRPORT FACTORS				
Taxiway full length	0	Available		
Taxiway > half length	-5	Not valid		
Taxiway half length	-10	Not valid		
Taxiway < half length	-20	Not valid		
Runway exits 1or 2	0	Not valid		
Runway exits > 2	+2	Available	+2	
Rapid exits 1 or 2	+3	Available	+3	
Rapid exits > 2 (increase over capacity with 1 or 2 rapid exits)	+2	Not available, possible in the future		+2
Departure sequencing pad	+2	Not available		+2
Estimated total capacity			**35**	**44**

Source: Compiled from IATA Airport Development Reference Manual.

The table indicates that the current capacity should be around 35 movements per hour (30 plus two for more than two runway exits and plus three for existing rapid exits). This is somewhere around 20–30 percent higher than present peak utilisation. It also indicates that there should be very good possibilities to increase the capacity beyond 35 without expensive infrastructure investments. An additional nine movements per hour can probably be obtained through improved efficiency in ATS routines, additional rapid exits and departure sequencing pads. However, in this case the present 8 NM approach separation can hardly be maintained but a transfer to 5 NM can be achieved with present equipment.

3.13.2 From movements to passengers

A very interesting task, and of great value if successfully completed, is to translate the number of peak hour aircraft movements into number of annual passengers. A lot of factors needs to be taken into consideration and the circumstances during which the translation is done must be clearly stated. The result will be an indication of the airport capacity, not an exact answer.

The total number of seats flown in and out from an airport varies with a lot of factors, among others:

- Aircraft mix;
- Traffic distribution during the day;
- Types of passengers (share of long-haul tourists, share of domestic business travellers etc.);
- Cabin factor of each aircraft;
- Airport layout (rapid exits, apron layout, number of stands etc.);
- Technical aids available;
- ATS routines.

Consequently, estimating the passenger capacity cannot be an exact science and the resulting value will give a hint of the **capacity during certain circumstances only.**

In the 2009 statistics for Ngurah Rai Airport, the peak hour traffic structure comprised on average 20 percent wide-body aircraft with a seating capacity of approximately 275–375 passengers. The remainder was narrow body aircraft of B737 size or smaller seating roughly 100–150 passengers. Data clearly stated that the maximum hourly peak movements were 30 in May, with July in second place with 26. May appears to be an isolated case so the July value will be used for the capacity discussion. Since the data quote hourly peak load passengers divided into four separated parts (domestic, international, arriving and departing peak passengers) not occurring at the same time, the total number of hourly peak passenger is not known.

Going from movements to passengers requires a formula taking into account the above-mentioned parameters for Bali, or at least for Indonesia. In the prognosis work carried out in the Open Sky project, stage 1 part, the following equations were used:

1. PDM = AM/340

and

2. PHM = PDM*(6.61/PDM+0.064)

where

PDM=Peak day movements

AM=Annual movements

PHM=Peak hour movement

Testing equation 1 with statistics from Bali (peak day movements were 243 in August and total annually movements 76,754) gives a result where the peak day value is overrated. By replacing 340 with 316, a correct result is obtained. In the same way equation 2 is modified by replacing the constant 0.064 with 0.08 giving the correct values for 2009.

In order to estimate the annual capacity, it is necessary to go from peak hour movements to annual movements. This is done by the following operations, using the modified constants above:

3. Equation 2 is modified into: PDM = (PHM-6.61)/0.08

and

4. Equation 1 is modified into: AM = PDM*316

Using these equations and the above values for aircraft mix and seating capacity, the following table can be assembled:

Table 9: From peak hour movements to annual passengers

Peak hour mvts	Peak day mvts	Annual mvts	Distribution Code C/D,E	Seating capacity code C	Seating capacity code D, E	Estimated capacity, million seats per year
26	243	76,754	80% C/ 20% D,E	100-150	275-375	**10.3-14.9**
35	355	112,100	80% C/ 20% D,E	100-150	275-375	**15.1-21.8**
44	467	147,625	80% C/ 20% D,E	100-150	275-375	**19.9-28.8**

Note that the calculation ends with the annual number of seats, not passengers. It can reasonably be assumed that a utilisation ("cabin factor") of 85 percent can be attained. Adding this prerequisite, the table should be interpreted as follows:

If

- the present peak hour capacity is 26 (and not the actually attained 30);
- 20 percent of the aircraft is Code C or D and the remainder Code C;
- the average C aircraft seats 150 and the average D/E 375;
  - then the airport could handle almost 15 million seats and 13 million passengers per year.

If

- the peak hour capacity can be increased to 35 in accordance with Table 8 Runway capacity estimation;
- all other prerequisites are retained;
  - then the airport could handle almost 22 million seats and 19 million passengers per year.

If

- the peak hour capacity can be increased to 44 in accordance with Table 8 Runway capacity estimation;
- all other prerequisites are retained;
  - then the airport could handle almost 29 million seats and 25 million passengers per year.

These results are surprisingly high for a single-runway configuration, but it should be noted that they pertain to *runway* capacity. At least in the case based on a peak hour capacity of 44 movements, massive investments in the terminals are required. On the other hand, the results do not include any of the potentials found in restructured traffic (Section 8.2) and peak spreading through restructured charges or other methods (Section 8.3). There is also some potential in increased cabin factors, i.e. fewer empty seats.

CHAPTER 4: TRAFFIC FORECASTS

Producing a traffic forecast is not a part of this project. The Team will base its analysis on the following sources:

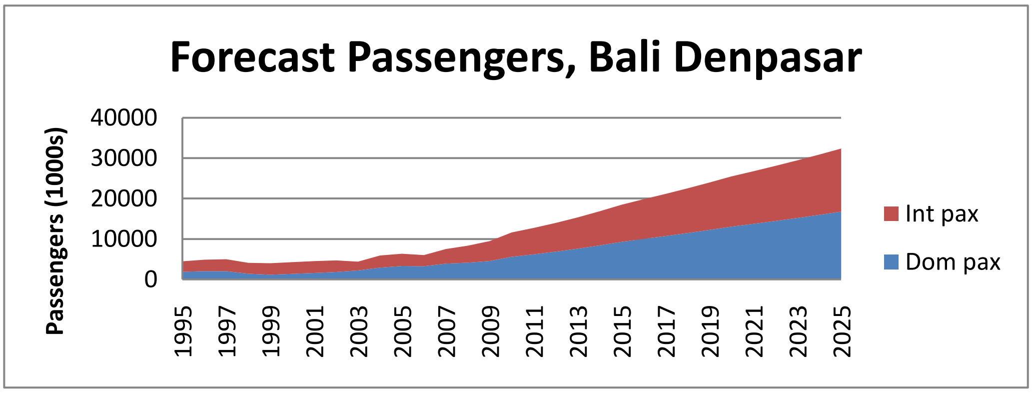
- Comprehensive traffic forecast in the IndII-founded "Report on Air Traffic Analysis" of August 2010;
- Angkasa Pura 1 forecast for the Bali Development Project Phase III;
- Ministry of Transport 2010 forecast.[4]

The first forecast is of a general character, designed with the requirements for overall CNS/ATM capacity in the future, and does not include attention to specific conditions of each airport. For information on applied methodology, see Chapter 4 of the 2010 report. The methodology of the AP1 forecast is unknown, but of minor importance in this context. Neither forecast is accepted at face value as the result of the fact-finding process justifies major modifications.

4.1 THE 2010 INDII FORECAST

As hinted above, this is a top-down forecast where the result for each airport is derived by applying the same growth rate to all, regardless of local conditions and restrictions.

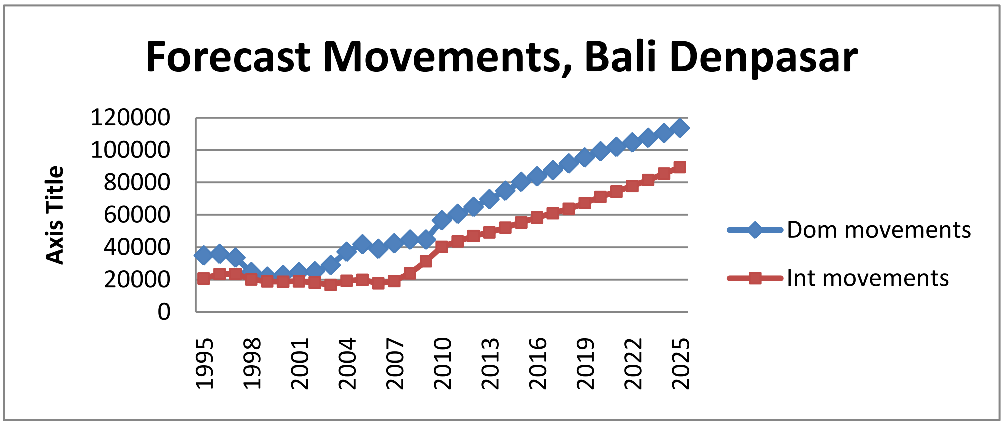
Figure 8: Current (-2009) and forecast passengers



This is the most "optimistic" forecast, ending with a good 30 million passengers in 2025. The movement forecast follows suit:

[4] Keputusan Menteri Perhubungan 364/2010.

Figure 9: Current (-2009) and forecast movements



Peak day and peak hour forecasts have been derived by the use of standard heuristics:

Figure 10: Forecast peak day movements

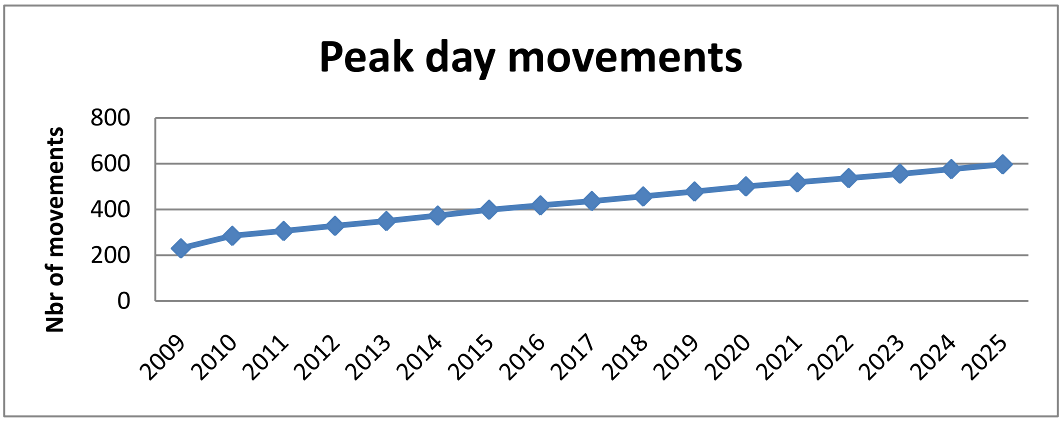
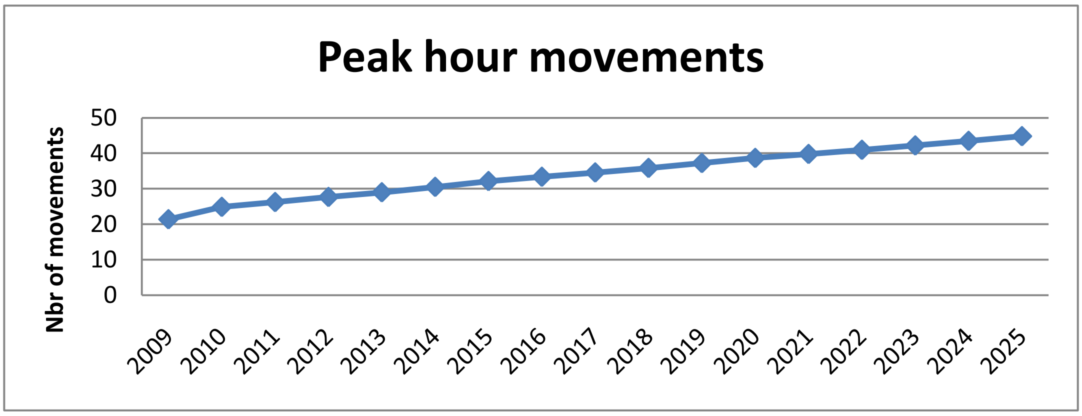


Figure 11: Forecast peak hour movements



Even in this upper-end forecast, the estimated runway peak hour capacity (35) will not be attained until 2017 and the estimated maximum single-runway capacity (44) not until 2024.

4.2 ANGKASA PURA 1 AND MINISTRY OF TRANSPORT FORECASTS

Ngurah Rai is operated by AP1. Its current forecast is somewhat lower than the one displayed in Figure 8. In 2025, not fully 25 million passengers are expected.

Table 10: AP1 passenger forecast for Bali Phase III project

Pax (,000)	2010	2015	2020	2025
Int'l	4,398	6,378	9,250	13,415
Dom	4,435	5,921	7,904	10,551
Transit	220	320	466	678
Total	9,053	12,619	17,620	**24,644**

Source: AP1

The Ministry of Transport made its own forecast for the Ngurah Rai Phase III extension project, most of which appears to be on hold. It is not quite clear which years the forecast contemplates. The end result is a bit higher than the AP1 forecast due to a higher number of international passengers.

Table 11 MoT passenger forecast for Bali Phase III project

Pax (,000)	Phase I	Phase II	Phase III
Int'l	5,660	7,720	16,240
Dom	4,880	6,030	10,750
Transit	140	200	420
Total	10,680	13,950	**27,410**

Source: See Footnote 4.

Inter alia, the following factors will be the drivers and limitations of air transport:[5]

[5] Points 1–6 taken from a recent paper by Mr. Tsuyoshi Isada and somewhat modified.

1. Rapid and continuous growth of Indonesia’s economy.
2. A growing middle class with a high propensity to go by air.

Factors 1 and 2 promote domestic aviation, domestic tourism and outbound international tourism.

3. Rapid economic growth also in China and India, promoting inbound tourism.
4. Growing low-cost carriers pushing airfares down, promoting mainly domestic aviation.
5. Application of a FTA and EPA will commence in the early 2010s.
6. ASEAN unification will commence in 2015.

Factors 5 and 6 will promote all aviation but the actual effect is hard to predict and may be less noteworthy. Phrased differently, it is not obvious that the present absence of a FTA, EPA and ASEAN unification really deters any air services or passengers and what the underlying mechanisms would be. On the other hand, some factors will work in the opposite direction:

7. The aviation industry will either voluntarily shoulder its environmental responsibility in terms of climate impact, or eventually be forced to do so. Either way, airfares will increase rapidly.
8. Real (i.e. inflation-purged) fuel prices will inevitably rise in the long run, outstripping the countervailing effect of increased aircraft fuel efficiency.

In the case of Bali, traffic distribution is heavily skewed toward inbound tourism. There is a limit to the capacity of Bali Island to cater for this activity and this limit may very well fall below the capacity of the airport. This issue is of crucial importance and elaborated in Chapter 5.

4.3 CARGO

As mentioned in Section 3.7, the airport handled 65,000 tons of cargo in 2009, all of which was transported in passenger airliners. Traffic with dedicated freighters is not expected to return. If the passenger volume increases, be it through larger aircraft or more movements, cargo capacity increases in parallel. Hence the cargo part of airport activity will not encroach on airport capacity and it is not expected to outgrow the existing and planned premises. Against this background, the Team sees no point in making a cargo forecast or to dwell on cargo issues at all.

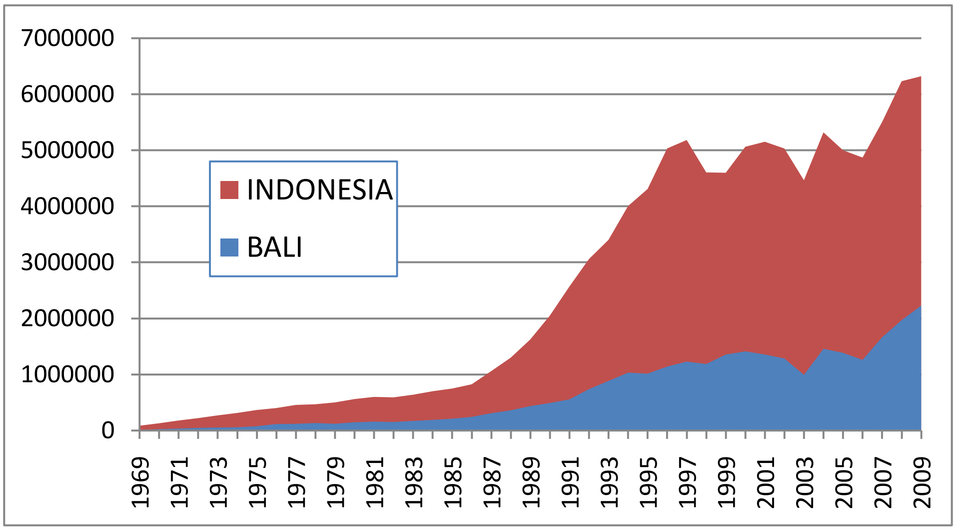
CHAPTER 5: CURRENT SITUATION AND FACTORS MODIFYING THE FORECAST

Transport has no intrinsic value; the demand for transport is in its entirety derived from other activities in society. Civil aviation is no exception, in spite of numerous attempts from the aviation industry to reverse the connection. In the light of these facts, it is of crucial importance to explore the main drivers of air transport demand, and in Bali, the incoming tourism overshadows all others.

5.1 THE ROLE OF BALI IN INDONESIAN TOURISM

Figure 12 shows the development of foreign tourist arrivals in Indonesia, and the part coming to Bali, for the 41-year period 1969–2009.

Figure 12: Foreign tourist arrivals in Indonesia and Bali share



Source: Compiled from Bali Tourism Statistics 2009.

Total arrivals have increased 73-fold from 86,000 in 1969 to 6,324,000 in 2009. To Bali, arrivals have increased *198-fold* from 11,000 in 1969 to 2,230,000 in 2009. This means that Bali's share of the foreign tourism of Indonesia has increased from 13 percent to 35 percent over the past 41 years.

Considering the fact that Bali comprises around 0.25 percent of Indonesia's land area and houses about 1.5 percent of its population, the island's share of foreign tourists is out of all proportion. With a different measure, the average square kilometre of Indonesia in 2009 was populated by about 120 people and received 3.3 foreign tourists while the average square kilometre of Bali received 396 – on top of its resident population of almost 700 people. A third way of looking at the situation is extrapolation, a method less suitable for forecasting than to test the sustainability of current trends. If the 1969–2009 trends continue another 41 years, Indonesia will enjoy 575 million foreign tourists in the year 2051, all of which will go to Bali as the island's share by then has attained 100 percent. Finally, the distribution of income from foreign tourists is extremely skewed. The average spending per foreign tourist can be assumed to be fairly even throughout all tourist destinations in Indonesia. If so, 1.5 percent of the population received about 35 percent of tourist revenues in 2009. Such an imbalance will not be tolerated by the other 98.5 percent in the long run.

5.2 BALI TOURISM IN A BROADER CONTEXT

Various events, such as the terrorist attack in New York in September 2001; the ensuing Afghanistan and Iraq wars; the SARS and Bird Flu epidemics; the 2004 tsunami and the Sumatra earthquake have stamped the first decade of the 21st century. Their effects on local and regional tourism may have been disastrous but on a global level, tourism continues to increase rapidly:

Table 12: World tourism 1980–2020

Year	1980	1985	1990	1995	2000	2005	2010*	2020*
Tourists (Million)	287	328	456	567	681	803	1,006	1,560
Annual growth (%)	-	2.71	6.81	4.45	3.73	3.35	4.61	4.48

Source: UNWTO 2009. Note*: UNWTO projection. Supplied by Mr. Tsuyoshi Isada.

Globalisation has put East Asia at its forefront. The prospect of rapid economic development in China, India and Indonesia for the next decade hints that world tourism could grow faster than above. Tourism development strategies and policies form a part of the national development strategies and policies of most countries in the world. Moreover, the future tourism industry must recognise the environmental challenges and continue to develop ecotourism, sustainable tourism, green tourism etc.

5.3 THE SIGNIFICANCE OF AIRPORT CAPACITY

Bali is a very special tourist destination and it would be presumptuous of foreign aviation consultants trying to describe it. The following quotations paint the image of Bali with indigenous eloquence:

"Bali is genuinely attractive to its natural resources, the friendliness of the people and the consistency of the society top upkeep their intrinsic culture, coupled by the internationalized behaviour of one and all. To enjoy Bali, Bandar Udara Ngurah Rai plays an indispensible role at the main entry point into the island which is often called the Islands of the God and the Island of a Thousand Temples. In short, it can be said that Bandar Udara Ngurah Rai is the gateway to paradise."[6]

"Why the Trunyanese are so defensive of their patch is an easy question to answer. The view across Lake Batur beats any northern Italian backdrop. The locals call their caldera's lake 'the sea': at more than 1,500 metres above sea level, small, wind-whipped waves cut across the deeply turquoise water. Opposite the 1,000-year-old-plus village, pistes of dark-grey lava from previous eruptions – the last was in 2000 – drip down the slopes of still-active Mount Batur."[7]

5.3.1 Gateway to paradise

The Trunyanese may be the most defensive group in Bali but their attitude (if correctly narrated) highlights a growing problem. Maintaining a position as a gateway to paradise entails a heavy responsibility. To preserve and develop the paradise to which the airport aspires to be the gate is an even heavier burden. It is only too obvious to any concerned visitor to Bali that the latter duty is the more demanding one and that paradise maintenance lags behind airport maintenance. In a real paradise there are no traffic jams, at least not those bordering on gridlock, nor widespread littering, open sewers, polluted rivers and conspicuous poverty, all of which meet the visitor within eyesight from the airport. The area from the airport over Kuta up to Denpasar bears every sign of massive overexploitation. Traffic congestion brings to mind peak-hour central Jakarta; local architecture and culture succumb to international chains or greedy property "developers"; litter is rife and rivers are clogged with garbage. Parts of Kuta Beach are extremely dirty and littered. From the residents' perspective, the huge sums spent by tourists appear to disseminate very sluggishly down to the poor while shrinking into trickles on their way.

Growing mass tourism will aggravate rather than alleviate these problems. The dilapidated area around Kuta will deteriorate further and grow to the north, as planning permissions for various construction projects appear not to be based on proper overall plans. Traffic jams cannot be cured by road construction; efficient public transport is required but no such plans have been found. The Bali Government Tourist Office is well aware of the littering and solid waste problem, but has not managed to draw attention to this acute issue in spite of serious efforts. Local residents have also other reasons to regard mass tourism with a skeptical eye. Some big hotels situated close to the shore are effectively privatising parts of the beach (this is not formally the

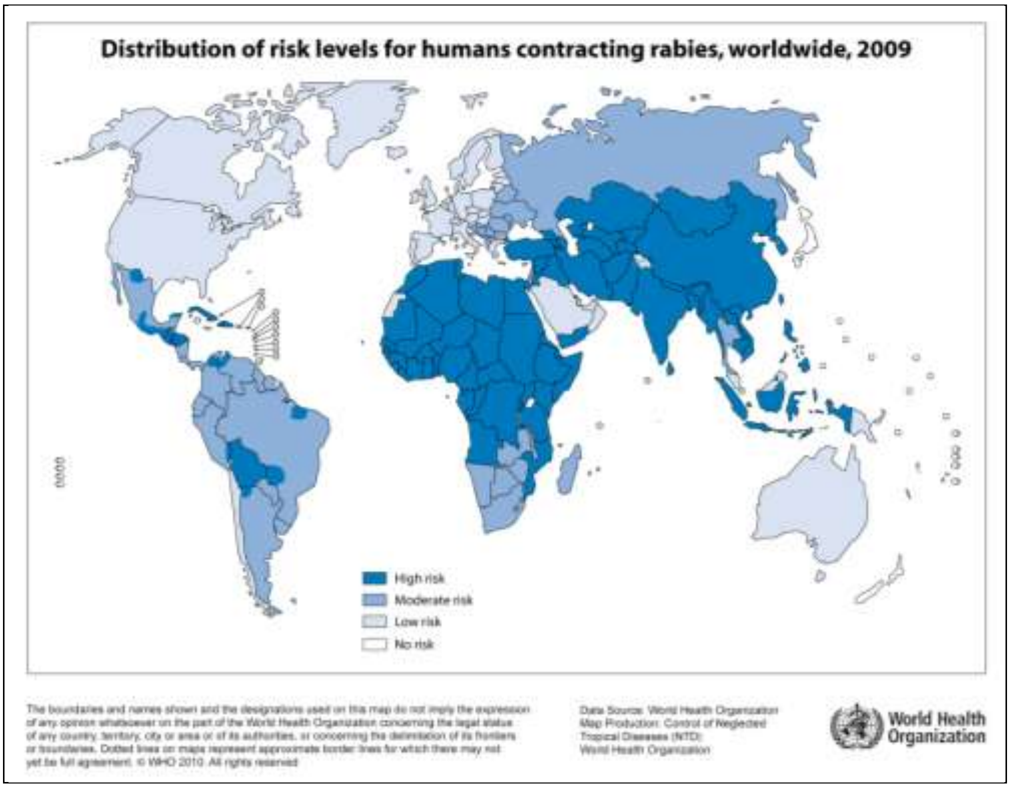
[6] Airport Bali – Gateway to paradise, 1930–2010. PT. Angkasa Pura 1. 2010.
[7] Garuda Indonesia inflight magazine, October 2010, page 66.

case but they make every effort to make it look so). Security gates are found here and there in the Nusa Dua area, hassling locals while evaded without effort by those wishing to do so. The fact that poverty is prevailing in spite of a long period of bulging tourism revenue may be interpreted by locals as if the benefits end up in foreign or central Indonesian pockets while all the drawbacks stay with the Balinese.

5.3.2 Rabies – a serious threat to tourism

Finally, a factor that is not very known poses a serious threat to tourism in Bali. Rabies, a lethal viral disease, is endemic in Bali and in many other areas around the world. The main source of infection in Asia is dogs, where the virus can go from the coat to a small, open scar in humans. A bite is not necessary. According to the Bali Tourism Office, the island houses more than a million dogs. An unknown number of these are roaming and carrying the contagion.

Figure 13: Rabies risk levels in 2009



Source: WHO, http://gamapserver.who.int/mapLibrary/Files/Maps/Global_rabies_2009.png

Countries in white are entirely free of rabies, while countries in light grey have isolated cases but the risk of catching the infection is extremely small. Japan and New Zealand are rabies-free while Western and Central Europe, Australia and Malaysia all belong to the low-risk group and their governments will go to any length to keep their countries there. In 2009, Japan, Australia and Malaysia accounted for 40 percent of all tourist arrivals in Bali. If a tourist domiciled there should die from rabies caught in Bali, recommendations not to go to Bali will be issued swiftly by national health authorities and permeate the news media, possibly swaying a huge number of tourists to other destinations. A large part of tourist income may be lost practically overnight. Against this background, the local government of Bali would be expected to inform arriving tourists on how to minimise risks in the aircraft, or at the latest at the airport. This is not the case and the Team's attention to the problem stems from an article in the Jakarta Globe[8], claiming that 130 people die from rabies in Indonesia every year, mostly in Bali. It may be possible that warnings are found on the Bali Government or Tourist Office websites; the Team has not been able to find out as the first one lacks information in English and the latter has been inaccessible throughout the entire project.[9] In favourable contrast, the Bali Hotels Association provides easily found, comprehensive and current information on rabies.[10] By failing to prepare visitors for the substantial danger they meet, the local government is exposing tourists and the tourist industry to unacceptable risks.

5.3.3 Conclusions on future tourism

Realising the already existing and worsening clash between tourism and local Balinese culture, the Team has reviewed all forecasts analysed in Chapter 4. The somewhat uncomfortable conclusion of the Team is as follows:

Even if civil aviation in South-East Asia and Indonesia grows in line with the general view, air traffic in Bali will, in all probability, not follow the forecasts of Chapter 4. Traffic volumes will grow, but at a significantly lower rate. The main reasons are that the physical, cultural and mental capacity of Bali, the Balinese and their culture to accommodate tourism is limited and cannot cope with 25 million passengers, or even 20 million.

The Team emphasises that there is very little correlation between the number of tourists and the size of tourist revenues. Bali could, and should, cater for the upper end of the tourist market. Tourists may be fewer than forecast, but their spending may very well follow or exceed the forecast.

There are several paths towards this future situation:

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[8] "Indonesia 5th for rabies in Asia, thanks to Bali deaths", Jakarta Globe, 30/31October, 2010.
[9] **www.baliprov.go.id** and **www.tourism.baliprov.go.id**.
[10] **www.balihotelsassociation.com/application/userfiles/data/files/rabiesv6.pdf**

a) The best solution is if the Government of Indonesia decides to distribute incoming tourism more evenly throughout the nation's huge archipelago. Balinese culture may be quite special and attractive, but tourists only interested in having a party life on the beach could be redirected to places more hardwearing and resilient to this activity. Since the Government cannot directly control the air traffic (and the substantial ferry traffic in the case of Bali), financial means of control must be applied. A tool close at hand is to levy a tax on tourists and adapt its level to various destinations.

b) If this is not deemed feasible, the Bali Government could decide that future growth should apply to tourist revenues rather than tourist volumes. Construction planning can be used in addition to a local tourist tax to prevent the tourist industry taking over a growing part of the island. A drawback of local solutions, compared with national, is that tourists may be relocated to destinations abroad instead of in Indonesia.

c) The third path is the result of a laissez-faire or wait-and-see policy, i.e. doing nothing. In this situation, mass tourism will continue to displace the local culture, gradually turning more and more areas into dilapidated, littered abodes for the low-end tourists interested more in having a party than in its location. This will spur a rapidly growing resistance not only from the local Balinese but also from tourists and resident foreigners who are truly interested in the unique qualities of Bali. Tour operators will react to the growing resistance and turn their interest elsewhere. The end result will be the same as in the two intentional paths above, but parts of the Balinese culture will be irrevocably destroyed in the process. Posterity's judgement will be harsh.

To illustrate this point, the Team has had a brief look at some other island resorts.

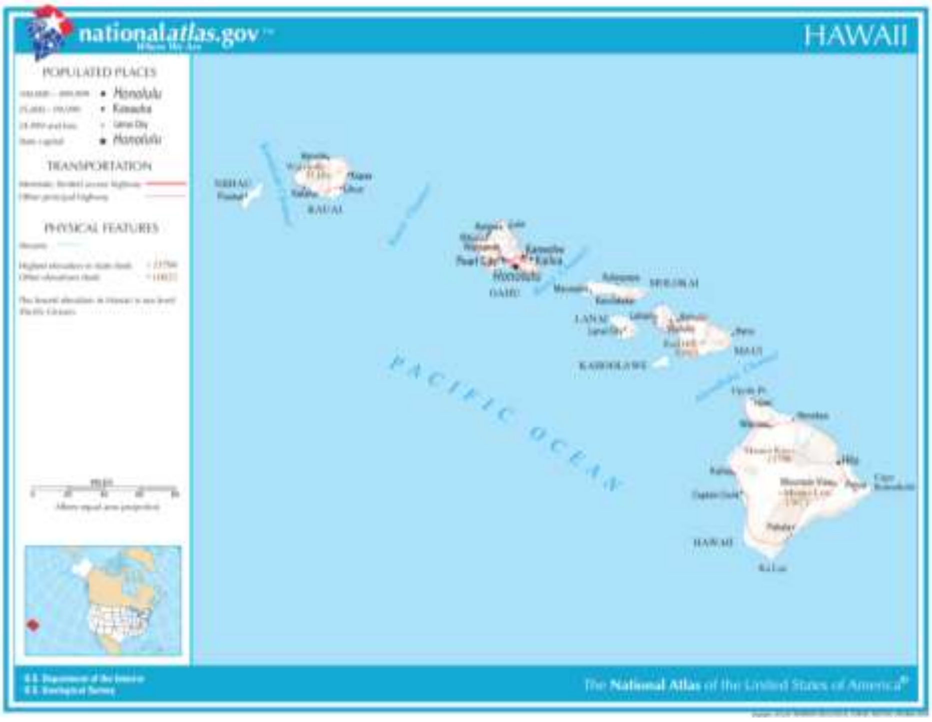
5.4 FINDINGS FROM OTHER MAJOR TOURIST DESTINATIONS

As input to a discussion whether tourist capacity rather than airport capacity is the limiting factor of passenger volume, the Team has had a brief look at three comparable island destinations. *These studies indicate that there is a saturation level of tourism and the Team cannot possibly see any reason why this conclusion should not apply to Bali.*

5.4.1 Hawaii

Hawaii is a group of six major islands and a number of smaller islands that formally became a state of the United States in 1959 after being under US influence since the late 19th century. Land area is 16,649km^2 and the population is around 1.31 million.

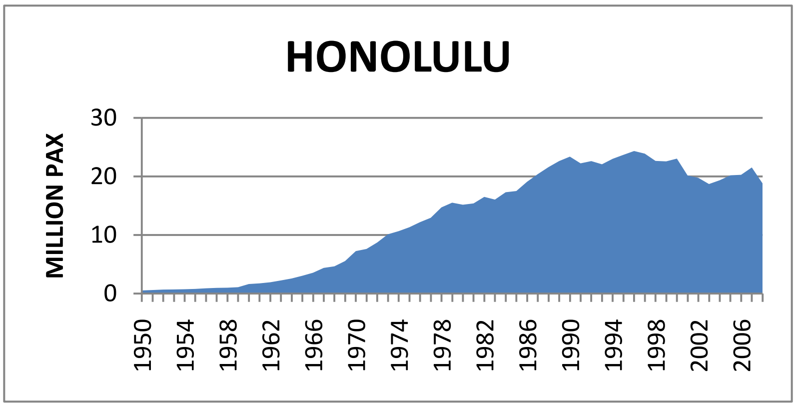
Figure 14: Map of Hawaii



Source: www.nationalatlas.gov

Tourism dates back to before World War II. The gateway is Honolulu Airport, served by 18 international and two local airlines. Overseas passenger volume passed 1 million in 1962, 10 million in 1982, peaked at 14.65 million in 1996 and was 12.9 million in 2007. In essence, the total growth of overseas passengers has been zero over a 23-year period. The number of visitors arriving by air or cruise ship was 6.52 million in 2009. A modest growth to 7.68 million in 2013 is forecast but will only return the volume to its 2007 level.

Figure 15: Passenger traffic at Honolulu Airport



Source: Compiled from http://hawaii.gov/hnl/airport-information/hnl-passenger-statistics-1931-2007

From the US west coast, flight time to Hawaii equals the time from southeast Australia to Bali. The tourism industry prospers not from the sheer quantity of tourists but on their spending. Compared to Bali, Hawaii, two-and-a-half times the land area, is less densely populated, much cleaner, much richer, almost as friendly but much more expensive. Its tourist capacity is many times higher than Bali's.

5.4.2 The Balearic Islands

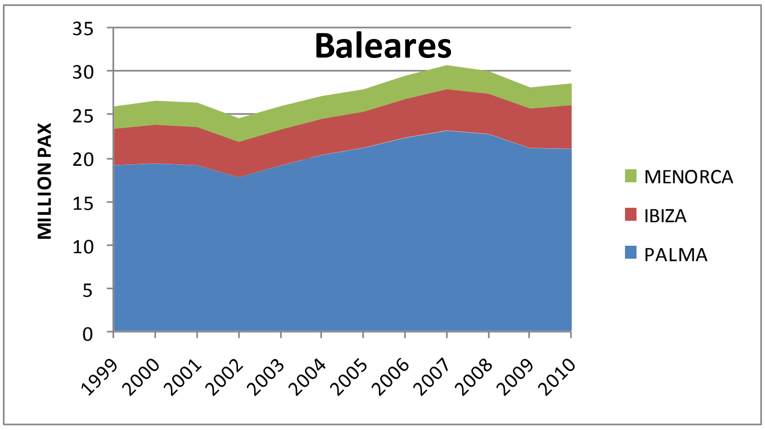
This Spanish archipelago in the northwest part of the Mediterranean Sea epitomises "charter tourism" for many people in Western Europe.

Figure 16: The Balearic Islands

Source: http://upload.wikimedia.org/wikipedia/commons/c/cc/Baleares-rotulado.png

Charter flights commenced in the early 1950s as the islands came within reach even for small airliners of that time, like the Douglas DC3 and the Curtiss C46. The land area is slightly smaller than Bali´s, 5,000km2, with 1 million inhabitants. Tourism has been the dominating source of income since the 1970s. There are three airports with international services, Menorca, Ibiza and Palma de Mallorca which receives about three-quarters of the total traffic. Since 1999, average traffic growth has been 0.9 percent per year:

Figure 17 Passenger traffic at the Balearic Islands Airports



Source: Compiled from Aeropuertos Españoles y Navegación Españoles, www.aena.es. Airport Son Bonet has no scheduled traffic.

Total traffic appears to level out slightly below 30 million passengers per year. In Europe, the Balearic Islands are perceived as a low-cost destination offering mainly beach activities and with few particular culture elements of their own. Compared with Bali, the archipelago is slightly smaller, less densely populated, somewhat cleaner and richer, maybe not as friendly and with roughly the same price level. Its tourist capacity is very far above that of Bali.

5.4.3 The Canary Islands

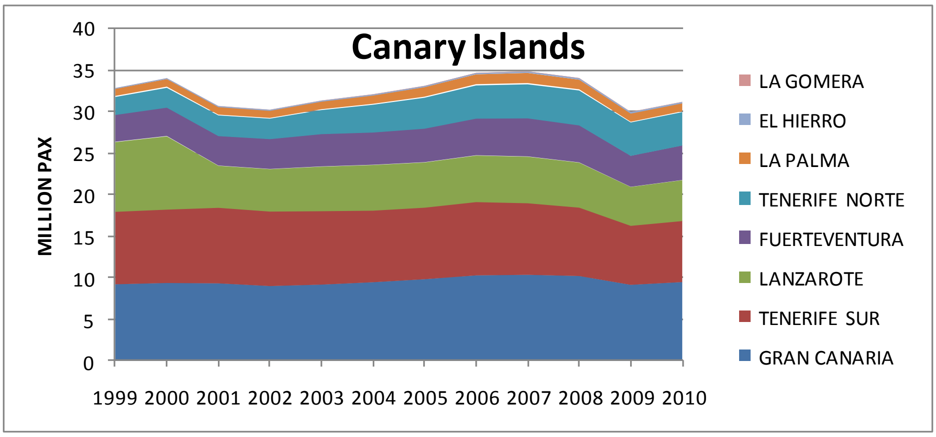
In wintertime, the northern part of the Mediterranean Sea that surrounds the Balearic Islands is not warm enough to entice swimmers and surfers. Another Spanish area, the Canary Islands off the coast of Morocco, offers a more even climate and bathing opportunities in the north hemisphere winter, being located close to the equator. The archipelago spans a landmass of 7,447km^2 and is populated by around 2 million inhabitants.

Figure 18: Canary Islands

Source: http://www.resoteket.se/kanarie/49-infor-resan/84-karta-kanarieoearna

Airborne tourism started in 1957. There are eight airports on the seven major islands, none of which has the dominating role of Palma de Mallorca for the Balearics. Only Tenerife has two airports. The following graph summarises passenger traffic at all airports 1999–2010:

Figure 19: Passenger traffic at the Canary Islands Airports



Source: See Figure 17.

Gran Canaria is the major destination, followed closely by Tenerife Sur and Lanzarote. The contribution of La Palma is marginal; El Hierro and La Gomera, which lack international traffic, are hardly visible. Total traffic has stabilised at a level of between 30 and 35 million passengers. Compared with Bali, the Canary Islands are a bit larger, less densely populated, somewhat cleaner and richer, not as friendly and a bit more expensive. Its tourist capacity is several times higher than that of Bali.

CHAPTER 6: FUTURE CHALLENGES

This chapter summarises the Team's opinion on the hurdles facing Ngurah Rai Airport in the future, bearing in mind the expected slowdown in annual traffic increase discussed above. In case this slowdown does not materialise, the airport will still face the same challenges but in a closer future.

6.1 CAPACITY CONSTRAINTS

Capacity problems in airport operations may appear in the ATS, on the runway, on the apron and in the terminals. As indicated in Sections 3.2 and 3.13, no problems are expected regarding runway capacity even after a substantial traffic increase. The same goes for apron capacity, see Section 3.3.

6.1.1 Imminent

The only imminent capacity constraint within the airport is the domestic terminal and this problem will be solved in 2013 with the completion of the new terminals. A more acute problem is the periodic road traffic breakdowns on the access road, to which no solutions are in the pipeline. In order to reduce (or at least not aggravate) traffic constraints, local bus transportation between the airport and nearby hotels should be started. Most incoming international passengers are tourists and the majority of these are staying at hotels in areas close to the airport. Efficient bus connections reduce the number of vehicles on the roads and lay a foundation for future expansion of public transport. The airport must address this issue by using the traffic management tools at hand.

6.1.2 Short- and medium-term

In the Draft Final version of this report, Table 8, Runway capacity estimation, was based on a minimum separation between approaching aircraft of 5 NM. This was in line with the top score of peak hour movements, which is 30. It was later discovered that the formal minimum is 8 NM, not 5, but the substantial capacity reduction, which the IATA standard attributes to a lack of 5 NM separation, is obviously not present at Ngurah Rai. The explanation appears to be that with an aircraft mix dominated by heavy jets, and with virtually no slow turboprops, the 8 NM separation is not an efficient restriction.[11] However, this situation is not sustainable in the medium term so 5 NM separation must be introduced. As the Team perceived the situation, this can be attained mainly through honing ATC procedures and with little or no requirements for upgraded equipment.

ATC routines can probably be further honed and made more efficient. Streamlining these routines is a prerequisite for utilising the inherent capacity of the existing runway. One example is the high-intensity runway operations (HIRO) concept, meaning that all aircraft entering the runway shall be prepared for immediate takeoff, i.e. all pre-flight preparations including copying of clearance shall be completed when lining up for takeoff. This will increase actual capacity utilisation beyond the reported 80 percent.

The attractiveness of off-peak flight operations can be increased by restructuring charges, see Section 8.3. If successful, the off-peak capacity offers a massive possible traffic increase within the existing facilities.

6.1.3 Long-term

Earlier master plans included two new rapid exit taxiways (RET) from the runway. These would increase peak hour capacity with three extra movements. As runway 09 is in use for about three-quarters of all movements, the eastern RET is more important than the western one.

It is worthwhile to investigate whether the radar separation of arriving and departing aircraft can be further reduced from 5 to 3 NM at acceptable investment costs. This would add five peak hour movements to the runway capacity.

The airport must be developed in cooperation with external stakeholders. Airport operations are a matter for the airport administration but the role of the airport in the region and the impact and needs emerging from airport activity must be handled in a broader perspective.

A long-term plan is required, not only for the airport but for Bali Island in its entirety. This plan should be developed in cooperation between local government agencies, DGCA, AP1 and the airport management, the Bali tourism agency etc., and should focus on future challenges in terms of creating sustainable tourism, creating efficient and capable infrastructure, the role of ferry traffic, an environmental development programme and possibilities of cooperation with, i.a. the island of Lombok.

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[11] With 30 movements per hour, even an hour heavily skewed toward landings will hardly comprise more than 20 landings, i.e. one every third minute. With an average approach speed of 160 knots, the distance between aircraft will be 8 NM anyway.

6.2 THE NEW TERMINAL PROJECT

A project to rebuild and renew the terminals at Ngurah Rai Airport is ready to start, pending only an approval from the environmental authority. It is scheduled to be carried through in 30 months, the new terminals to enter operations in mid-2013 to be ready for i.a., an ASEAN summit meeting. The project comprises an all-new international terminal of 129,000m^2 while the existing international terminal will be renovated and adapted for domestic use and connected to the new international terminal. The existing domestic terminal will be demolished. In addition, existing infrastructure systems outside the terminals, like taxi and bus drop-off and parking areas, will be relocated.

The plan is to expand the terminal in one step, bringing the anticipated required area for 2025 into reality in 2013, if the time schedule will be met. In the traffic forecast, it is assumed that 10.5 million passengers will be domestic while 13.5 million are international travellers. Approximately 700,000 are assumed to be transfer passengers. This means that the number of domestic passengers is supposed to be doubled during the period and that these will be handled on an area of 63,000m^2 instead of the 10,500m^2 available today. There are two main conclusions: first, this part of the project is definitely necessary and second, there will be no capacity constraints in the “new” domestic terminal.

The new international terminal will be more than twice as big as the existing one, 129,000m^2 compared with 63,000. If the traffic pattern in terms of passenger types, times of operation during the day, aircraft sizes etc. remains, the hourly peak load of passengers will grow reasonably in parallel with the overall traffic growth. During the maximum peak hour 2009, 2,033 passengers departed from the airport. With these assumptions, approximately 5,500 passengers will depart during maximum peak hour in 2025, (13.5/5x2,033≈5,500) if the forecast of Chapter 4 becomes reality. This corresponds to an increase of 270 percent.

According to AP1, there are plans for 96 check-in counters and 16 security lines. Compared with the current terminal which has 62 check-in counters and four security lines, the increase is 154 and 400 percent, respectively. The number of counters may seem inadequate, but it must be remembered that the hourly departing passengers do not equal the hourly checked-in or the hourly security-controlled passengers. Probably, the check-in itself has taken more than two hours, which in reality gives a peak load in the check-in hall of less than half of the peak departing passengers. In addition, growing air traffic may entail different traffic patterns, e.g. flight operations spread more evenly over the day, other aircraft sizes, other types of passengers etc. The compound effect on peak load is difficult to forecast but as runway capacity is far from exhausted, the peak capacity can increase even further.

There will be 16 control lines available instead of four in the security process. This represents a welcome quantum leap in capacity. Since aviation authorities and the security industry are keen inventors of new methods and processes, not all of them representing security or capacity improvements, there will be future challenges in the security process. In order to meet these challenges, extra capacity and space will be of major importance.

Regarding other processes in the new terminal, the Team has very little information but assumes the design has been carried out with the aim of balancing capacity between different processes. In general, to avoid unnecessary queuing, the capacity should increase the longer a passenger proceeds into the departure flow.

The conclusion is that the capacity of the new or renovated terminals will be no problem in the foreseeable future. Rather, the question should be raised if the planned capacity overshoots the need too much. Most probably, as discussed earlier in Section 5.3.3, there will be saturation in the traffic growth before 2025 and if so, 25 million annual passengers is not a probable volume in a foreseeable future. In that case the terminal may be unnecessarily big and the capacity too high.

Finally, a few recommendations:

- Easy orientation reduces problems for passengers and speeds up the flow.
- As far as possible, reduce distances on landside, for example walking distances from bus stops, taxi drop-offs etc.
- To the extent possible, reduce the number of changes in level – where passengers have to move from one storey to another. When level change is a must, it shall be carried out as easily as possible.
- Aircraft bridges should be of a multi-aircraft model to increase flexibility and utilisation of the bridge.
- Remote parking stands are mostly good enough to start with. Bridge connections can be constructed at a later stage, spreading the investment costs over a longer period.

CHAPTER 7: RECOMMENDATIONS RELATED TO CONSTRUCTION

In general, the need for construction projects at the airport is modest. Most future challenges can be met with minor improvements.

7.1 AIRSPACE IMPROVEMENTS

The surveys performed in this report have not revealed any noteworthy capacity constraints related to airspace design or navigational aids. While in Bali, the Team monitored about 20 hours of radio communication on all frequencies used at Ngurah Rai and found no indications of frequency congestion. In the long run, it is necessary to reduce the present 8 NM separation between aircraft on approach, notwithstanding the fact that the present minimum in essence is not an efficient restriction. It appears that only negligible investments are required for a reduction to 5 NM. Whether a further reduction to 3 NM, with the probably far-from-negligible investments required, is worthwhile should be further investigated if and when the need for such a reduction is visible.

1. Reduction of minimum separation from 8 to 5 NM should be prepared, and implemented when feasible. Further reduction to 3 NM should be investigated but will probably not be justified.

As regards navigation, it is however somewhat odd that runway 09 is used for around four-fifths of all movements while the approach procedure performance on this runway is clearly inferior to runway 27, see Section 3.2. This situation is a result of favourable weather conditions where the approach performance of runway 09 will suffice most of the time. According to air traffic controllers interviewed by the team, diversions to other airports due to adverse weather conditions in Bali are extremely rare. The opposite situation is slightly more common, i.e. aircraft destined for, i.a., Makassar and Mataram divert to Bali. Wind conditions may prevent the use of runway 27 in bad weather, and in that case, the inferior performance of the VOR/DME procedure to runway 09 may pose a problem.

2. Against this background, the Team recommends installation of an ILS also for runway 09, realising that the isolated benefits for Ngurah Rai will be insignificant but the total benefits may make such an investment worthwhile.
3. In contrast, the Team finds very little reason for retaining the NDB radio beacon. The system is outmoded, the beacon does not form part of any primary approach procedure, it does not contribute to safety and no airline nowadays relies on it for area navigation.

4. It may be justified to design overlay procedures based on satellite navigation but this issue is beyond the scope of this report, as such procedures will not affect airport capacity.

7.2 RUNWAYS, TAXIWAYS AND APRON

Today´s runway and taxiway system can handle all existing passenger aircraft, including Airbus A 380. Ordinary maintenance should, of course, be performed.

The capacity of the apron is enough to handle the current traffic without limitations. According to the airport management, a maximum of 33 stands are occupied simultaneously and 38 stands are available, which indicates no imminent capacity constraints. In addition, another 10 stands, intended for aircraft sizes including B 737 and Airbus A 320, will be constructed in the western parts of the apron. The conclusion must be that as long as the mix of aircraft at the airport does not change in a way where there will be a lack of stands for jumbo aircraft, there will be no need for further expansion.

5. In the future, and along with an expected traffic growth, the recommendation for runway improvement is to take measures in order to utilise 100 percent of the declared capacity instead of today´s 80 percent. This can probably be done with more efficient ATS routines and improved technical aids.
6. If these measures are combined with two extra rapid exits from the runway, the increase in capacity will handle the traffic situation for many years to come.

The capacity of the apron must follow an increase of runway capacity.

7. The recommendation is therefore to expand it with additional stands for jumbo aircraft on the A and B areas.
8. Today, these areas house stands for code C aircraft and an effective and flexible development would be to construct combined-type stands available for both narrow body and wide body aircraft.
9. A recommendation is also to take a deeper look into the possibilities of having code F aircraft (in the foreseeable future only Airbus 380) at the airport.
10. It may be wise to expand one or two code E stands to accommodate code F aircraft.
11. Although more intensive in terms of labour, remote stands with bus transportation of passengers are recommended since they requires much less investment.

These recommendations follow the intentions from the comprehensive DGCA plan.[12] To expand airside this way means that no extraordinary investments need to be carried through and the very good flexibility of the apron will be preserved.

Figure 20: Aircraft bridge

7.3 RUNWAY EXTENSION AND SECOND RUNWAY

JICA's 1997 Master Plan contains a 600-metre runway extension to the east and also a second, 2,500-metre runway situated south of the present runway and with the same orientation. Neither of the proposals appears to have been analysed in more detail and the Team would assume that the terms of reference required only indicative descriptions of the projects. Both were included in a proposed Phase III which, according to some voices heard by the Team, is to be regarded as shelved. Still, both issues tend to surface frequently and the Team has also noted that the analysis has not progressed beyond the 1997 level. For this reason, some efforts have been spent in analysing the possible benefits of both projects. There is no data available for analysis of the costs.

7.3.1 Runway extension

A suitable starting point is the restriction on air traffic associated with the present runway. It is obvious that the runway width and the bearing strength pose no

[12] "Keputusan Menteri Perhubungan nomor 364 tahun 2010 tentang rencana induk banar udara internasional Ngurah Rai kabupaten badung provinsi Bali."

restrictions but the runway length, 3,000 metres, may do so by not allowing the use of maximum takeoff weight (MTOW). The Team has used performance data for the following Boeing models:[13]

- 747-400 with Rolls-Royce RB211-524G2 engines and optional stabiliser fuel tank, MTOW 377 tons;
- 747-400 ER (extended range) with Pratt & Whitney 4062 engines, MTOW 413 tons;
- 777-300 ER with General Electric GE90-115B1 engines, MTOW 352 tons.

Boeing 747-400 is a mid-1990s derivative of the original, four-engine twin-storey 747 which entered the market in 1969 and remained the biggest passenger airliner until the recent arrival of Airbus 380. Garuda Indonesia operates three 747-400s, seating 428 passengers in a two-class configuration. The twin-engine 777 started deliveries in 1995 and Boeing intends to continue production until the mid-2040s. Garuda has no 777s but Thai operates three 777-300ERs, seating 312 passengers in a three-class configuration. Both models come with a choice of engines, with minor differences in thrust and performance. The engines in the list above are those with the highest thrust. RB 211 produces 258 kN, P&W 4062 282 kN, and the GE90 a massive 514 kN.

Takeoff performance is far more demanding than landing. The Team used maximum takeoff weight as a starting point and used performance diagrams to estimate the reduction of takeoff weight required for accommodating takeoff on from Ngurah Rai's 3,000-metre runway on a hot (more than 30 degrees Celsius) day. In all three cases, the reduction was found to be around 15 tons, e.g. the 777-300 can take off at a weight of 337 tons. The reduction must be taken from the fuel load, **provided that** maximum payload is attained. In this case, a reduction in range of about 1,000 kilometres is the result. In most cases though, this restriction is less binding or not at all effective:

- If payload falls short of maximum, the 15-ton reduction is partly accommodated by empty seats. The 777 has a maximum payload of 70 tons which means (somewhat simplified) that when cabin factors fall below 75 percent, the entire reduction is accommodated by the payload.
- Most destinations served from Bali in the foreseeable future are not distant enough to require use of maximum fuel capacity, i.e. the aircraft will start below MTOW anyway.
- Runway length at Bali will not, in any case, restrict fuel load for incoming aircraft. The effective restriction in this case is maximum landing weight, which 100 tons below MTOW for the 777.

Another factor to consider is the technical problems with an eastward extension. A huge area must be reclaimed from the sea. As shown in Deliverable 1, the local religion will not accept the relocation of the Ngurah Rai Bypass road into a tunnel. Hence

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[13] Data gleaned from the document "Aircraft Characteristics for Airport Planning", available at www.boeing.com.

additional land must be reclaimed to accommodate the road between the runway threshold and the sea, but the road cannot pass too close to the threshold. This is due to the huge jet blast from the engines during takeoff. Behind a Boeing 777, exhaust velocity will exceed 50 metres per second more than 150 metres behind the aircraft. Either additional land has to be reclaimed to accommodate the road with a sufficient margin to the threshold, or the road must be placed in a cutting to pass well below the runway level. As the runway is only 5 metres above sea level, this will create drainage problems in the cutting when the road is lowered below sea level. Other solutions exist but the Team finds no reason to further explore the matter.

The present runway will accommodate a Boeing 747 and even an Airbus 380, although this type may create problems at the apron and terminals. These problems are, of course, not remedied by a runway extension. It follows that a runway extension will not enable operations with larger aircraft and consequently, the extension will not bring about any increase at all in passenger capacity. It could also be the case that increased runway length will entice landing aircraft to reduce speed by more air-braking and less wheel-breaking (which is quite costly), thereby increasing the runway occupancy time.

Summing up, the present runway length is, in every respect, a marginal problem with little or no impact on airline operations. Its effect will diminish further with the lapse of time as aircraft performance tends to increase continuously, reducing the need for runway length.

12. The Team's recommendation regarding runway extension is unambiguous: shelve the project until further notice. It is highly improbable that future development will ever justify this complicated, costly and only marginally beneficial project.

7.3.2 Second runway

The 1997 Master Plan indicates, as mentioned, a second runway, parallel to the existing one and 2,500 metres long. Such a project appears at first glance to bring about a quantum leap in airport capacity, but a closer scrutiny contradicts this conclusion entirely.

To bring about an increase in the number of movements per hour that the airport can accommodate, the second runway must be separated from the existing one by at least 1,035 metres. According to the master plan drawing, the distance is only a few hundred metres, which is far below the minimum distance for independent operations. This means that an approach to or a climb from the second runway must always be coordinated with movements on the first runway, effectively crowding out some of these movements. Furthermore, once an aircraft has landed on the second runway, it must taxi across the first runway in order to reach the terminals as these are situated on the north side. This taxi movement will block the first runway whenever it cannot be fitted into a space between the movements there. At the end of the day, peak hour capacity of Ngurah Rai will not increase at all and probably decrease significantly. A second runway to the south of the present one is a completely meaningless project. Additional complications include the insurmountable economic, political and religious obstacles to an acquisition of the required land.

13. The Team's recommendation regarding the second runway is even more straightforward: leave the project on the shelf, indefinitely. No foreseeable future change will justify this project.

CHAPTER 8: RECOMMENDATIONS RELATED TO TRAFFIC

The previous chapter addresses limits to capacity but an equally important factor is to utilise existing and future capacity more efficiently. This calls for various traffic management measures.

8.1 SLOT COORDINATION

Big airports, normally those handling more than 4–5 million passengers annually, distribute their capacity by means of slots. A slot is a narrow time window for departure or arrival. Airlines distribute slots among themselves at annual slot conferences. Slots may be exchanged between airlines but not sold, although this restriction can be easily circumvented by making a parallel, under- or overpriced deal regarding something else, e.g. an aircraft, spare parts or maintenance.

According to the local ATS, Ngurah Rai is part of the slot coordination system although opinions differed somewhat regarding the formally declared capacity. Twenty-two to -three appeared to be the average consensus but, as shown in Table 4, up to 30 movements per hour has been attained at several instances. If the declared capacity is 23 and the actual is (at least) 30, there is a 30 percent capacity margin which is presently not utilised.

14. The Team suggests that the declared capacity is increased, but slowly.

It is desirable to tap another source of increased capacity, an increase in the average aircraft size, and this development will be expedited if airlines perceive the slot allocation as somewhat scarce.

8.2 RESTRUCTURED TRAFFIC

A closer look at Table 4 also reveals that aircraft up to class C make up more than three-quarters of the peak hour movements. The Team has not made an in-depth analysis of which aircraft types actually form the “up to class C” category at Ngurah Rai Airport, but normally the bulk of types within the class is made up by Boeing 737 and Airbus A320. The D and E category can be assumed to comprise mostly the Airbus A 330/340, B777 up to Boeing 747 types, seating around 350–450 passengers. Assume that the average “up to class C” carries 100 passengers less than the average D or E class, which is on the cautious side. Assume also that the declared capacity in a not-too-distant future will be 30 movements per hour, and that the peak hour distribution between class D or E and up to class C prevails. This means that around 22 peak hour movements would be up to class C and the remaining eight class D. If all movements were class D, then the peak hour capacity would increase by 2,200 passengers. As shown in Table 6 and Table 7, the top domestic and international passenger peak hours in 2009 comprised 1,595 and 2,082 passengers. These top-notch hours did not occur simultaneously, but even if they did, the potential of restructured traffic – in this simplified example – is in the range of a 50 percent increase.

It may, however, not be desirable to increase what is, in essence, runway peak hour passenger capacity to the extent indicated above, as this may create problems at the apron and in the terminals. Another option is to increase the off-peak capacity *utilisation*, i.e. using existing or future capacity more efficiently. Restructuring user charges is the prime method.

8.3 RESTRUCTURED CHARGES

Almost invariably, airline fares for the same service vary widely with the time of day, the weekday, proximity to major holidays and high/low season of the year. Most airlines also have a choice of aircraft type to fly a particular service. Finding the optimal airfare structure, i.e. the one turning in the highest profit, is a very complicated problem that could only be solved with rule-of-thumb methods until the arrival of mainframe computers around 1970. Forty years later, most airports still apply flat user charges where the cost for the airline is the same, regardless of landing or takeoff time. There is ample scope for changing the peak load pattern by differentiated user charges. Experiences indicate, however, that a very pronounced differentiation is required to make airlines change their schedules. This is due to the fact that airport charges constitute a rather small proportion of an airline's total cost.

Figure 6 shows a total number of movements of 77,000 in 2009 while Table 4 shows peak hour movements around 25, with 30 as an exception in May. Assuming that it would be possible to accommodate 25 movements per hour for at least 6, 000 hours out of 8,760 in a year, the number would double to 150,000 within present peak capacity. This is only a theoretical exercise and would require a very extreme variation in user charges.

15. In the Team's opinion, a capacity (utilisation) increase of around 20 percent can be attained through restructured user charges while still keeping the required charge variation acceptable to the airlines.

The peak load pricing issue is elaborated in 0 added to this final version.

8.4 RESTRUCTURED MODAL SPLIT

Modal split refers to the distribution of traffic between air and surface transport. In the case of Bali, a huge number of tourists arrive via the short Gilimanuk-Ketabang ferry connection. The number of passengers on this service has increased from 1.94 million in 2005 to 3.16 million in 2009. At present, this is the only ferry connection.

16. If the capacity situation at Ngurah Rai Airport – contrary to the findings of this report – turns into a problem in the long run, there is some scope for alleviating the situation by increasing the share of surface transport.

The capacity of the Gilimanuk-Ketabang service is not known to the Team but, in general, it is not a giant problem to increase port and ship capacity for ferry connections. A much more salient problem is land transport on Java. Massive investments in road and rail infrastructure is required before surface transport to Bali will attract foreign tourists, but these investments are justified anyway. Domestic tourists may be more willing to endure transport on existing roads.

17. Another option, although a bit more strained, is to use Mataram Airport on Lombok, forwarding tourists by ferry transport to Bali (business travellers will never choose this option).

In contrast to the short Gilimanuk-Ketabang service, the sea distance is considerable. This solution is complicated also by the poor safety record of SE Asian passenger boat services, not only in Indonesia but also in Malaysia and the Philippines. It will also be much more expensive than direct flights to Ngurah Rai. Nevertheless, the option exists, should the need ever arise, and its potential is in the range of several million passengers per year.

CHAPTER 9: OTHER RECOMMENDATIONS

As indicated in Section 3.8, ground transport is totally dominated by private cars and motorbikes. Taxis and occasional hotel minibuses are the only signs of public transport. This situation has already entailed frequent and severe traffic congestion on the airport access road, creating huge problems for passengers. The primary solution is traffic management rather than road construction and, fortunately, efficient means are at the airport's disposal as all road traffic is routed via entry and exit tollgates where the airport charges drivers for access and parking.

18. Car and motorbike parking and access charges should be increased very sharply, but the increase should be announced well in advance to allow hotels etc. to adapt their transport offers.

This will reduce congestion, entice hotels to offer bus services to a much larger extent than at present; reduce the propensity of passengers to park at the airport during their stay; make parking areas sufficient for a long time to come; and increase airport revenues.

19. The grove in the northwest part of the runway strip should be removed, but if this is not possible¸ obstacle lighting should be installed in accordance with ICAO Annex 14.
20. As long as the grove still exists, data should be published in the Air Information Publication (AIP).
21. Technical equipment on the strip, necessary for airport operations, should be fitted with obstacle lighting in accordance with ICAO Annex 14.
22. Obstacle measurements and inspections should be performed on a regular basis.
23. Inspections, performed visually from the ground, should be repeated at least once a year while obstacle measurement, which is an airborne inspection, should be carried out every second or third year.
24. The noise footprint shape is impressionable by the airport through the introduction of noise abatement takeoff procedures, possibly including restrictions on applied climb power. Whether such procedures are justified is beyond the knowledge of the Team.
25. Noise from airport operations can be remedied by supplying electricity and conditioned air at the aircraft stands.
    a) For remote stands, electricity should be supplied through mobile ground power units (GPU).
    b) The use of APUs should be prohibited at stands offering both electricity and conditioned air services but may have to be accepted at remote stands on hot days when cooling is required.

26. It appears to the Team that the relatively undisturbed airspace around the joint control zone of Ngurah Rai and Mataram offers a suitable area for introducing and testing continuous descent ("green") approaches in Indonesia.
27. As shown in Section 1, the obstacle situation is auspicious but some of the obstacles are reported to be growing trees to the east of the runway. To monitor the situation, periodic obstacle inspection must be performed. Trees should be preserved even if they constitute obstacles, but careful pruning must be performed.
28. After a meeting with the local authorities and organisations, the Team was left with the impression that local engagement in the airport's operations and future plans could be better. A special but permanent cooperation committee may be a solution.
29. The planned number of check-in counters in the new terminal is 96. It may be worthwhile to reconsider this part of the design and determine whether the use of check-in machines, internet check-in etc. could reduce the number. Most tourists are accustomed to these machines and local passengers will be so in the near future.
30. Ground handling is deregulated in terms of operators but the airport should set a limit to the amount of ground support equipment allowed. This would render apron utilisation more efficient.
31. The airport should keep an annual record of the quantity of waste produced, its source, types and storage and disposal methods.

Rabies has the potential of halving the tourist revenues virtually overnight if not properly managed.

32. The rabies situation must be attended to at once by the local Balinese Government and the airport must make sure that arriving passengers are properly informed on how to minimise risk and deal with possible infection.

CHAPTER 10: COMMENTS ON THE DRAFT FINAL VERSION

A Draft Final version of this report was presented to, i.a., DGCA, AP1 and IndII at DGCA headquarters on 25 January, 2011. The following comments were assembled by IndII:

The Team gratefully acknowledges these comments and the text has been adjusted and amended where appropriate. In addition, the Team makes the following observations on the different items:

1. Regarding the timing of the project and its scope, the Team can only refer to the terms of reference. The view that the terminal is the most imminent problem is heavily supported in the report.
2. The Team shares the opinion that landside access is a crucial and acute problem, while outside the airport's domain of influence. Section 3.4 and Recommendation 18 deal with the possibilities of the airport management to indirectly force hotels and other associations to develop public transport. These possibilities appear quite promising.
3. This discussion has been supplemented in 0
4. Hawaii, the Balearic and Canary Islands have not been chosen randomly. They are all archipelagos where air traffic is heavily dominated by incoming tourism. Their history as tourist magnets is longer than Bali's, hinting that there are lessons to be learned as to whether tourism will level out and, if so, at what volume. All three cases indicate clearly that there is a saturation level. This conclusion is by no means contradicted by the present growth rate at Ngurah Rai. Rapid growth may very well continue for another decade, but it will come to an end. Furthermore, in order to preserve the precious cultural heritage of Bali for posterity, it is *desirable* that incoming tourism levels out far below a volume corresponding to 20 million annual air passengers, and in the opinion of the Team, it should be made to do so intentionally. As regards the proper time for construction of a new airport, it is the opinion of the Team that there will never be a right time. Capacity at Ngurah Rai will suffice for an acceptable tourism level and a new airport, whether replacement or complement, will entail an unacceptable encroachment into the landscape as well as the culture. A replacement airport should, in order to offer a quantum leap in capacity, have two independent, 3,000 by 45 metre runways with the terminals in the middle. Such a design will require an area of at least 1,500 hectares.
5. The Team would agree that under a flat charging regime, it is very difficult to restructure traffic, as the airlines have nothing to gain from utilising off-peak hours. With peak load pricing, the situation changes. Off-peak hours offer a huge capacity reserve, indicated in Sections 8.2 and 8.3.
6. Recent forecasts are discussed in Chapter 4 traffic forecasts, but in the opinion of the Team, traffic volumes will level out far below the 200,000 movements forecast in Figure 9 Current (-2009) and forecast movements for

2025. Airspace capacity can accommodate growing traffic with minor adjustments, as discussed in Section 7.1.

7. The Team must admit to having devoted very little thought to this issue, as none of our contacts indicated that the area south of the runway constitutes a problem. In this context, the only problem appeared to be the Hindu temple in the middle, severely restricting use of the area. However, for airport operations there seems to be very little scope for a meaningful use of this land, and from a civil aviation point of view it can be regarded as next to barren land. Any aviation-related use would require vehicles or aircraft crossing the runway. It may be worthwhile for AP1 to investigate whether part of the area could be leased out for non-aviation usage, although these activities must be noise-insensitive. Another option could possibly be a land swap if the airport could acquire more useful land north of the runway in exchange.
8. With all due respect, the Team begs to disagree. The disaster-relief aspect adds virtually nothing to the benefit side of a new airport. Contingency plans for the extremely unlikely event of an accident blocking the present runway for more than a few hours should include buses via the Gilimanuk-Ketabang ferry, boat transport to Lombok and possibly helicopter evacuation.

CHAPTER 11: MISCELLANEOUS ISSUES

This section debates some issues not directly covered by the terms of reference, but having indirect effects on the eight specific national air transport priorities.

11.1 LABOUR MARKETS

A "pilot shortage" was recently flashed on the front page of the Jakarta Globe,[14], allegedly threatening the future growth of aviation in all of Asia. This kind of alarm reports occurs regularly but leaves little, if any, impact. European and North American airlines have lain off huge numbers of pilots in recent years, many of which would happily work for Asian airlines. Most unemployed pilots are not immediately available as their ratings rapidly "freeze" if not maintained. A first officer job requires a commercial pilot license (CPL) with instrument and multi-engine ratings, all being possible but expensive to maintain without being employed. A captain job requires an airline transport pilot license (ATPL) which is extremely expensive to maintain without employment as recurring proficiency tests in an airliner are required. However, frozen licenses can normally be thawed out within a month or two, unless they have been frozen for more than three years when the process is more complicated.

The Swedish CAA explored the "pilot shortage" issue at length in a year 2000 report, concluding that the pilot labour market is by no means more prone to shortages than the markets for any other comparable skill. Another finding was that "shortage" in an airline management sense sometimes referred to a situation where these were forced to offer even new, inexperienced first officers decent employment conditions.

Air traffic control operators (ATCO) are a related issue. While training time from scratch to a rated ATCO is about equal to the CPL above, the labour markets differ considerably. Training possibilities for commercial pilots are found at a huge number of locations, while ATCO training is normally provided only by the national civil aviation authorities, although signs of deregulation are visible. Still, the ATCO community constitutes one of the last remaining guilds, with the privileges for those within and the drawbacks for the customers normally associated with guilds. These privileges and drawbacks are the reason behind almost all other guilds (barring, i,a., trial lawyers) having been abolished many decades ago. There is even a worldwide organisation called the Guild of Air Traffic Controllers (GATCO) but at present, it is not represented in Indonesia.[15] The rigid and somewhat archaic structure of the ATCO labour market will lead to a sluggish response to increased demand and the need for long-term supply planning by the DGCA. Details on the Indonesian ATCO situation are found in the IndII

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[14] "Shortage of pilots threatens to stall airline´s big plans", Jakarta Globe, 24 October, 2010.
[15] See www.gatco.org.

"Report on Indonesian ATM Review" of August 2010, indicating a substantial training backlog.

Summing up, the Team cannot see that labour market issues will have other than short-term effects on Indonesian civil aviation.

11.2 SECURITY

Security refers to the protection of air transport against unlawful interference while flight safety refers to avoiding accidents. Flight safety has achieved continuous and very impressive improvements since the arrival of modern jet airliners in the late 1950s. In contrast, security is not characterised by the quest for efficiency inherent in most aviation activities. Some solutions and regulations appear surprisingly ineffective or even counterproductive, and are obviously being conceived without any reference to cost-benefit or cost-efficiency analysis. An infamous example is the European Union regulation on liquids, preventing the passenger from bringing water, soap, toothpaste, perfumes etc. through the security check in quantities exceeding 0.1 litre altogether. At most airports, these liquids can be bought in optional quantities and brought onboard the aircraft after the security check.[16] Some airports force the passenger to spill water remaining in opened bottles, after which these can be replenished in the gate lavatory or onboard the aircraft. Liquids bought at the airport may be brought onboard if put into a sealed plastic bag with a printed ban on opening before reaching the destination. Why a prospective terrorist, intent on hijacking or blowing up the aircraft, should be deterred by such an admonition defies logic.

Another example is the suitcase strapping machines used at many airports, presumably preventing the traveller from opening the suitcase after the security check but allowing an entire tumbler to be inserted without breaking the strap.

Figure 21: Instances of pointless security

[16] Regulations are found in the EU ordinance 185/2010.

The security industry has been very successful in marketing sophisticated and expensive equipment with questionable or no effect on the core objective of security, to prevent unlawful interference. British Airways chairman Martin Broughton put it this way at a recent conference: *"We all know there's quite a number of elements in the security programme which are completely redundant and they should be sorted out".*[17]

33. Within the limits given by international regulations, the approach toward airport security should be that it focuses on the probable rather than the possible. All equipment and other investments should be subject to meticulous analysis prior to decision, where the decisive question should be "is this a cost-efficient way to achieve our goals".

[17] Quoted in **www.ft.com/cms/s/0/3e2166c4-e13f-11df-90b7-0144feabdc0.html**; see also **www.ft.com/cms/s/0/0b68d6be-4b20-11df-a7ff-00144feab49a.html** for a warning example.

CHAPTER 12: APPENDIX 2 RECORD OF MEETINGS

In addition to several meetings with IndII and occasional meetings at DGCA head office where the Team had its premises, the Team has enjoyed meetings with the following officials:

2010

25 October	Bambang Tjahjono, Director of Airports, DGCA, with staff
26 October	Suyono Dikun, Universitas Indonesia
1 November	Budy Prasetyo, DGCA Ngurah Rai, with staff
	Syahabuddin, Airport Operations Manager Ngurah Rai, with staff
2 November	Wayan Kusumawathi, Head of Foreign Trade Division, Industry and Trade Office, with staff
	IGA. Ambari, Executive Secretary, Bali Government Tourism Office, with staff
	Ekapria Dharana K, Bappeda Provinsi Bali, with staff
3 November	Syahabuddin, Airport Operations Manager Ngurah Rai, and a number of air traffic controllers
	Heru Legowo, General Manager, AP1 Ngurah Rai
	Gunung Banendro, Technical Manager, AP1 Ngurah Rai
	Budi Prasetyo, Deputy of Administration Ngurah Rai, with staff
4 November	Bambang Tjahjono, Director of Airports, DGCA
5 November	Yudhaprano Sugarda, D.D. Teknik, AP1, with staff
	Suwardi B Hermanto, Head of Planning and MIS Bureau, AP1, with staff

2011

25 January	Presentation at DGCA head office

CHAPTER 13: APPENDIX 3 PROSPECTS FOR PEAK LOAD PRICING

This appendix has been added in response to comments on the Draft Final version, see Chapter 10. The intention is to explain present charges and discuss the possibilities of applying a charging scheme adapted to load variations while the actual design of such a scheme must be referred to a separate project.

13.1 PRESENT CHARGES

In 2010, Ngurah Rai Airport levied the following charges on the airlines:

Table 13: Ngurah Rai Airport charges 2010 and Airbus A340-300 example

Ngurah Rai Airport charges 2010		
Landing, per ton	**Domestic**	**International**
Up to 40 ton	Rp 4,050	USD 4.18
40 to 100 ton	Rp 5,385	USD 4.82
More than 100 ton	Rp 6,285	USD 5.43
Pax service, per pax	Rp 40,000	*USD 17.65**
Parking, per ton	Rp 945	USD 0.43
Parking surcharge/ton	Rp 200	USD 0.11
Enroute fee	Rp 1,000	USD 0.65
Counter fee, per pax	Rp 1,100	USD 0.55
Aviobridge		
Up to 100 ton	Rp 37,000	USD 37
101 to 200 ton	Rp 94,500	USD 93
201 to 300 ton	Rp 157,500	USD 155
More than 300 ton	Rp 175,000	USD 175
* Rp 150,000 in original document, converted at 1 USD = Rp 8,500		

Airbus 340-300 example, int'l	
Weight	275 tons
Seats	245
Occupancy 80% =	196
Charges in	**USD**
Landing	1232
Pax service	3459
Parking	118
Parking surcharge	30
Enroute fee	1
Counter fee	108
Aviobridge	155
TOTAL	**5103**
= per passenger	26,0

Source: Compiled from Tarif Aeronautika PT Angkasa Pura1, January 2010. Landing charges are cumulative. The enroute fee applies per flight, in spite of its modest level. Parking up to two hours is free. Parking surcharge applies in the evening.

Charges based on weight refer to maximum takeoff weight as the landing weight is never known. As an enroute fee of 65 US cents per flight appears meaningless but AP1 has confirmed that it applies per flight and not per ton, which appears more plausible. An Airbus A 340-300 will be charged a total of USD 5,103 or USD 26 per passenger at 80 percent occupancy. With all seats occupied, the charge will be USD 20.8 per passenger. All charges are flat, i.e. there is no variation over time or season except for the parking surcharge. As customary, charges for international flights are higher than for domestic flights, although in the case of Ngurah Rai the difference is extreme. At an exchange rate of Rp 8,500 per USD, the domestic landing charge is 48 US cents up to 40 ton. The international charge is USD 4.18, corresponding to an "international mark-up" of 8.8 times. It is a bit bewildering that this mark-up varies widely, from 8.8 down to 3.9 for the parking charge.

13.2 PRINCIPLES AND APPLICATION OF PEAK LOAD PRICING[18]

The United Kingdom is surrounded by water, barring the short land-frontier to the Republic of Ireland. British Airport Authority, BAA, operates London airports Heathrow and Stansted, the airports in Glasgow, Edinburgh, Aberdeen and Southampton plus Naples in Italy. Heathrow is the largest airline hub in Europe. In spite of its government-sounding name, BAA is nowadays owned by ADI Limited, a consortium led by Spanish Groupo Ferrovial. For the two London airports, BAA airport charges are regulated by the British Civil Aviation Authority (CAA). This arrangement is a solution to the textbook problem that optimal pricing of an infrastructure monopoly is much higher seen from the owner's point of view compared with the society's point of view.

BAA has a long history in peak load pricing, its first attempts dating back to 1972 when BAA established a "runway movement charge" at the busiest time of day at Heathrow. Passenger peak charges were implemented in 1976. Peak surcharges and definition of peak periods have changed considerably over the years. A number of differentiations for peak landing fees have been tried but these were eventually succeeded by a uniform peak hour fee.

Peak load pricing of services is potentially desirable where demand varies by time. If prices are uniform over time irrespective of differences in willingness to pay and incremental costs of meeting demand in different periods, there will be excess demand in peak periods and subdued demand in off-peak periods. If the airport then aimed at accommodating all demand, including at the peak, it would require the installation of costly capacity which will be under-utilised in off-peak periods. Typically, airlines take this into account by charging fare premiums for seasonal, weekly or daily peaks. Airport peak load pricing tries to achieve the following main objectives:

[18] Information for this section has been gleaned from various parts of BAA website www.baa.com, www.heathrowairport.com and CAA website www.caa.co.uk in February 2011.

- Providing airlines and passengers with the incentives to shift demand to off-peak periods when there are airport facilities available at short run marginal costs which do not reflect new capacity requirements;
- Possibly creating additional demand in off-peak periods through lower charges, thereby making better use of existing capacity;
- Allocating the costs of expanding airport capacity only to those users who contribute to the need to increase capacity.

As regards Heathrow, its intricate charging structure is published on the web, **http://www.heathrowairport.com/assets/Internet/Heathrow/Heathrow%20downloads/Static%20files/Conditions_of_Use.pdf**. Due to the special conditions at this airport, its peak charge design may be less useful for more normal airports. One example is its charge for use of aerobridges (piers) which is GBP 7.08 plus 0.113 per metric tonne for every 15 minutes.[19] The Airbus 340 in Table 13 would pay about Rp 2.3 million per hour. The peak load surcharge is applicable from 07:00 to 12:29 hours and is 200 percent. Landing the 340 is GBP 776 (Rp 11.6 million) but a 150 percent surcharge is applied between 00:00 and 03:39 hours.

Stansted, while still very big, offers a somewhat more standard example of peak load pricing but the peak extends for five months:

Table 14: London/Stansted landing charges

Helicopters	94.00				93.70			
Fixed wing aircraft not exceeding 16 metric tonnes	113.50				102.00			
	¨Ch 2 & Non cert	@Ch 3 High	*Ch 3 Base	•Ch 4 & Ch 3 Minus	¨Ch 2 & Non cert	@Ch 3 High	*Ch 3 Base	•Ch 4 & Ch 3 Minus
Fixed wing aircraft over 16 Metric tonnes not exceeding 55 metric tonnes	508.50	254.25	169.50	152.55	377.40	188.70	125.80	113.22
Fixed wing aircraft over 55 metric tonnes not exceeding 250 metric tonnes	831.60	415.80	277.20	249.48	468.00	234.00	156.00	140.40
Fixed wing aircraft over 250 metric tonnes	1,432.80	716.40	477.60	429.84	810.60	405.30	270.20	243.18

Source:
www.stanstedairport.com/assets/Internet/Stansted/Stansted%20downloads/Static%20files/STN_Conditions_of_Use_2010-11.pdf.

[19] At present, 1 GBP is about Rp 15,000.

The left column refers to peak and the right to off-peak. Landing the 340 will cost GBP 477.60 (Rp 7.2 million) in the peak period and GBP 270.20 (Rp 4.1 million) off-peak.

A huge number of documents on airport pricing is available from BAA and CAA and even though these refer to extremely big airports, it is obvious that general principles useful for Indonesia can be fished out.

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