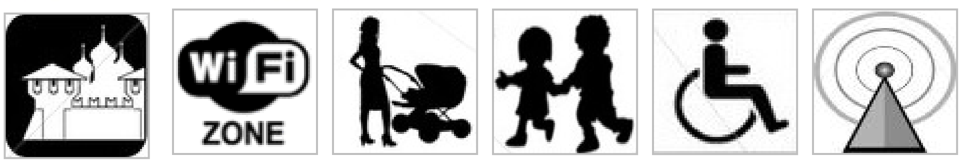
AIRPORT PLANNING & CONFIGURATION

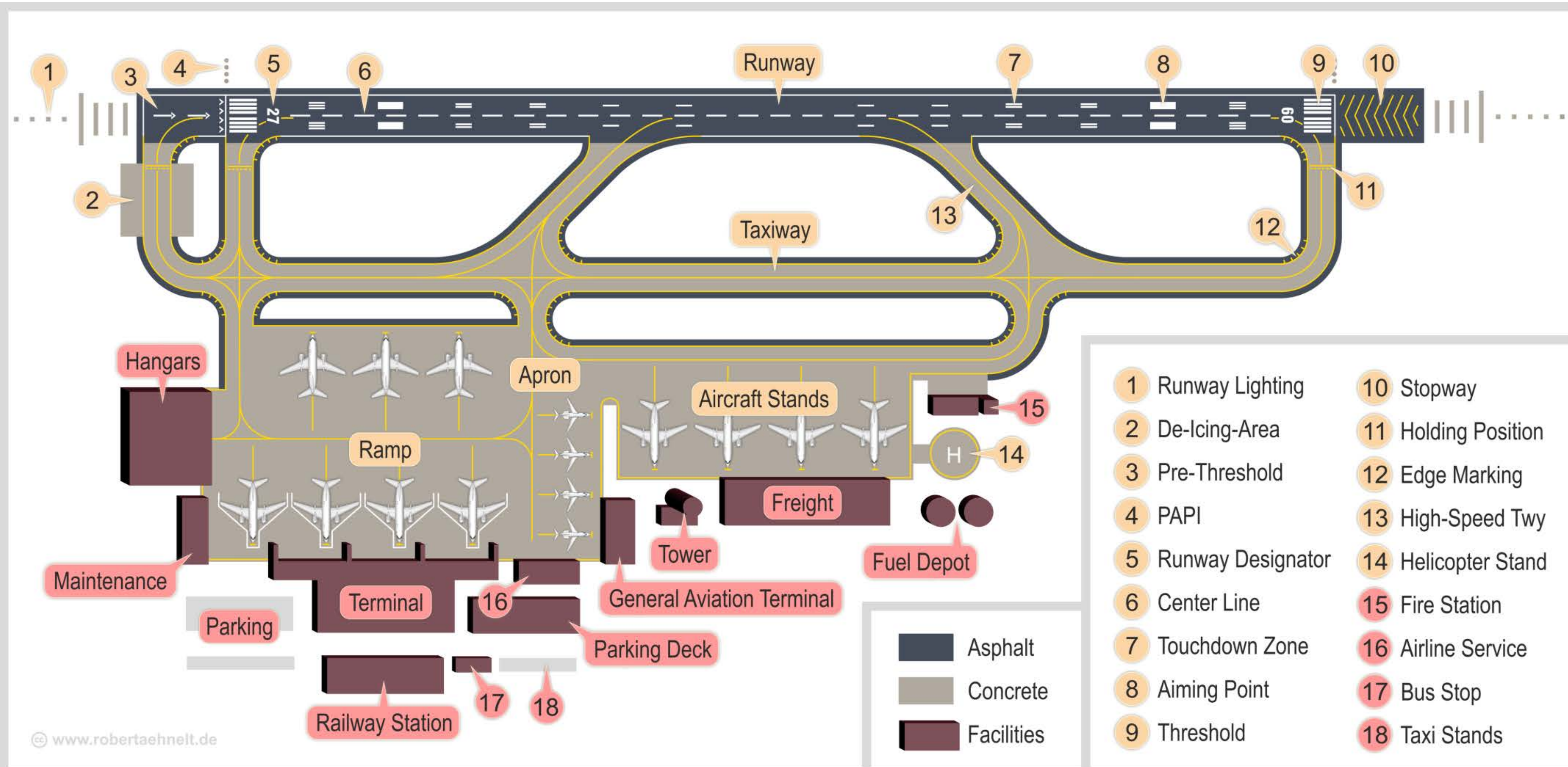






Module – 04
Airport Engineering
Dr. Nadeem

Airport Configuration



Introduction

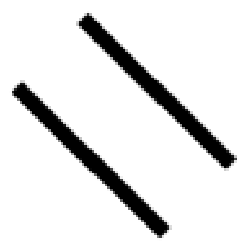
- **Airport configuration means the number and orientation of runways and location of terminal area relative to runways**
  - **Number of runways depends upon volume of traffic**
  - **orientation depends on prevailing wind pattern, land use, size/ shape of the area and air space restrictions**
  - **Terminal area is located relative to runways to provide easy and timely access to runways**

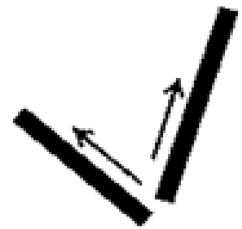
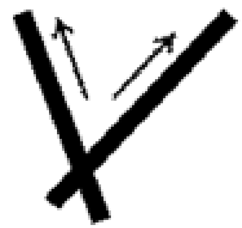
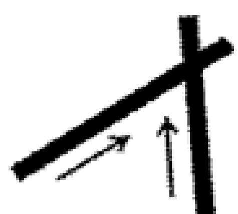
Runways

- A runway is a rectangular area on the airport surface prepared for the takeoff and landing of aircraft
  - Primary Runway – oriented into prevailing winds
  - Crosswind Runways –oriented toward the most common crosswind direction
- Runways should be arranged so as to:
  - Provide adequate separation in air traffic pattern
  - Cause least interference and delays in operations
  - Provide shortest taxing distance from terminal area to runway end of runways
  - Provide adequate taxiways so landing ac can leave the runways as quickly as possible

Runway Configuration

- **Basic Configurations**
  - **Single Runway**
  - **Parallel Runways**
  - **Open – V Runways**
  - **Intersecting Runways**

Runway Type	Sub-type	Diagram	Notes
Single	Single		Simplest of the four configurations. Positioned primarily according to prevailing winds.
Parallel	Close parallel		Runways are less than 2,500 feet apart. Positioned similar to the single runway.
	Intermediate parallel		Runways are between 2,500 and 4,300 feet apart. Positioned similar to the single runway.
	Far parallel		Runways are greater than 4,300 feet apart. Positioned similar to the single runway.
	Dual-line		A pair of parallel runways that have 4,300 feet or more between them. Positioned similar to the single runway.

Runway Type	Sub-type	Diagram	Notes
Open-V	[toward the intersection]		Used when there is little to no wind. Both runways can be use simultaneously. Where there is strong winds, only one is typically used.
	[away from intersection]		Similar as above, but it can accommodate a greater capacity because take-offs and landings are moving away from the vertex.
Intersecting	[cross at near threshold]		Intersecting runways are the best configuration for relatively strong prevailing winds that change over the course of the year. It takes up less space than the open-V configuration and provides the benefit of relatively large capacity.
	[cross at midpoint]		
	[cross at far threshold]		

Runway Configuration

Single Runway

Figure	MI	Hourly Capacity ops/hr		ASV ops/yr
		VFR	IFR	
	0 to 20	98	59	230,000
	21 to 50	74	57	195,000
	51 to 80	63	56	205,000
	81 to 120	55	53	210,000
	121 to 130	51	50	240,000

Runway Configuration

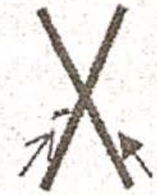
A- Single-engine, 12,500 pounds or less maximum certified takeoff weight
B- Multi-engine, 12,500 pounds or less maximum certified takeoff weight
C- Multi-engine, 12,500 to 300,000 pounds maximum certified takeoff weight
D- Multi-engine, more than 300,000 pounds maximum certified takeoff weight

visual flight rule (VFR) and instrument flight rule (IFR).

VFR minimums are in effect when the cloud ceiling is at least 1,000 feet above the airport elevation and visibility is at least three statute miles. Annual Service volume (ASV)

The mix index is the mathematical expression of the aircraft mix, and is the percent of C aircraft plus three (3) times the percent of D aircraft [%(C+3D)].

Other Basic Configuration and Salients	Classification	Figure	Capacity ops/ hr	
			VFR	IFR
<u>Parallel</u> *Outer runway is for arrivals, inner for departures. *Limitation is crossing of taxiways across active runways. *Compared to single runway handles 60-70% more traffic. <u>Parallel (Staggered threshold)</u> *Necessitated by shape of land available or for reducing taxiway distance. *For optimum results, one exclusively for landing and other for TO.	<u>Close or Dual Lane</u>. Operations on one are dependent on operations on other. Spacing 700' to < 2500'		100-200	55-60
	<u>Intermediate.</u> Arrival at one is independent of departure on other. Spacing 2500' to <4300'		100-200	60-75
	<u>Far.</u> Operation on one is independent of operation on the other. Spacing = or > 4300'		100-200	100-125

<u>Intersecting</u> *When two or more intersect in different directions. *Necessitated when relatively strong wind blows in more than one direction. Only one may operate in strong winds. *Capacity of system depends upon: - +Location of intersection +Strategy of operation i.e. direction of operations.	Near end intersection Far.		50-100	40-60
	Near end intersection		70-175	60-70
	Middle intersection		60-100	45-60
<u>Open V</u> *Runways in divergent directions, not intersecting *Highest capacity when operations are away from 'V'. * In strong winds, system may be used as a single runway.	Operations away from V		60-180	50-80
	Operations towards V		50-100	50-60

Runway Orientation

- Runways are oriented in the dir of prevailing winds to min the effect of crosswind. Excessive crosswind component creates problems and aircraft operations may have to be stopped
- Max permissible crosswind component depends upon
  - Size of aircraft i.e. large aircrafts requiring more runway length can manoeuvre in comparatively more crosswind component
  - Wing configuration of certain aircrafts reduces the effect 'of crosswind
  - Pavement condition i.e. dry or wet as it affects the runway length being utilized
- Typically, but not always, runways are oriented in such a manner that they may be used in either direction
- Wind data is recorded with ref to true north whereas runways are designated/ numbered with reference to magnetic north
- Wind data is available in 16 segments of 22.5 deg increment

Runway Orientation

- According to ICAO, for planning purposes, 95% of the time crosswind component should not be greater than the listed specifications

All Airports		Utility Airports
Runway ≥ 1500 M	Runway 1200 – 1500 M	Runway < 1200 M
20 knot	13 knot	10 knot

- Once max cross wind component for a proposed airport is selected, desirable direction of primary runway can be det by examining the wind characteristics under fol conditions
  - Entire wind coverage regardless of visibility or cloud ceiling
  - Wind conditions when the ceiling is at least 1000 ft and the visibility is at least 3 mi (VMC)
  - Wind conditions when ceiling is between 200 and 1000 ft and/or the visibility is between ½ and 3 mi (IMC)

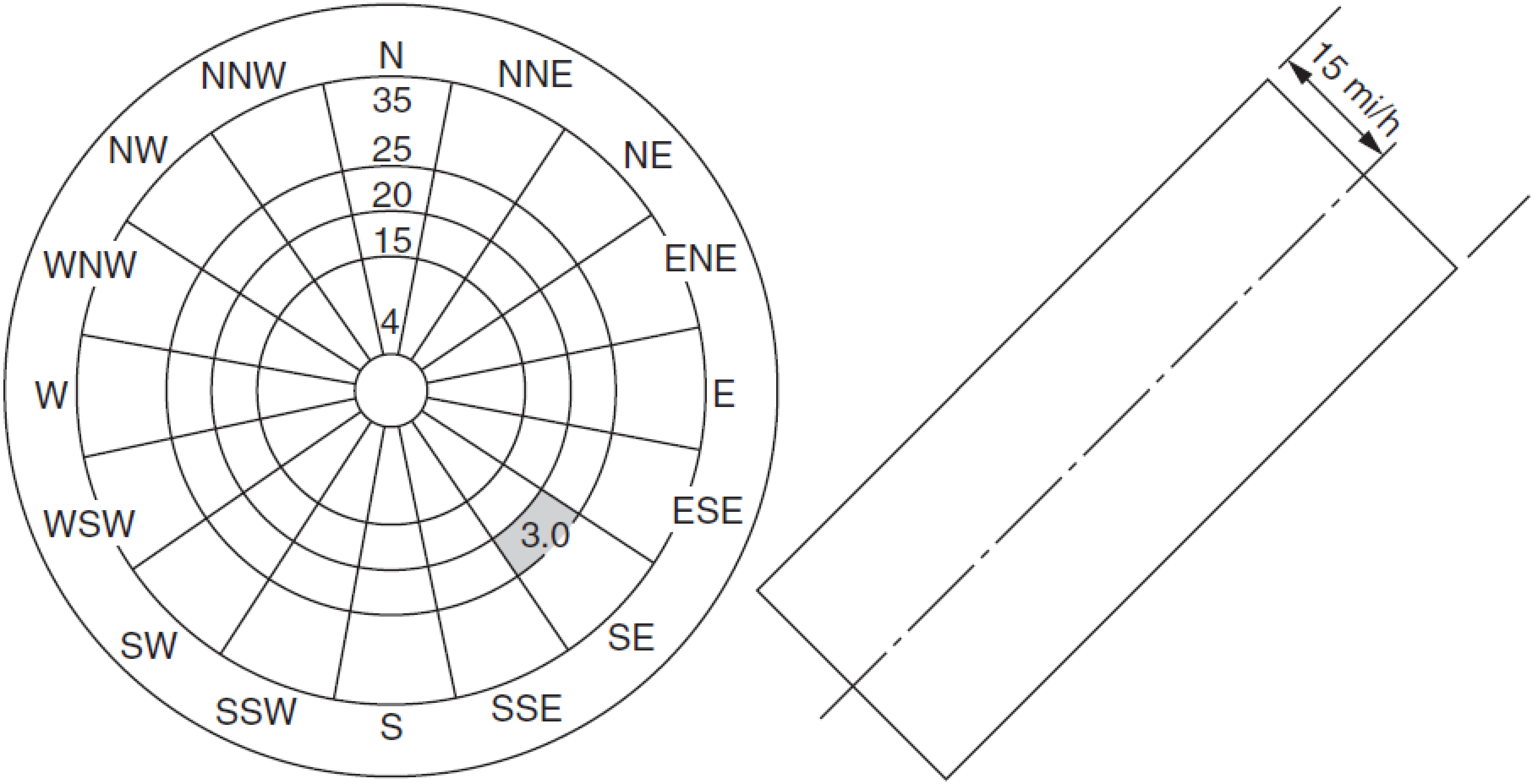
Wind Rose

- **Definition.** **It is a graphical vector analysis method to determine best runway orientation**
- **Procedure**
  - **Available wind data is arranged according to velocity, direction and frequency in % of time**
  - **Concentric circles are drawn to the scale indicating wind speed ranges**
  - **Directions are centred in between successive radials**
  - **Data is transferred in respective segments thus representing graphically (wind rose)**
  - **A transparent template with three parallel lines to the same scale is prepared. Centre line indicates runway centre line and outer lines indicate permissible crosswind**

Wind Rose

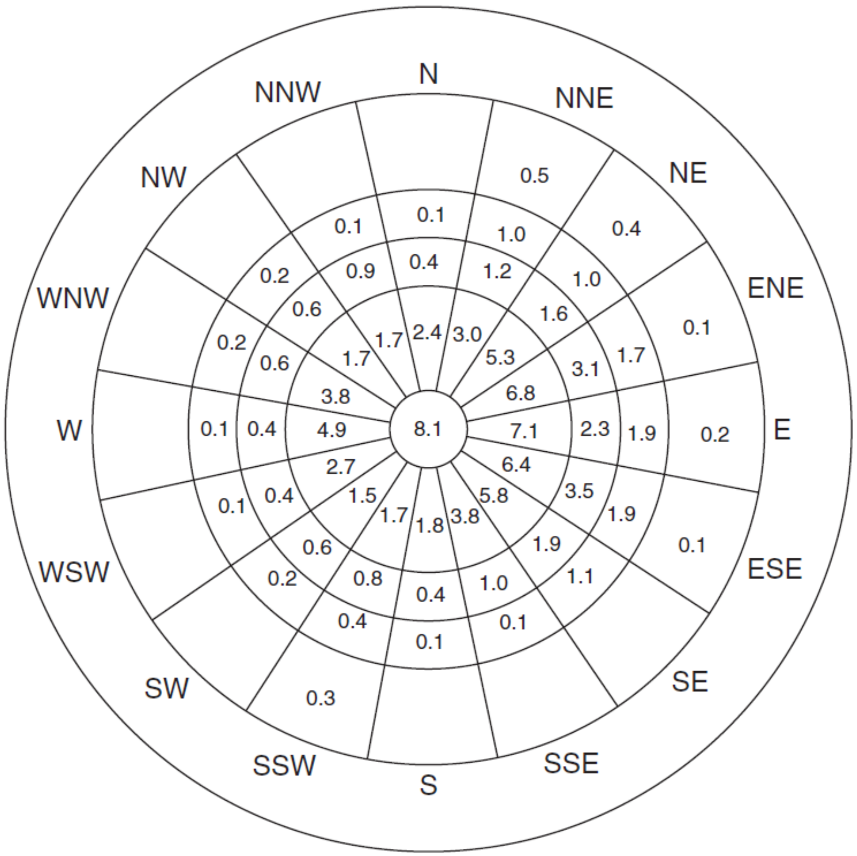
- Template is placed on wind rose ensuring centreline passes from the centre of circles
- Template is rotated so that added % between two outer lines is maximum. % is approximated when outer line crosses segmented area indicating magnitude
- True bearing is read and converted to magnetic bearing for record and designation purposes. This will be the runway. orientation
- Similar procedure is used for VMC and IMC wind data. Finally the % is assessed which should be minimum 95%. If not so then orientation of another runway is determined in similar fashion i.e. finding next maximum %

Wind Rose



Wind rose coordinate system and template

Example Runway Length (1400 m) and Orientation to Cptr Program

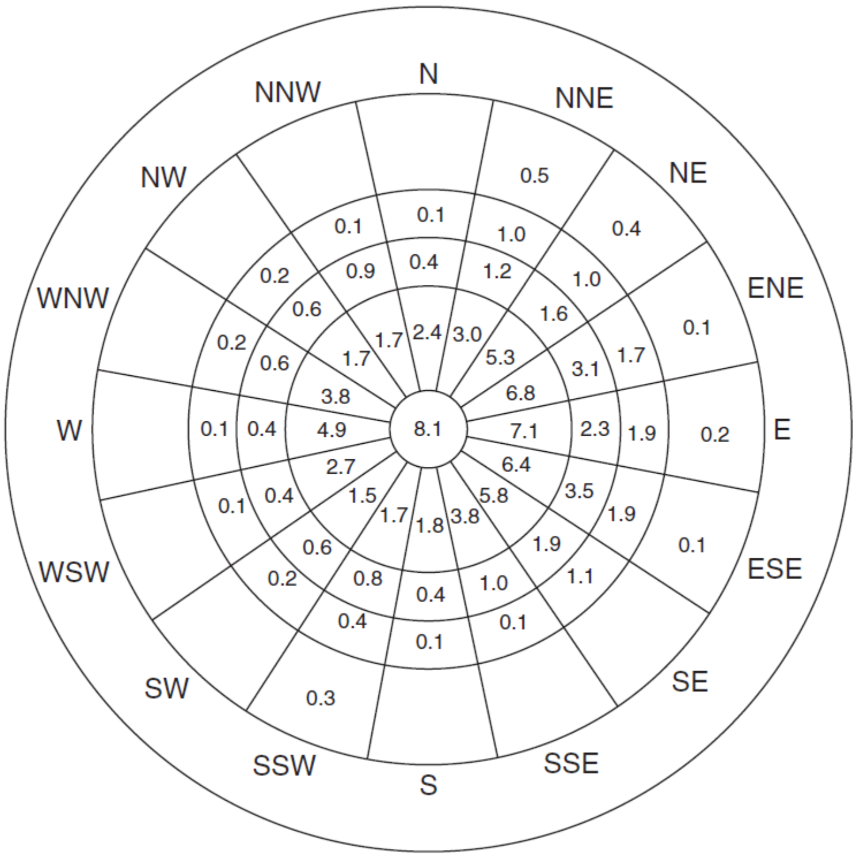


Wind data in wind rose format.

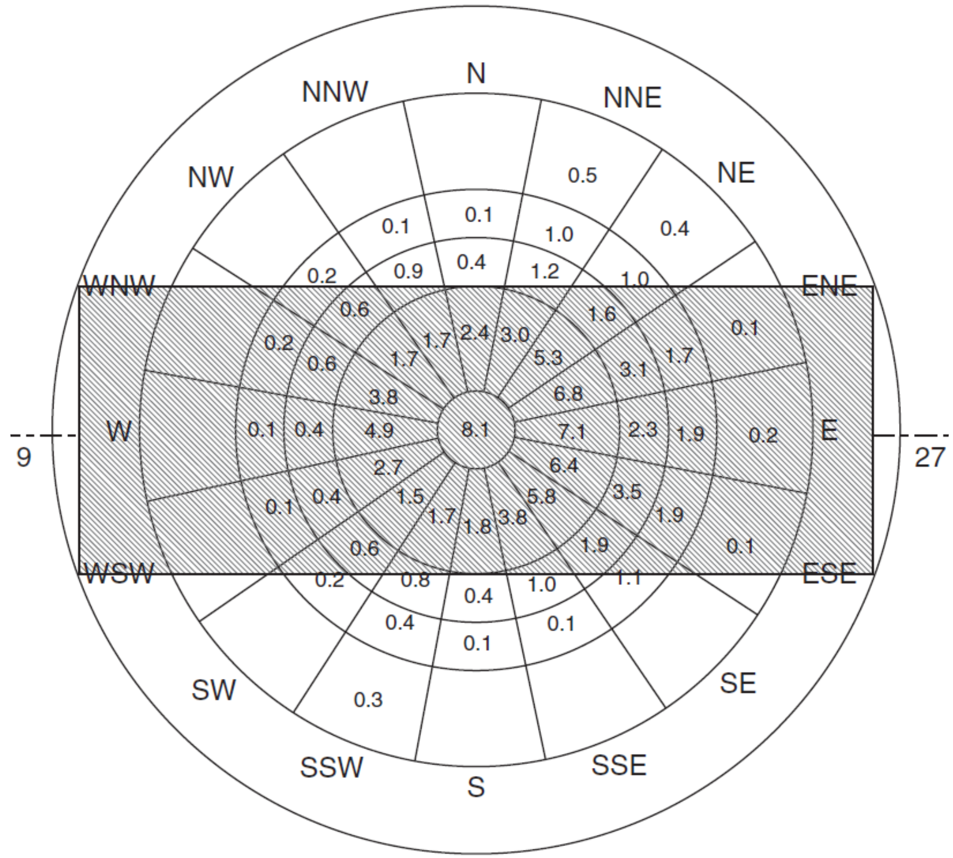
Sector	True Azimuth	Wind Speed Range, mi/h 4–15	15–20	20–25	25–35	Total
		Percentage of Time				
N	0.0	2.4	0.4	0.1	0.0	2.9
NNE	22.5	3.0	1.2	1.0	0.5	5.7
NE	45.0	5.3	1.6	1.0	0.4	8.3
ENE	67.5	6.8	3.1	1.7	0.1	11.7
E	90.0	7.1	2.3	1.9	0.2	11.5
ESE	112.5	6.4	3.5	1.9	0.1	11.9
SE	135.0	5.8	1.9	1.1	0.0	8.8
SSE	157.5	3.8	1.0	0.1	0.0	4.9
S	180.0	1.8	0.4	0.1	0.0	2.3
SSW	202.5	1.7	0.8	0.4	0.3	3.2
SW	225.0	1.5	0.6	0.2	0.0	2.3
WSW	247.5	2.7	0.4	0.1	0.0	3.2
W	270.0	4.9	0.4	0.1	0.0	5.4
WNW	292.5	3.8	0.6	0.2	0.0	4.6
NW	315.0	1.7	0.6	0.2	0.0	2.5
NNW	337.5	1.7	0.9	0.1	0.0	2.7
Subtotal		60.4	19.7	10.2	1.6	91.9
Calms						8.1
Total						100.0

Table 6-4 Example Wind Data

Example Runway Length (1400 m) and Orientation to Cptr Program

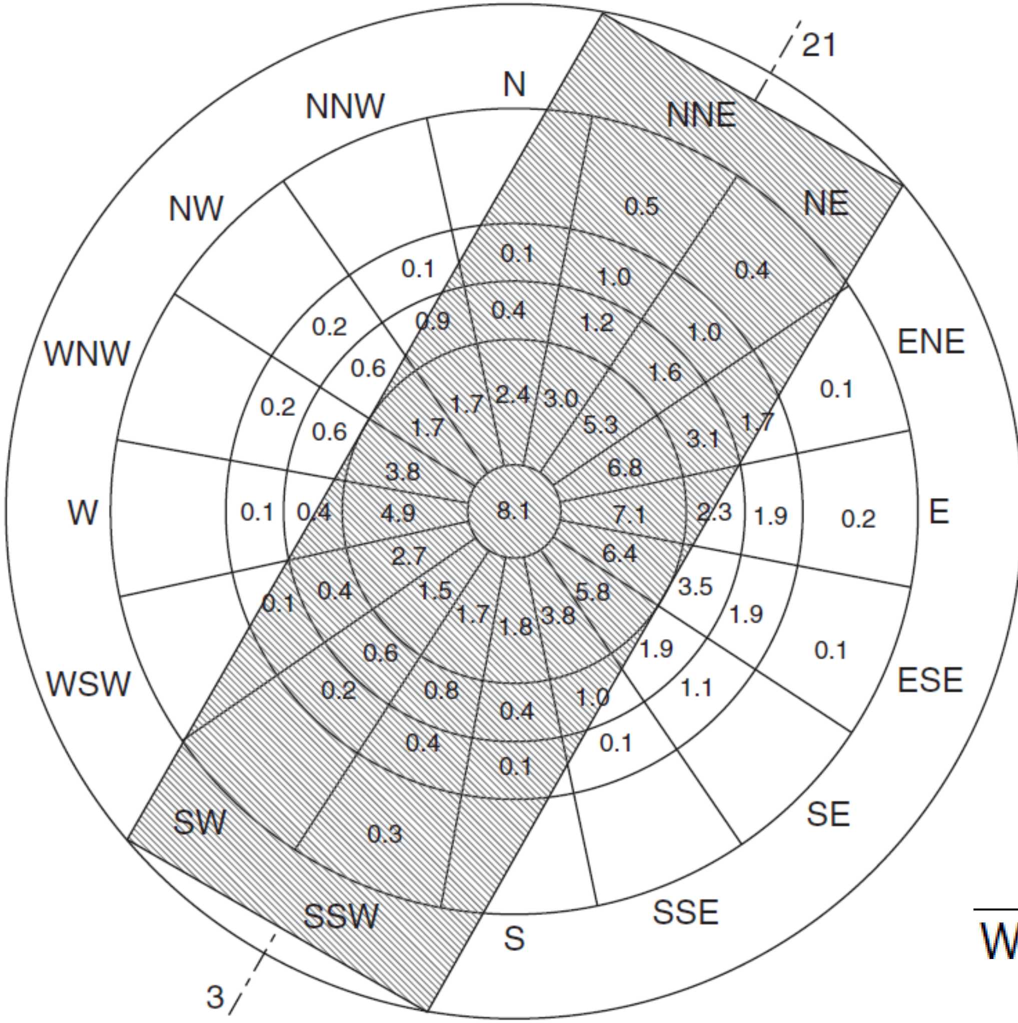


Wind data in wind rose format.



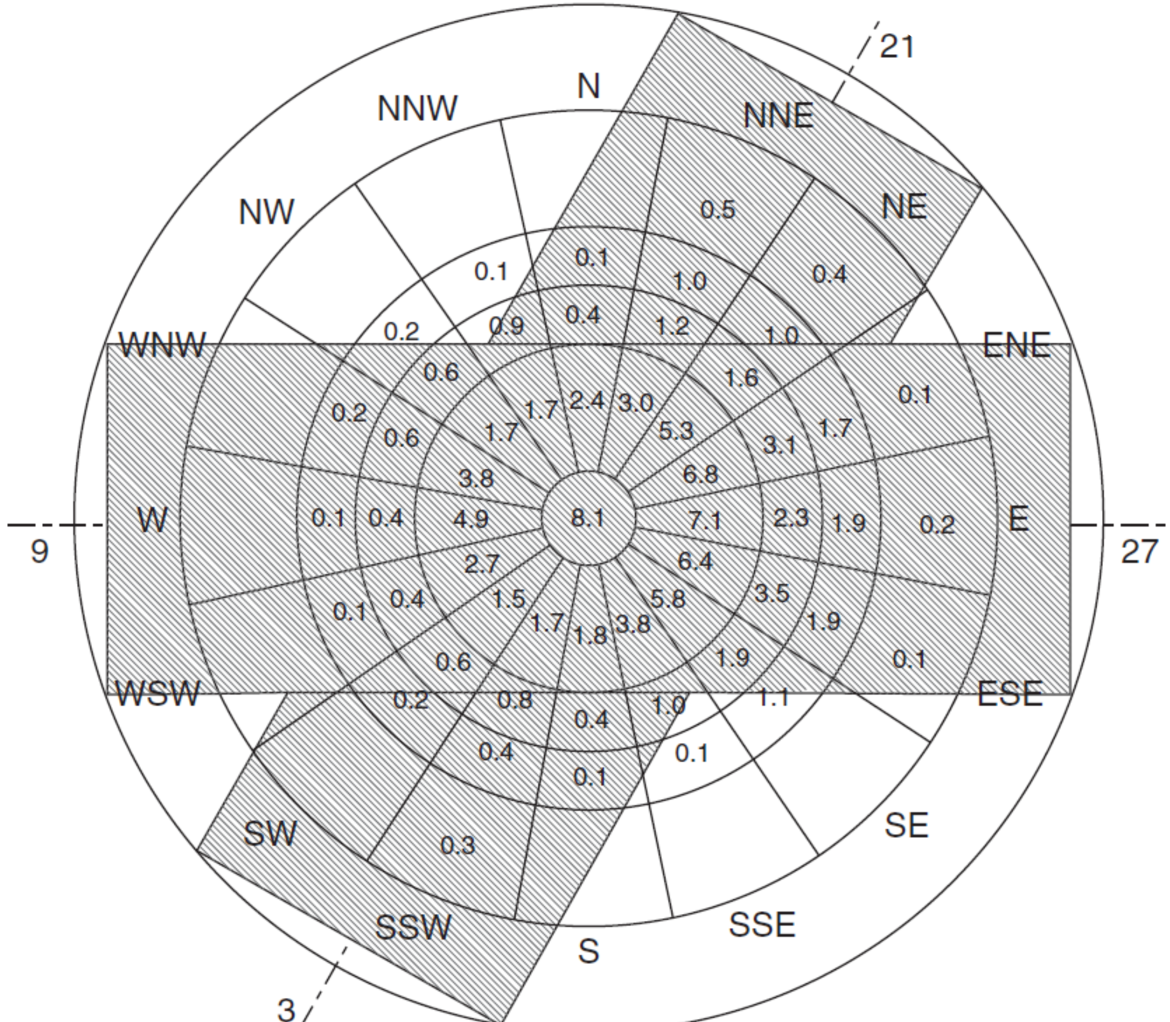
Wind coverage for runway 9–27

Example Runway Length (1400 m) and Orientation to Cptr Program



Wind coverage for runway 3–21

Example Runway Length (1400 m) and Orientation to Cptr Program



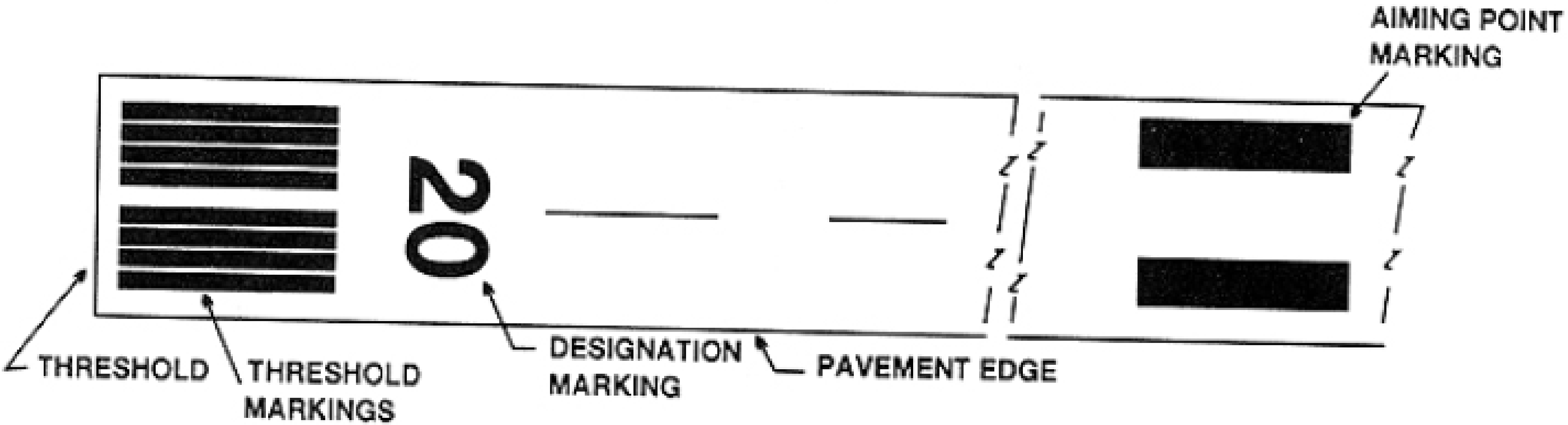
Wind coverage for runways 9–27 and 3–21

Runway Markings

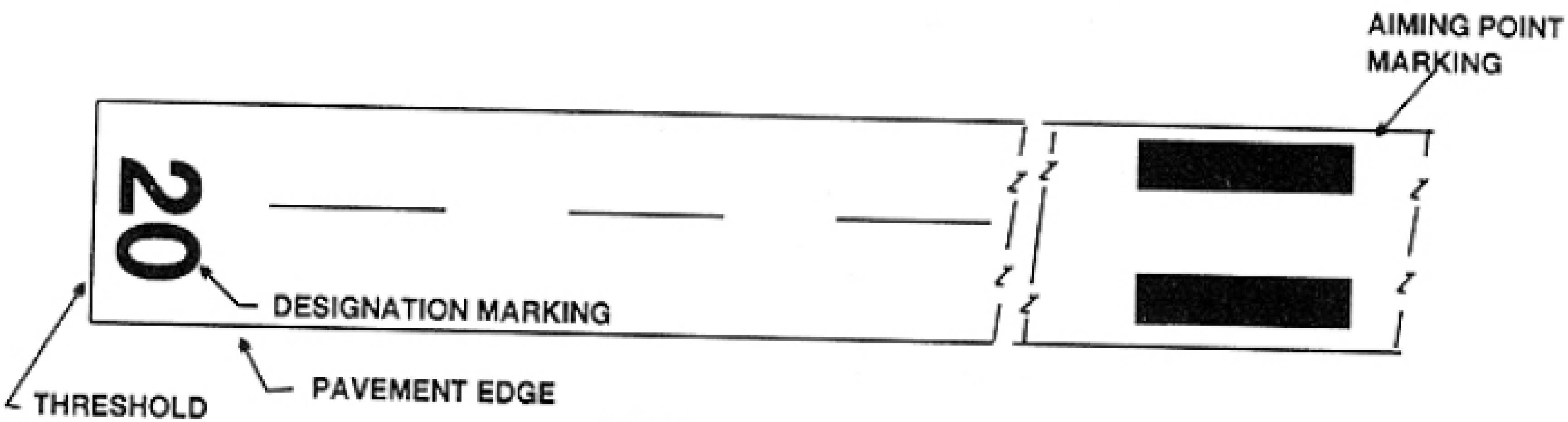
- **Runways are defined/identified by their orientation with respect to magnetic north (270 deg runway is Runway 27)**
- **When the same runway is used from opposite directions the runway is identified by both orientations (Runway 09/27)**

Runway Markings

Visual and Non-Precision Runway Markings (FAA AIM)



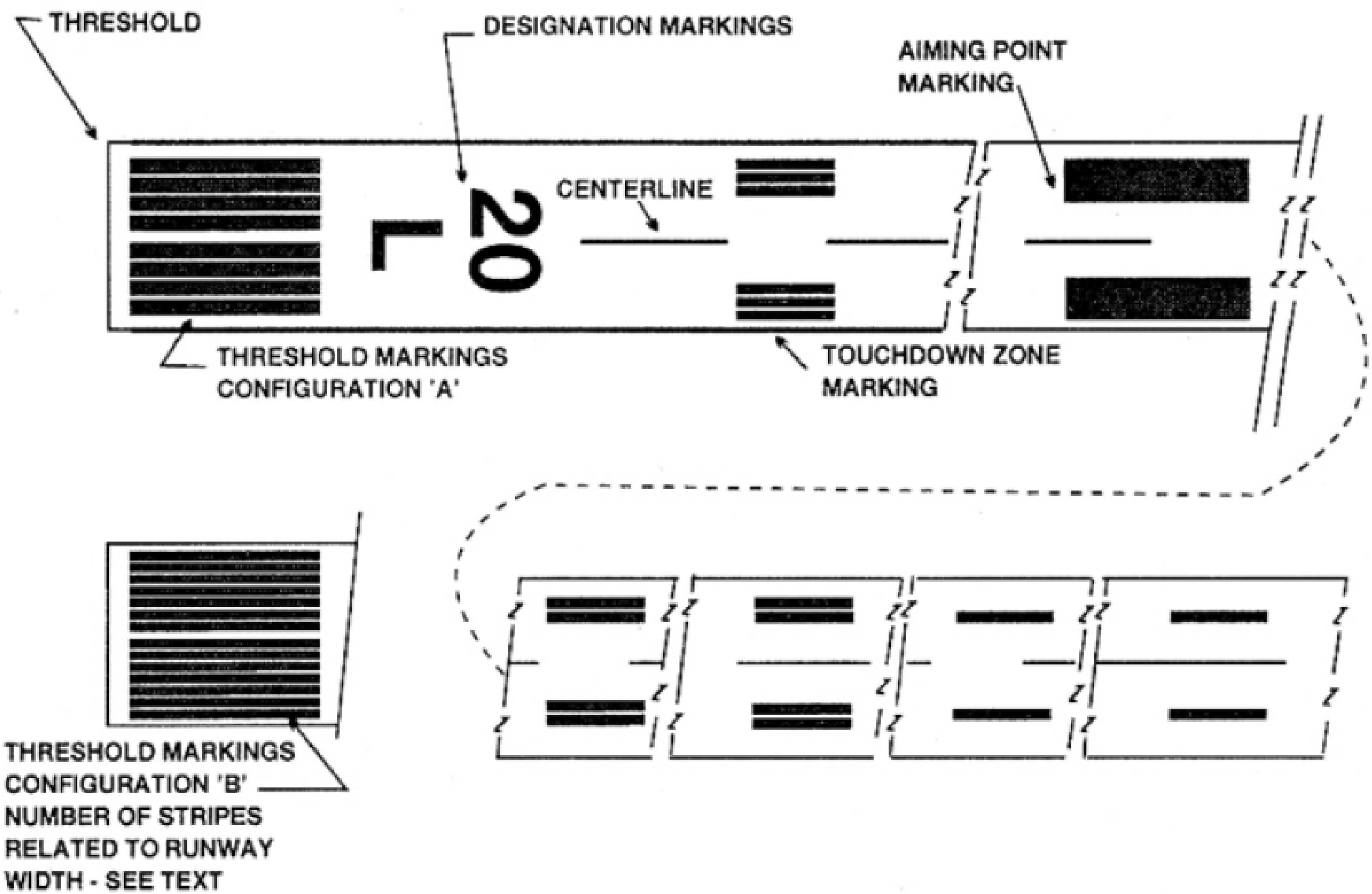
NONPRECISION INSTRUMENT RUNWAY MARKINGS



VISUAL RUNWAY MARKINGS

Runway Markings

Precision Runway Markings (FAA AIM)



Runway Threshold Stripes

Runway Width	Number of Stripes
60 feet (18 m)	4
75 feet (23 m)	6
100 feet (30 m)	8
150 feet (45 m)	12
200 feet (60 m)	16

Taxiways

- **Provide access from runways to terminal /service areas**
  - **Exit Taxiways (turnoffs) are used by landing aircrafts**
  - **Entrance Taxiways used by the aircrafts which are due to takeoff**
  - **Parallel taxiways are with reference to runways**
  - Bypass Taxiways
- **Salient points are:**
  - **Taxiways should be so arranged that landing aircrafts do not interfere with takeoffs**
  - **One-way parallel taxiways should be provided when movement is expected in both directions**
  - **Shortest possible route from terminal area to takeoff end of the runway should be selected**
  - **Whenever possible taxiways to be routed to avoid crossing**
  - **Exit taxiways should be located at various points along runways to enable landing aircraft to clear runways for other operation**

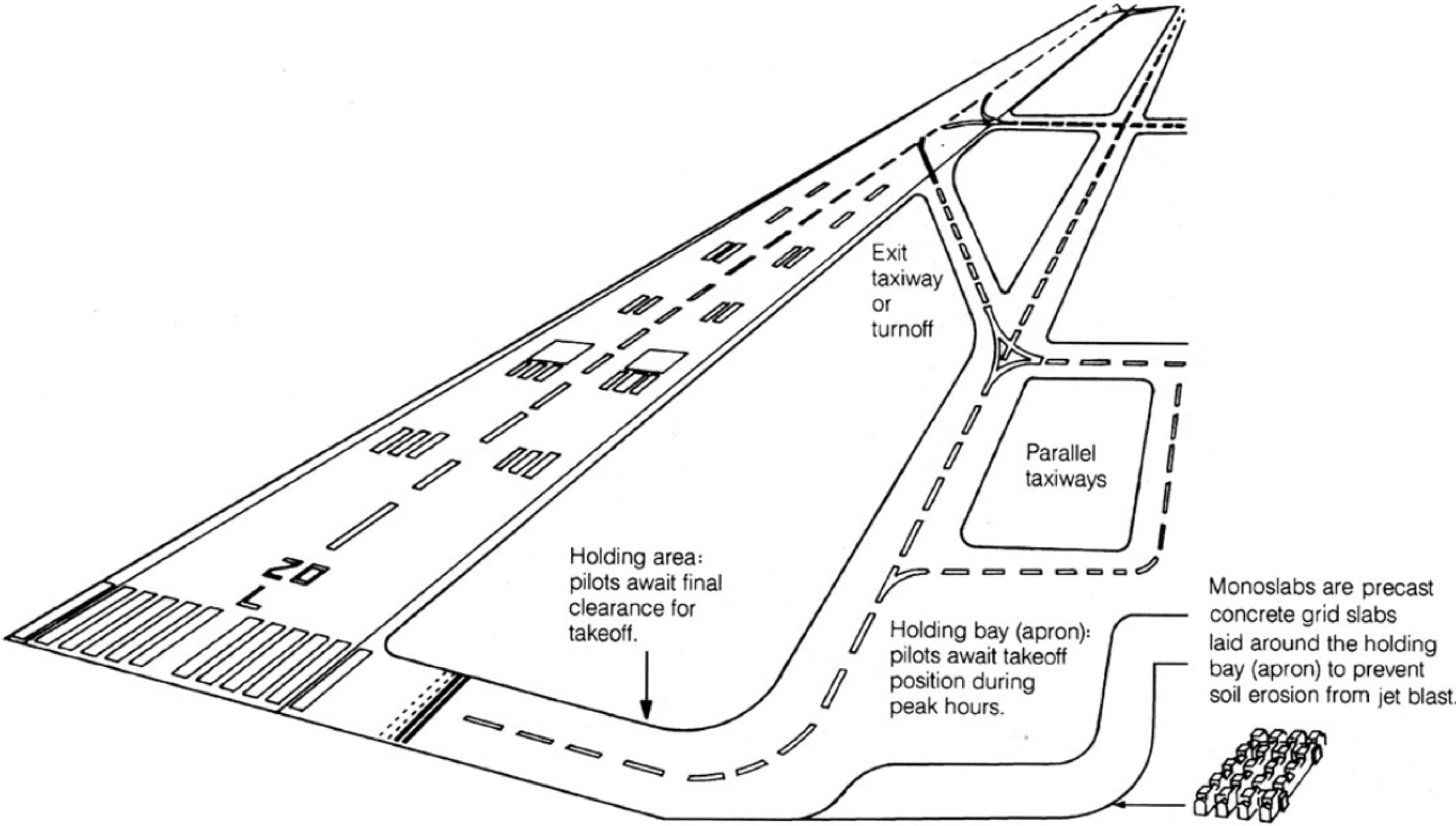
Holding Bays

- Also known as run up/warm up pads. Necessary at near runway end for final checks prior to takeoff for piston engine aircrafts and wait for takeoff clearance for all aircrafts. Some time a bypass taxiway is provided. Size depends upon the volume of traffic
- Salient are:-
  – Large enough to allow aircrafts to bypass.
  – Accommodates 2 - 4 large aircrafts.
  – Permits departing aircraft to enter runway $< 90°$ and as close as possible to the end of runway to have least interference for landing aircraft.
- Held aircrafts should be outside the bypass route to prevent blast effect

Holding Aprons

- **Small aprons, at convenient location for temporary storage of aircrafts waiting for a gate**
- **ATC is responsible for directing to holding bays**
- **Not required once capacity matches the demand**
- **Good measure to cater for future saturation capacity conditions**

Holding Bays & Aprons



Environments at Airport

- **Temperature.** Higher the temperature, the longer the runway required because of lower air densities resulting in lower out-put of thrust. Relationship is non linear. The rate of increase is greater at higher temperatures. The increase can be specified in terms of the % of runway length at 59°F (Standard Temperature). For 59 to 90°F increase in temperature is 0.42 to 0.65 %
- **Surface Wind.** Greater the headwind, shorter will be the runway. For computing of take off weight, regulations allow to use 0.5 times the reported headwind and 1.5 times the reported tailwind (max 10 knots). A 5-knot headwind reduces the take off runway length by 3%, whereas a 5-knot tailwind increases this length by about 7 %. No wind is considered for airport planning purposes

Environments at Airport

- **Runway Gradient.** An uphill gradient requires more runway length than a level or downhill gradient, the specific amount depending on the elevation airport and the temperature. Relationship is nearly linear. For turbine-powered aircrafts it amounts to 7 to 10 % for each 1 % of uniform gradient (max 1.5 %). Not much difference between average uniform gradient (straight line joining the ends of the runway, as long as no intervening point lies more than 5 ft above or below used by aircraft industry) and effective gradient (the difference in elevation between the highest and lowest points on the actual runway profile divided by the length)

Environments at Airport

- **Altitude**. All other things being equal, the higher the altitude of the airport, the longer the runway required. This increase is not linear but varies with weight and temperature. At high altitudes the rate of increase is higher than at low altitudes. For planning purposes an increase from sea level of 7 percent per 1000 ft of altitude will suffice for most airport sites except those that experience very hot temperatures or are located at high altitudes. Then the rate of increase can be as much as 10 percent.
- **Condition of Runway Surface**. Slush, wet snow or standing water makes braking extremely poor and causes a significant retarding force, especially on takeoff to the extent that takeoff may not takes place. Jet operations are limited to no more than 0.5 in of slush or water. Between 0.25 and 0.5 in, the takeoff weight must be reduced..........................

Environments at Airport

- **Condition of Runway Surface. Adequate drainage required. Hydroplaning is a phenomenon of tires riding on surface of slush or water. It is primarily a function of tire inflation pressure and to some extent the condition and type of grooves in the tires. Speed in miles per hour where hydroplaning develops = 10 x (tire inflation pressure in lb/in^2)$^{0.5}$. The range of inflation pressures are 120 to over 200 lb/in^2. Therefore the hydroplaning speeds would range from 110 to 140 mph or more. The landing speeds are in the same range. Therefore hydroplaning can be a hazard to jet operations. It can occur when the depth of water or slush is on the order of 0.2 in or less. To reduce the hazard of hydroplaning, runway pavements have been grooved in a transverse direction. The grooves normally were 0.25 in wide and deep and were spaced 1 in apart**