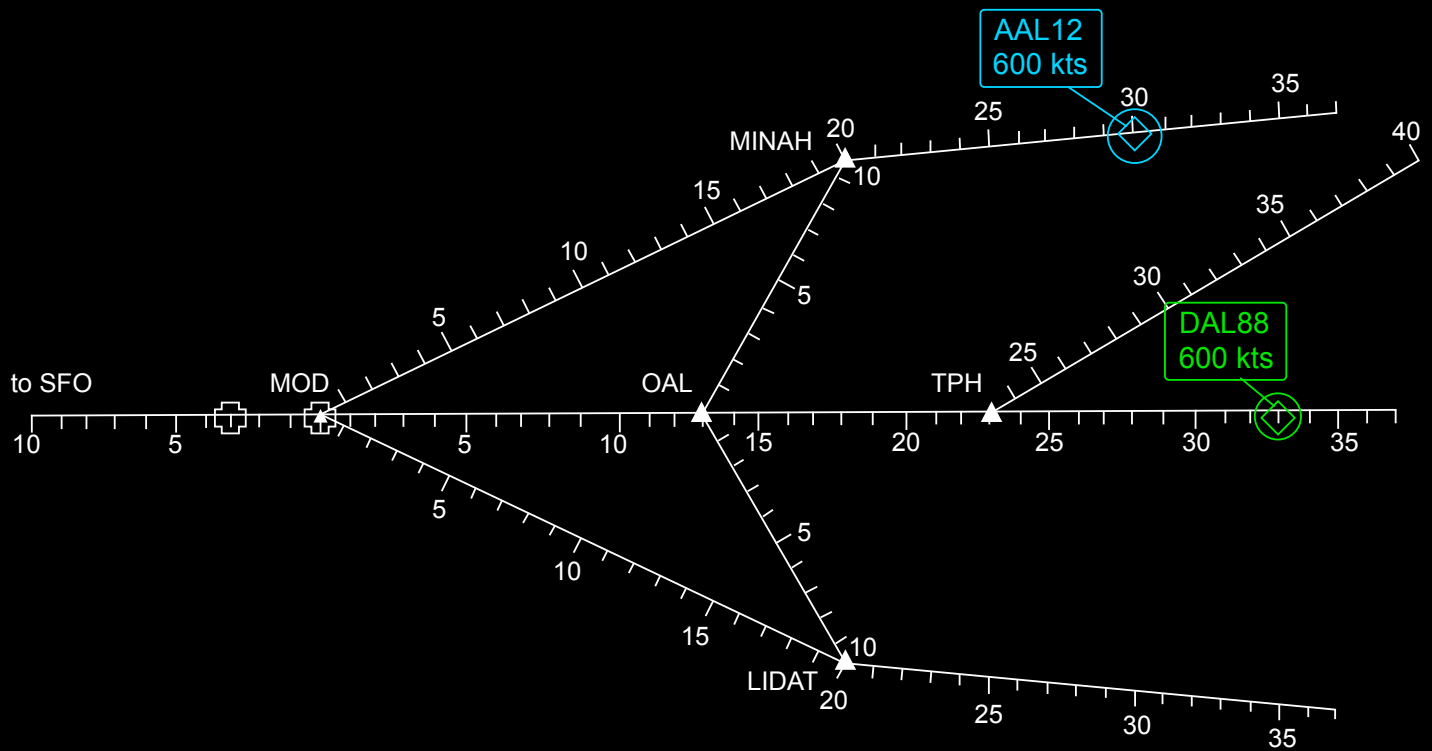




LineUp with Math

Math-Based Decisions in Air Traffic Control

STUDENT WORKBOOK A

Introduction to Air Traffic Control

- * Units of Measurement
- * Sector Display
- * Sector Information
- * Spacing Information

Understand Sector Information

UNDERSTAND UNITS OF MEASUREMENT

Distance

Travel on land is measured in statute miles — commonly called “miles”.

Travel in the air and on the sea is measured in **nautical miles (NM)**. A nautical mile is a little *longer* than a statute mile.

Speed

Speed on land is measured in miles per hour (mph).

Speed in the air and on the sea is measured in nautical miles per hour — commonly called **“knots” (Kts)**. Just as a nautical mile is a little longer than a statute mile, 1 knot (nautical mile per hour) is a little faster than 1 mile per hour.

1 nautical mile = 1.15 statute miles

1 “knot” = 1 nautical mile per hour

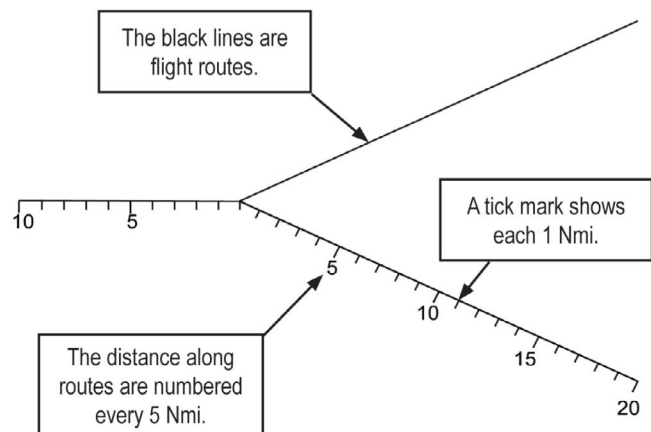
UNDERSTAND THE SECTOR DISPLAY

A **sector** is the air space above a specific geographical section of the country. Each sector has air traffic controllers responsible for the safe and efficient flight of all aircraft in that sector.

A sector is composed of many interconnected **routes** which are invisible pathways in the sky.

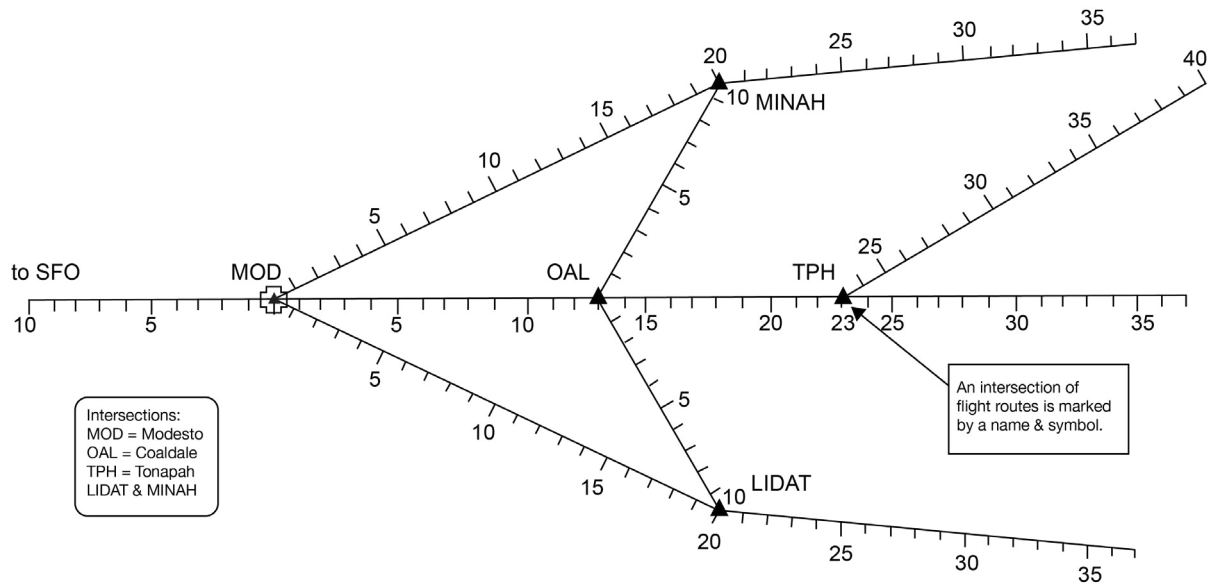
When looking at an air traffic problem display, you will see:

- Colored lines to show the routes of each plane
- Numbers at each 5 nautical mile increments
- Tick marks at each 1 nautical mile increment



Understand Sector Information (continued)

This is **Sector 33**, an example of the real sector in northern California. All routes lead to San Francisco (SFO) but must first pass through Modesto (MOD). Air traffic controllers merge traffic onto a single route to MOD.



It is important to understand the distances between intersections marked by a name and a symbol.

1. Circle the intersections at MOD and MINAH.

2. What is the direct distance from:

MINAH

TPH

LIDAT

_____ NM

_____ NM

_____ NM

To MOD?

_____ NM

_____ NM

_____ NM

To OAL?

3. How far is it from MINAH to OAL to MOD? _____ NM

4. How far is it from MINAH to MOD directly? _____ NM

5. How much shorter is it to go from MINAH to MOD directly rather than by way of OAL?

_____ NM

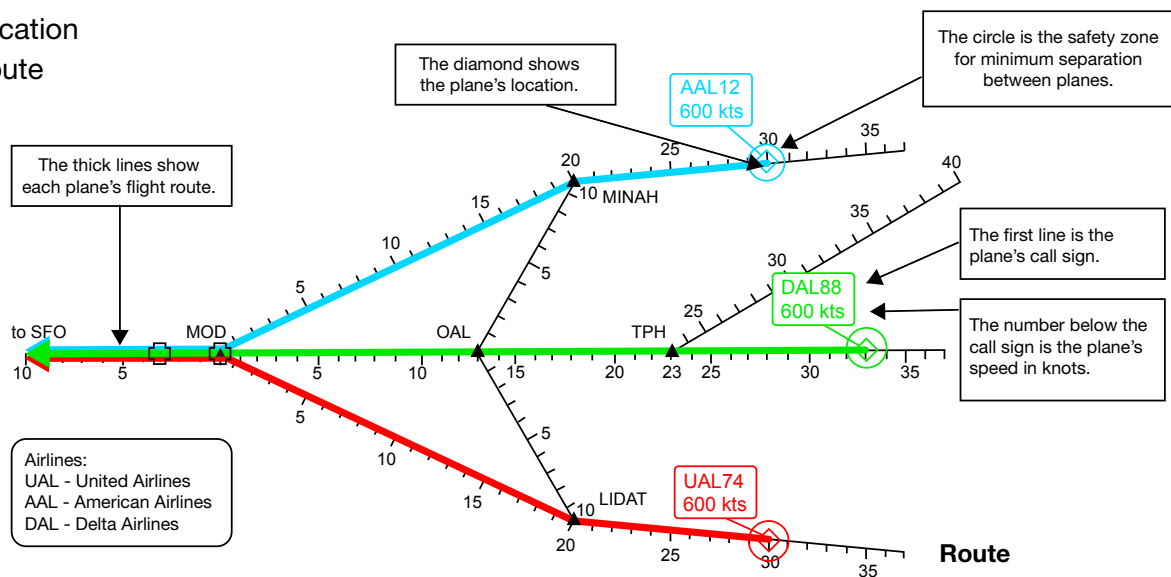
6. How much further is it to go from LIDAT to MOD by way of OAL rather than directly?

_____ NM

Understand Sector Information (continued)

Information for each plane is shown on the sector display.

- Plane call sign
- Speed in knots
- Location
- Route



7. Circle the diamond for the Delta Airlines flight on the sector display.

8. What is the speed of the Delta Airlines Flight? _____ knots.

A **flight plan** is a plane's route of travel from an intersection, its speed (in knots) and altitude. For the Smart Skies program, the altitude will be the same for all planes.

9. Locate flight AAL12 and write the intersections (in order) for it's flight plan to San Francisco (SFO):

To: _____ Then To: _____ Then To: _____

10. What is the length of the flight route of AAL12 from it's current position to MOD? _____ nautical miles.

11. What is the length of the flight route of UAL74 from its current position to MOD? _____ nautical miles.

Understand Aircraft Spacing Requirements

✦ The **Objective** of air traffic control is to move planes **safely** and **efficiently** to their destinations.

SAFETY–Minimum Spacing

To be **safe**, planes must **always** be kept far enough apart that collisions and near-misses **NEVER** happen.

- The Federal Aviation Administration (FAA) has established the least distance allowed between planes called the minimum separation.

Minimum Separation = 2 nautical miles

- On air traffic control displays, this minimum separation is shown by a “safety circle” around the plane symbol. The circle radius is 1 nautical mile.
- When two circles just touch, the distance between the plane is 1 nautical mile + 1 nautical mile = 2 nautical miles, the minimum separation.

EFFICIENCY–Ideal Spacing

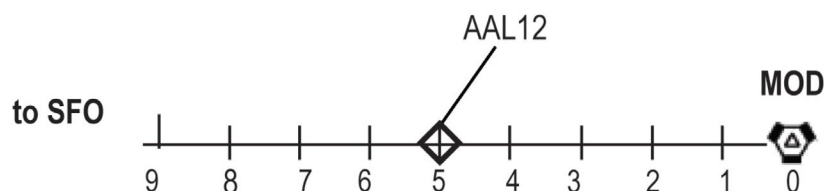
- At SFO, planes arrive from Sector 33 and other sectors so, at MOD, the air traffic controllers must leave more than 2 nautical miles to let planes from other sectors merge after MOD.
- This greater spacing is referred to as **ideal spacing**.

Ideal Spacing at MOD = 3 nautical miles

- Aim for ideal spacing at MOD and at least minimum separation everywhere else in the sector.

Understand Aircraft Spacing Requirements

- What is the minimum separation requirement? ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 nautical miles
- What is ideal Spacing? ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 nautical miles
- On the route line below, AAL12 is flying from MOD to SFO. Using the Minimum Separation, draw a “safety circle” around the flight symbol for this flight.



- UAL74 is **following** AAL12 to SFO. On the route line above, draw a diamond to show UAL74 at minimum separation.
- Draw a “safety circle” around the diamond for UAL74.
- DAL88 is ahead of AAL12 to SFO. On the route line above, draw a diamond and a safety circle to show DAL88 at the ideal spacing.
- In each diagram, check all the boxes that are **true**.

Safe? ☐ Yes ☐ No Ideal? ☐ Yes ☐ No

Safe? ☐ Yes ☐ No Ideal? ☐ Yes ☐ No

Safe? ☐ Yes ☐ No Ideal? ☐ Yes ☐ No

Safe? ☐ Yes ☐ No Ideal? ☐ Yes ☐ No

National Aeronautics and Space Administration

NASA Headquarters

300 E. Street, SW
Washington, DC 20546

[nasa.gov](https://www.nasa.gov)