LineUp With Math™

Math-Based Decisions in Air Traffic Control
for Grades 5–9

Problem Set A

Introduction to Real Air Traffic Control

Teacher Guide with Answer Sheets

Overview of Problem Set A	In this Problem Set, students will be introduced to the key ideas, vocabulary, units, and graphical representations of air traffic control.

An introductory two-minute video, *What is LineUp With Math*™?, introduces students to the *LineUp With Math*™ activities.

The heart of the Problem Set is a six-minute instructional video, *Welcome to Sector 33*.

Both videos are available on the *LineUp With Math*™ website and can be projected for whole class viewing. Alternatively, students can access the videos from the ATC Simulator homepage and watch them on an individual computer monitor.

After viewing *Welcome to Sector 33*, students reinforce their understanding of the key concepts via the Problem Set A Student Workbook that provides a structured learning environment with paper-and-pencil worksheets. |
| **Objectives** | Students will:

• Learn the vocabulary of air traffic control.
• Learn the units (nautical miles and knots) of air traffic control.
• Learn to read and interpret an airspace sector diagram.
• Learn the air traffic control spacing requirements for safety and efficiency. |
| **Prerequisites** | None |
| **Materials** | • Three Videos:
    -- *Animation of 24 hours of flight in the US*
    -- *What is LineUp With Math*™
    -- *Welcome to Sector 33*
• Student Workbook A (print-based)

The materials are available on the *LineUp With Math*™ website:

https://www.nasa.gov/lineup-with-math |

Videos	All three videos can be streamed from both the *LineUp With Math*™ website and the Simulator website.

The first video, *Animation of 24 hours of flight in the US*, compresses 24 hours of flight paths to one minute. The video illustrates the world's biggest distance-rate-time-problem and motivates the study of air traffic control.

The second video, *What is LineUp With Math*™?, introduces students to the overall goals and activities, and features scenes of students engaged in *LineUp With Math*™.

The third video, *Wecome to Sector 33*, presents the vocabulary, units, and graphical representations used in air traffic control. It prepares students for their first session with the interactive ATC Simulator. It also prepares students for the activities in the first Student Workbook (Problem Set A). |
| **Student Workbook**

It is recommended that you have a copy of Workbook A open while you read these notes. | The Workbook consists of two worksheets.

For each worksheet, the key points are briefly described as follows.
Worksheet: *Understand Sector Information*

- Students may confuse "nautical miles" and "knots." "Nautical miles" are a measure of distance; "knots" are a measure of speed (nautical miles per hour).
- Students may have difficulty reading a sector diagram to determine a plane's exact start-ing distance from MOD. For example:

    -- When the distance is not a multiple of five (e.g., for distances such as 28 nautical miles.).
    -- When a plane passes through OAL on its way from LIDAT or MINAH.

Worksheet: *Understand Airplane Spacing Requirements*

- At MOD, air traffic controllers line up all Sector 33 planes to proceed to the next sector. Controllers aim for Ideal Spacing (3 nautical miles) at MOD. Everywhere else, planes must have at least Minimum Separation (2 nautical miles). |
| **Answer Sheets** | Answer sheets for each worksheet in Student Workbook A can be found in Appendix I of this document. |

Math-Based Decisions in Air Traffic Control

Student Workbook A

Appendix I

- **Introduction to Real Air Traffic Control**
  - Units
  - Sector Problem
  - Aircraft Information
  - Spacing Information

Workbook Answers

Investigator: _____

An Airspace Systems Program Product

Understand Sector Information

Investigator: _____

Understand Units

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 (Nmiles)**. A nautical mile is a little *longer* than a statute mile.

> ## 1 nautical mile = 1.15 statute miles

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)**.

> ## 1 "knot" = 1 nautical mile per hour

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.
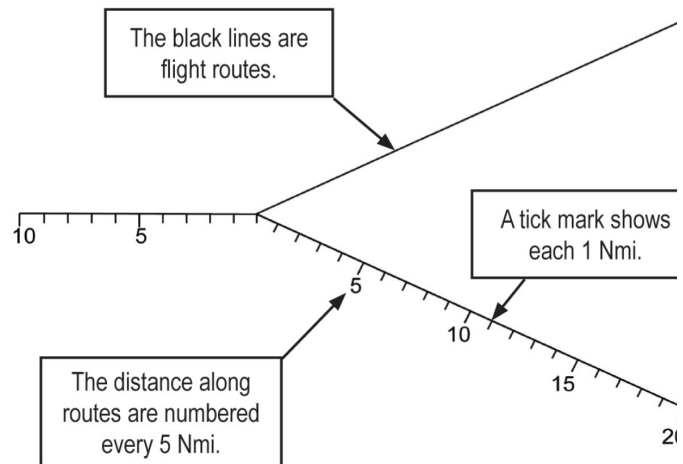
Understand the Sector Display

A **Sector** is the air space above a specific geographical section of the country.
Each sector has 2 air traffic controllers. They are responsible for the safe and efficient flight of all aircraft in that sector.

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

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

- Lines to show the routes
- Numbers at each 5 nautical mile distance
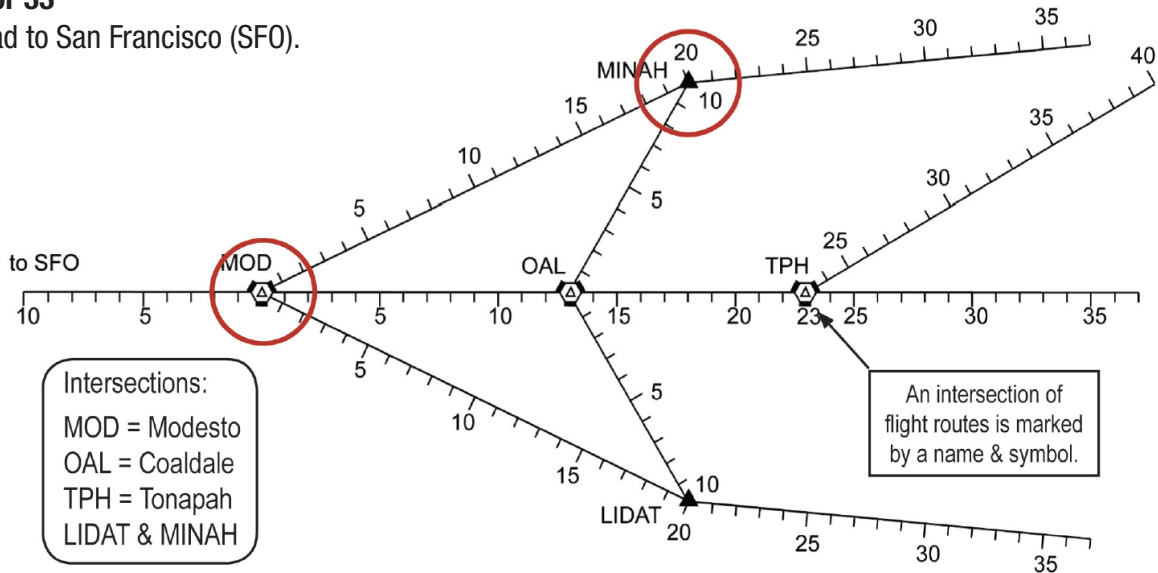- Tick marks at each 1 nautical mile distance

The black lines are flight routes.

A tick mark shows each 1 Nmi.

The distance along routes are numbered every 5 Nmi.

10   5   5   10   15   2(

Continue to Next Page

Smart Skies™

- This is **Sector 33**
- All routes lead to San Francisco (SFO).

Intersections:

MOD = Modesto
OAL = Coaldale
TPH = Tonapah
LIDAT & MINAH

An intersection of flight routes is marked by a name & symbol.

- Sector 33 is a real sector in northern California. But we've used different distances.
- Sector 33 controllers merge traffic onto a single route to MOD.

It is important that you understand the distances between intersections.

1   Circle the intersections at MOD and MINAH.

2   What is the direct distance from:

	MINAH	TPH	LIDAT
To MOD?	**20** Nmi	**23** Nmi	**20** Nmi
To OAL?	**10** Nmi	**10** Nmi	**10** Nmi

3   How far is it from MINAH to OAL to MOD?   **23** nautical miles

4   How far is it from MINAH to MOD directly?   **20** nautical miles
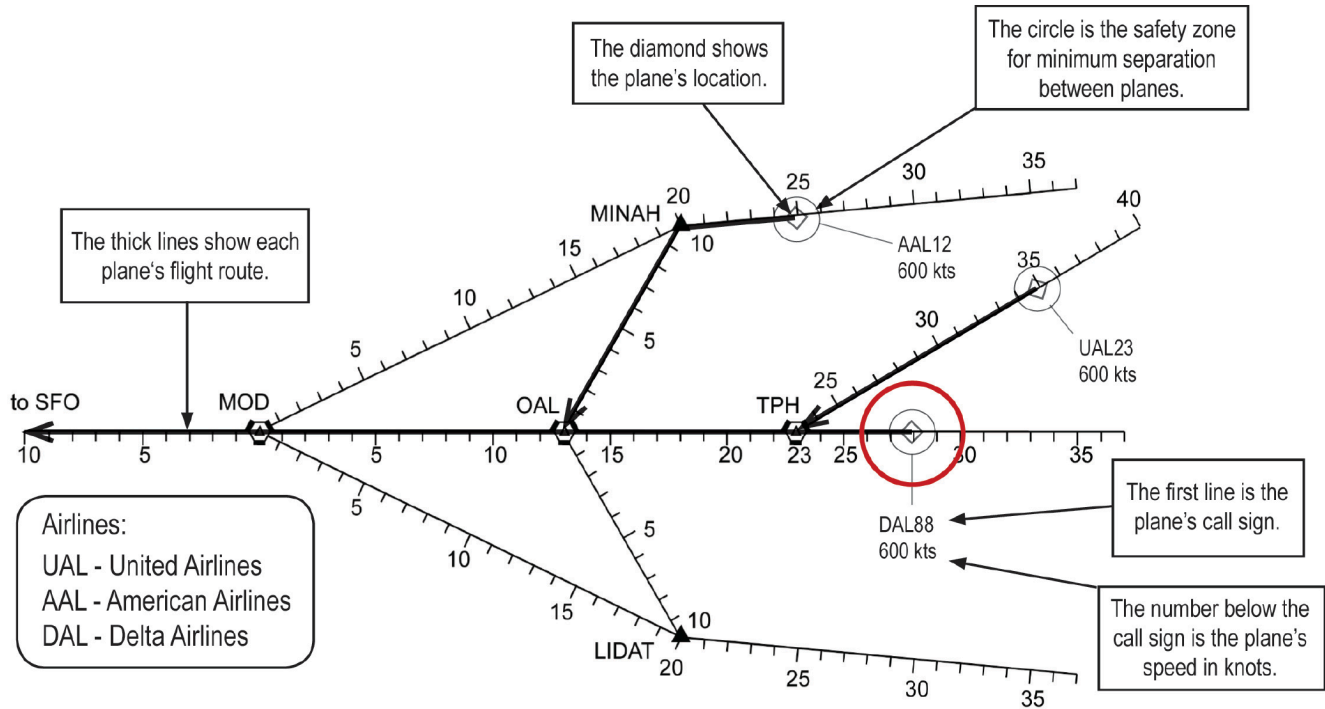
5   How much shorter is it to go from MINAH to MOD directly rather than by way of OAL?   **3** nautical miles

6   How much further is it to go from LIDAT to MOD by way of OAL rather than directly?   **3** nautical miles

Continue to Next Page

Smart Skies™

- Information for each plane, including it's position, is shown on the sector display.

The diamond shows the plane's location.

The circle is the safety zone for minimum separation between planes.

The thick lines show each plane's flight route.

Airlines:
UAL - United Airlines
AAL - American Airlines
DAL - Delta Airlines

The first line is the plane's call sign.

The number below the call sign is the plane's speed in knots.

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

8   What is the speed of the Delta Airlines flight?   **600**   knots

A **Flight Plan** is a plane's route of travel from intersection, including speed (knots) and altitude. In our case, the altitude will be the same for all planes.

9   Locate flight AAL12 and write the intersections (in order) for its flight plan to San Francisco (SFO):

To: **MINAH**   Then To: **OAL**   Then To: **MOD**

10   What is the length of the flight route of AAL12 from it's current position to MOD?   **28**   nautical miles

5 + 10 + 13 = 28

11   What is the length of the flight route of UAL23 from its current position to MOD?   **35**   nautical miles

Understand Airplane Spacing Requirements

Investigator: _____

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

Safety - Minimum Separation

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

- The Federal Aviation Administration has established the least distance allowed between planes. This is called the **Minimum Separation**.

You will use   `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.
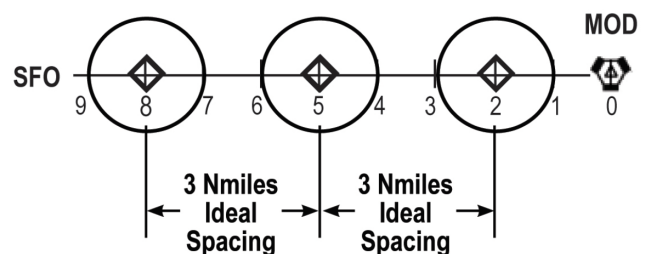
Minimum Separation
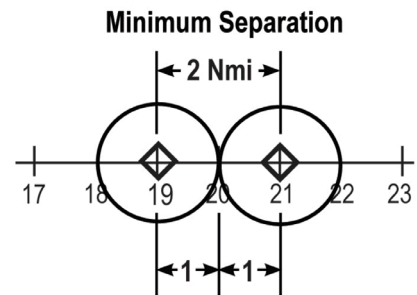
Efficiency - Ideal Spacing

- At SFO, planes arrive from Sector 33 and from other sectors.
  So, at MOD the Sector 33 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`

- You must aim for Ideal Spacing at MOD.
  Everywhere else you need at least Minimum Separation.
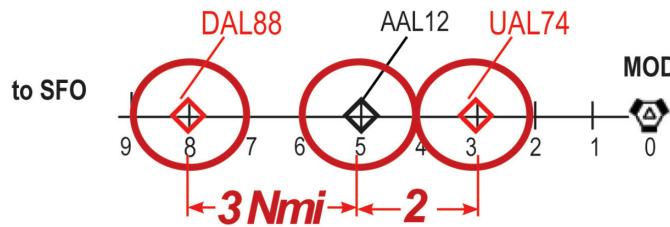
Continue to Next Page

Smart Skies™

1   What is the <u>Minimum</u> Separation requirement?   ☐ 1   **X** 2   ☐ 3   ☐ 4   ☐ 5   nautical miles

2   What is <u>Ideal</u> Spacing?   ☐ 1   ☐ 2   **X** 3   ☐ 4   ☐ 5   nautical miles

3   On the plot below, AAL12 is flying from MOD to SFO. Using the Minimum Separation, draw a "safety circle" around the flight symbol for this flight.

4   UAL74 is following AAL12 to SFO. On the route, draw a diamond to show UAL74 at the <u>Minimum</u> Separation.

5   Draw a "safety circle" around the diamond for UAL74.

6   DAL88 is ahead of AAL12 to SFO. On the route, draw a diamond and a safety circle to show DAL88 at the <u>Ideal</u> Spacing.

7   In each Diagram, check all boxes that are **true**.