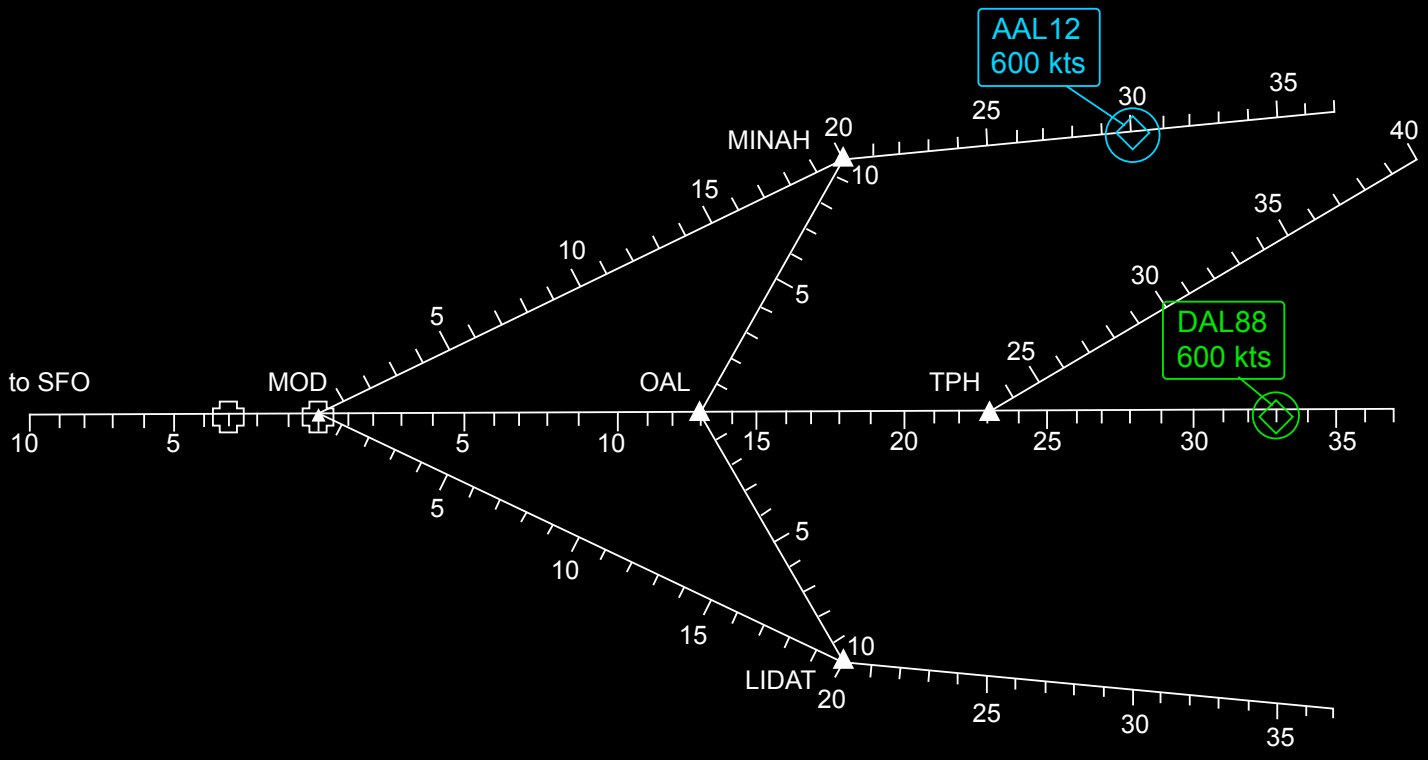
National Aeronautics and Space Administration



LineUp with Math

Math-Based Decisions in Air Traffic Control

FACILITATOR GUIDE A

Facilitator Guide with Answer Sheets
Introduction to Air Traffic Control

Facilitator Guide with Answer Sheets

Overview of Problem Set A

Estimated class time: 1 to 2 hours

In Problem Set A, students are introduced to the key ideas, vocabulary, units of measurement, and graphical representations of air traffic control using worksheets and three introductory videos: *Animation of 24 hours of flight in the US*, *Welcome to Sector* 33 and *I'm a Controller*.

Prerequisites

Students will:

- Learn the vocabulary of air traffic control.
- Learn the units of measurement (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.

Materials

The materials are available on the Smart Skies: LineUp with Math™ website: https://www.nasa.gov/lineup-with-math

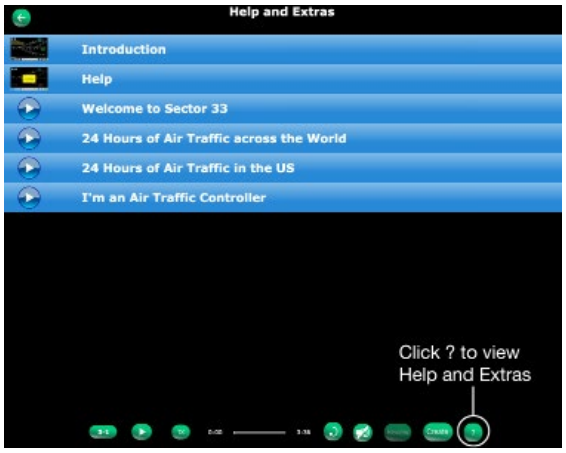
Videos:

- Animation of 24 hours of flight in the US
- Welcome to Sector 33
- I'm a Controller
- 24 Hours of Air Traffic across the World (Optional)

- Student Workbook A:
  - Fillable PDF versions
  - Printed copies

Videos

Three videos are available on the Smart Skies: LineUp with Math™ website. All videos can be found in the air traffic control (ATC) simulator, Smart Skies: LineUp with Math help page (see image on right). Videos can be projected for whole class viewing or used on individual devices.



Facilitator Guide with Answer Sheets
(continued)

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 is the heart of Problem Set A, Welcome to Sector 33 presents the vocabularly, units of measurement, and graphical representations used in air traffic control. The six-minute instructional video prepares students for the activities in the first Student Workbook for Problem Set A and their first session with the interactive ATC simulator.

The third video, I'm a Controller, introduces students to the role and career of an air traffic controller. The fourth (optional) video, Animation of 24 hours of flight across the World, compresses 24 hours of flight paths around the world to one minute.

Student Workbook

Student Workbook A consists of two worksheets: Understand Sector Information and Understand Airplane Spacing Requirements.

Worksheet #1: Understand Sector Information

- Nautical miles (NM) are a measure of distance when traveling by air or by sea. (How far or close)
- Knots (kts) are a measure of speed in nautical miles per hour when traveling by air or sea. (How fast or slow)
- Learn to read a sector diagram to determine a plane's route and its exact starting distance from MOD by counting tick marks.

Worksheet #2: Understand Airplane Spacing Requirements

- All planes will line up at MOD before moving on to the next sector, SFO.
- Minimum separation (2 nautical miles) is the least distance allowed between planes when not at MOD.
- Controllers aim for ideal spacing (3 nautical miles) at MOD and at least minimum separation everywhere else in the sector.

APPENDIX I

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 statue 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).** 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 “knot” = 1 nautical mile per hour

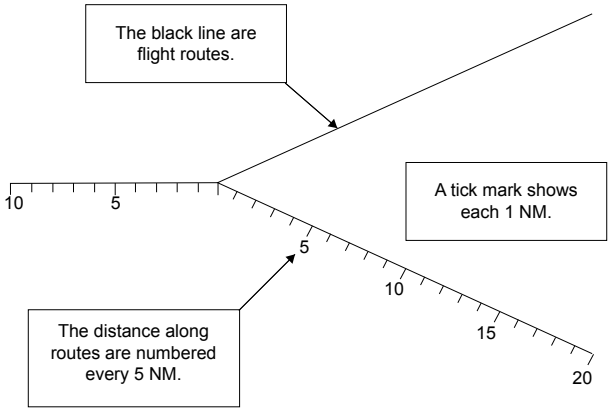
UNDERSTAND THE SECTOR DISPLAY

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.

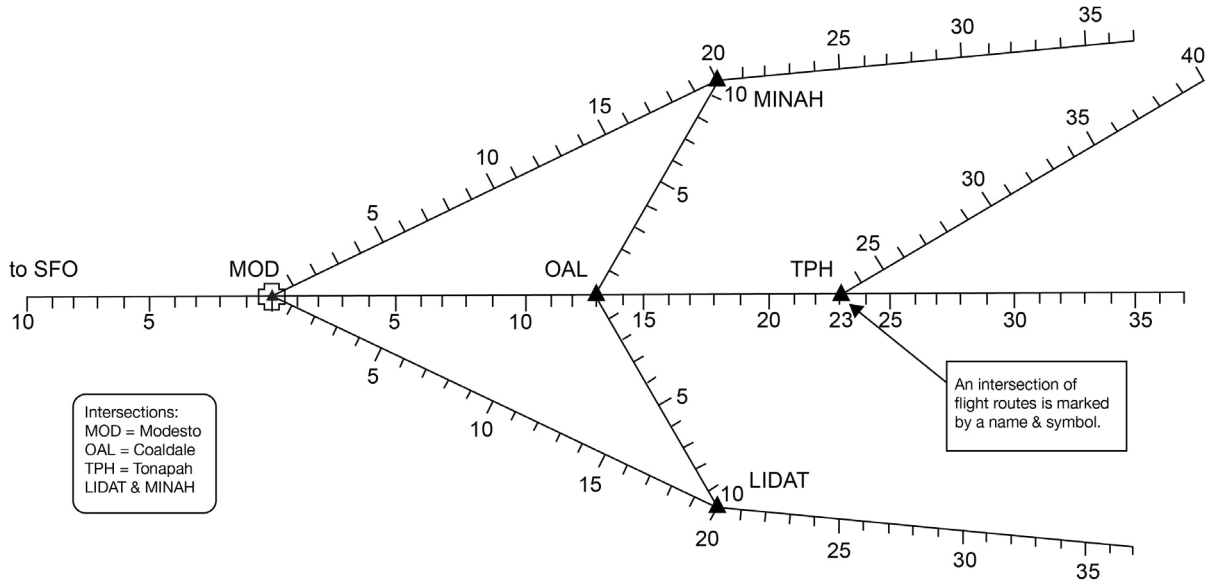
When looking at an air traffic problem display, you will see:

- ✈ 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 are 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	
20 NM	23 NM	20 NM	To MOD?
10 NM	10 NM	10 NM	To OAL?

3. How far is it from MINAH to OAL to MOD? 23 NM

4. How far is it from MINAH to MOD directly? 20 NM

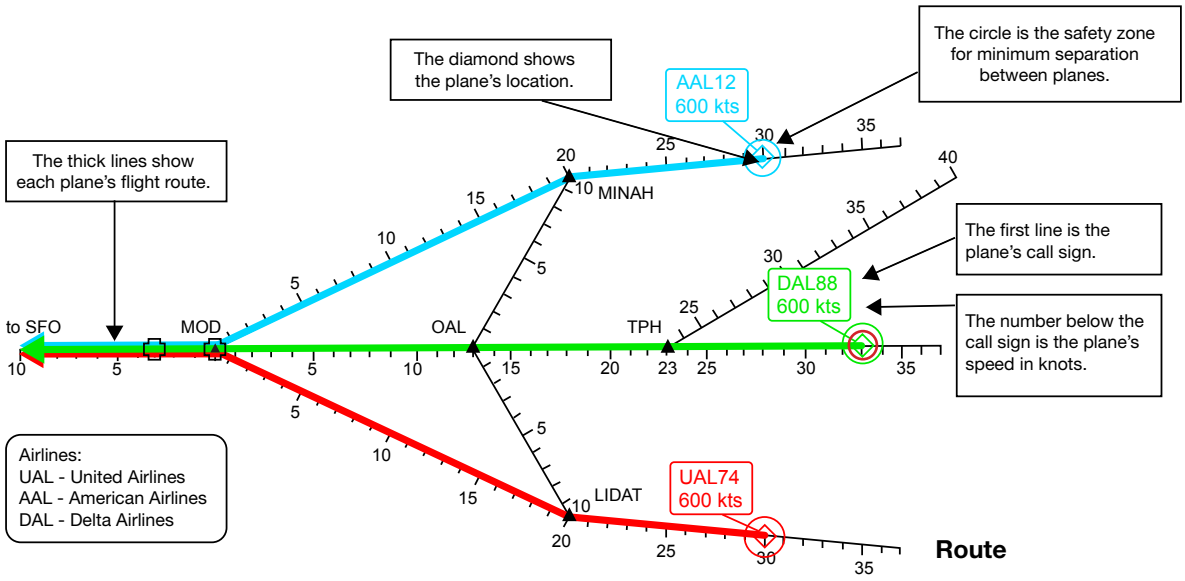
5. How much shorter is it to go from MINAH to MOD directly rather than by way of OAL?
   3 NM

6. How much further is it to go from LIDAT to MOD by way of OAL rather than directly?
   3 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? ____600_____ 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: ___MINAH_____ Then To: __OAL_____ Then To: __MOD_____

10. What is the length of the flight route of AAL12 from its current position to MOD? 28 nautical miles.
    5 + 10 + 13 = 28

11. What is the length of the flight route of UAL74 from its current position to MOD? 35 nautical miles. 12 + 10 + 13 = 35

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

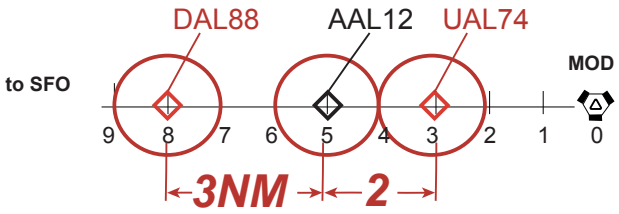
✈ Aim for ideal spacing at MOD and at least minimum separation everywhere else in the sector.

Understand Aircraft Spacing Requirements

1. What is the minimum separation requirement? ☐ 1 ☑ 2 ☐ 3 ☐ 4 ☐ 5 nautical miles

2. What is ideal spacing? ☐ 1 ☐ 2 ☑ 3 ☐ 4 ☐ 5 nautical miles

3. 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 AAL12.

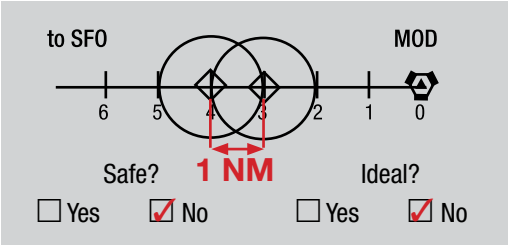


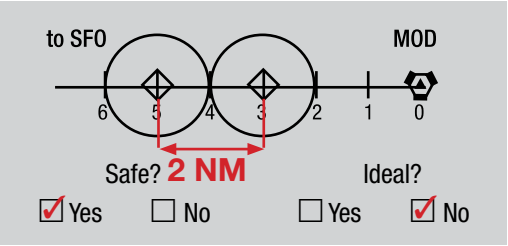
4. UAL74 is **following** AAL12 to SFO. On the route line above, draw a diamond to show UAL74 at minimum separation.

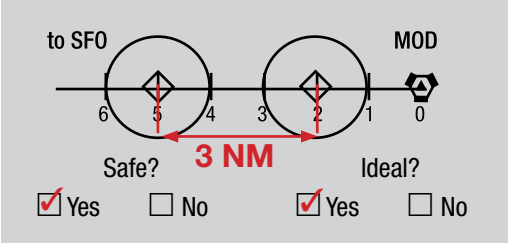
5. Draw a "safety circle" around the diamond for UAL74.

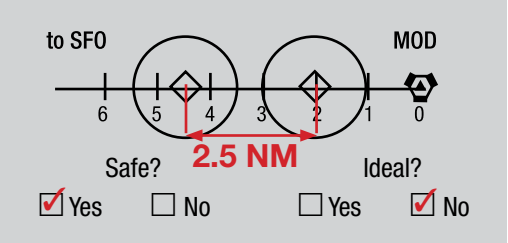
6. DAL88 is ahead of AAL12 to SFO. On the route line above, draw a diamond and a safety circle to show DAL88 at the ideal spacing.

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









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