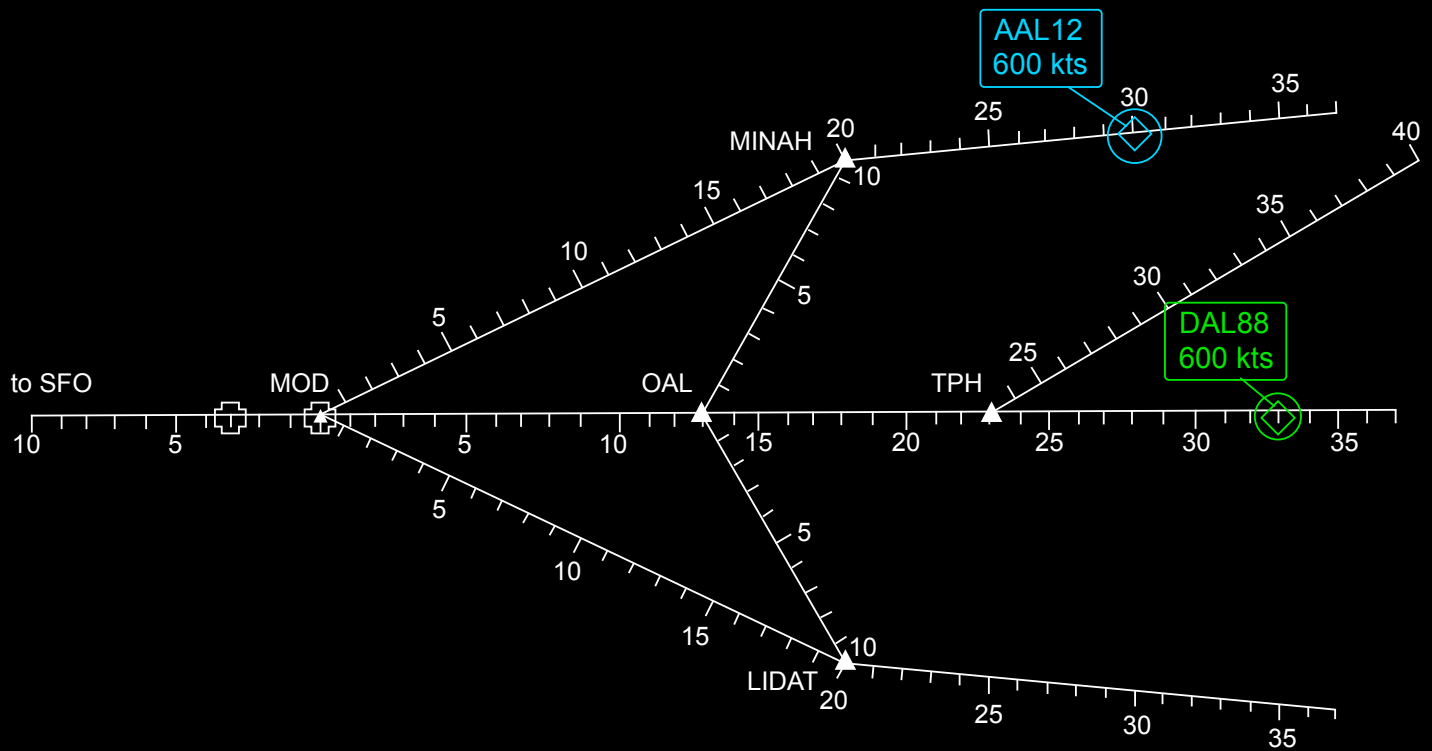




LineUp with Math

Math-Based Decisions in Air Traffic Control

FACILITATOR GUIDE B

Facilitator Guide with Answer Sheets

Resolving 2-Plane Traffic Conflicts by Changing Route

Facilitator Guide with Answer Sheets

Overview of Problem Set B

Estimated class time: 1.5 to 2 hours

In Problem Set B, students will determine whether two planes traveling at the same constant (fixed) speeds, on different merging routes will line up with proper spacing at MOD, the last intersection before the planes leave the airspace sector. If the spacing is not adequate, students will analyze an alternate route for one plane.

Each problem will be explored using the interactive Air Traffic Control (ATC) simulator. Three problems are more closely examined with Student Workbook B.

Objectives

Students will:

- Analyze a sector diagram to identify a spacing conflict between two planes, each traveling at the same speed.
- Resolve the conflict by changing the route for one plane.

Prerequisites

Complete Problem Set A, the introduction of essential air traffic control vocabulary, units of measurement, and graphical representations.

Materials

Access the materials by visiting the Smart Skies: LineUp with Math™ website: <https://www.nasa.gov/stem-content/smart-skies-lineup-with-math2/>

- Smart Skies: LineUp with Math ATC simulator
 - use online
 - download
- Student Workbook B:
 - Fillable PDF versions
 - Printed copies

Facilitator Guide with Answer Sheets (cont'd)

ATC Simulator

Interactive Air Traffic Control Simulator

A complete description of the ATC simulator can be found in the Facilitator Guide for Smart Skies: LineUp with Math™, and the animated tutorial can be viewed in the video: *Welcome to Sector 33*.

Each problem in this set features a 2-plane conflict that can be resolved by a route change. The simulator problems for Problem Set B are: 2-1, 2-2, and 2-3.

Answer Sheets

Facilitator analysis and solutions for each of the problems can be found in Appendix I. The worksheet answer keys for Student Workbook B can be found in Appendix II.

Student Workbook

Student Workbook B consists of three worksheets, one for each problem: 2-1, 2-2, and 2-3. Each problem features a spacing conflict with different starting conditions.

Worksheet #1: Problem 2-1

- Analyze the diagram to understand each plane starts at a different distance from MOD, and the intersection points.
- The closer plane represents a "headstart" and maintains its headstart because the planes are traveling at the same speed.
- Analyze route changes which may provide additional spacing. Understand additional spacing does not guarantee ideal spacing.

Worksheet #2: Problem 2-2

- Further analyze the ATC simulator information to understand plane locations, distances from MOD, routes, and spacing from other planes.

Worksheet #3: Problem 2-3

- Analyze and identify the spacing conflict presented by this problem in the ATC simulator.

APPENDIX I

Simulator Solutions for Problem Set B

2-1, 2-2, and 2-3

Problems are supported by Student Workbook B

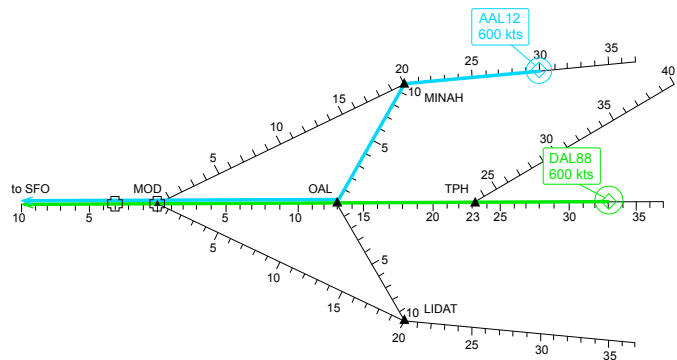
ANALYSIS OF WORKSHEET #1

Problem 2-1

STARTING CONDITIONS

Plane	From	Through	To	Distance	Speed
AAL12	MINAH	OAL	MOD	33	600
DAL88	TPH	OAL	MOD	33	600

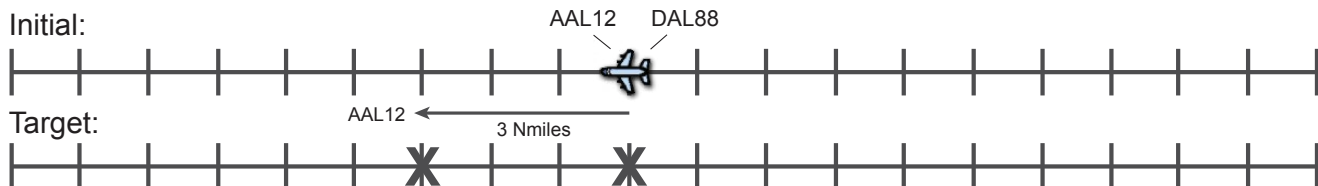
Ideal spacing at **MOD** is 3 nautical miles.
Minimum separation is 2 nautical miles.



FLIGHT ANALYSIS

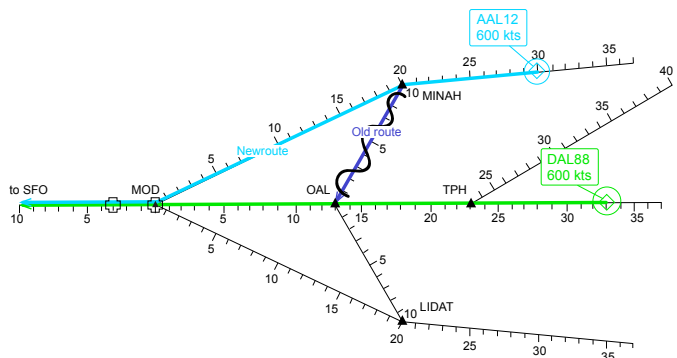
- ➔ **DAL** and **AAL12** will arrive at MOD at the same time.
- ➔ **AAL12** must change route to avoid collision and accomplish ideal spacing.

Projected Arrival	Plane	Distance Along Flight Plan	Initial Spacing
1st	AAL12	33	→ 0
1st	DAL88	33	



SOLUTION

- ➔ **AAL12:** Reroute direct to MOD through MINAH to move forward 3 nautical miles to achieve ideal spacing at MOD.
- ➔ **Target Time:** 3 minutes and 18 seconds.



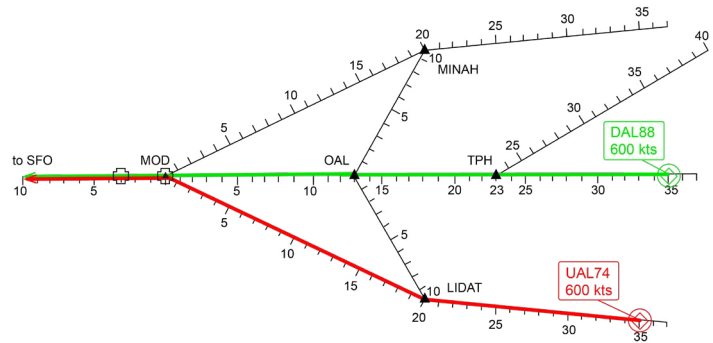
ANALYSIS OF WORKSHEET #2

Problem 2-2

STARTING CONDITIONS

Plane	From	Through	To	Distance	Speed
DAL88	TPH	OAL	MOD	35	600
UAL74	LIDAT		MOD	35	600

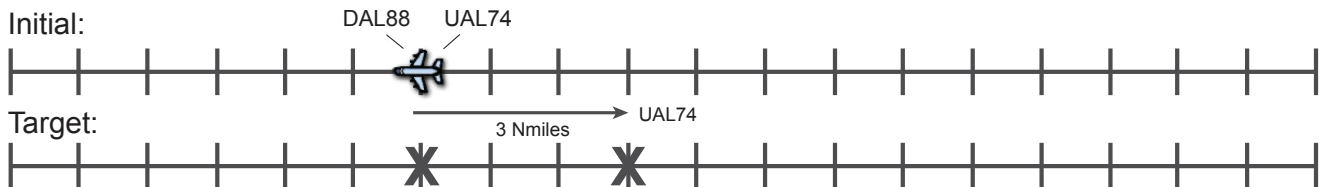
Ideal spacing at **MOD** is 3 nautical miles.
Minimum separation is 2 nautical miles.



FLIGHT ANALYSIS

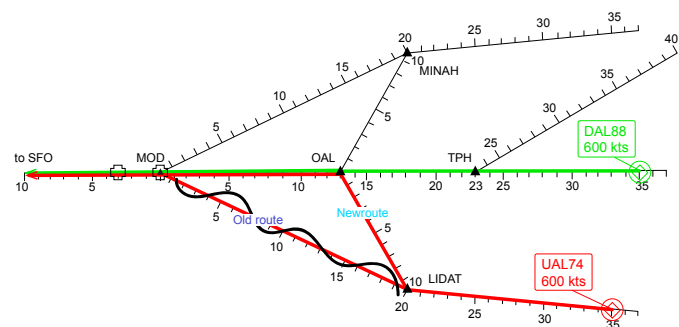
- **DAL** and **UAL74** will arrive at MOD at the same time.
- **UAL74** must change route to avoid collision and accomplish ideal spacing.

Projected Arrival	Plane	Distance Along Flight Plan	Initial Spacing
1st	DAL88	35	→ 0
1st	UAL74	35	



SOLUTION

- **UAL74:** Reroute through OAL to fall back 3 nautical miles and achieve ideal spacing at MOD.
- **Target Time:** 3 minutes and 48 seconds.



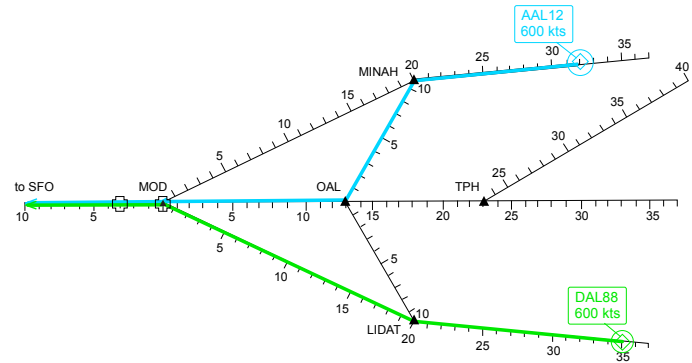
ANALYSIS OF WORKSHEET #3

Problem 2-3

STARTING CONDITIONS

Plane	From	Through	To	Distance	Speed
AAL12	MINAH	OAL	MOD	35	600
DAL88	LIDAT		MOD	35	600

Ideal spacing at **MOD** is 3 nautical miles.
Minimum separation is 2 nautical miles.

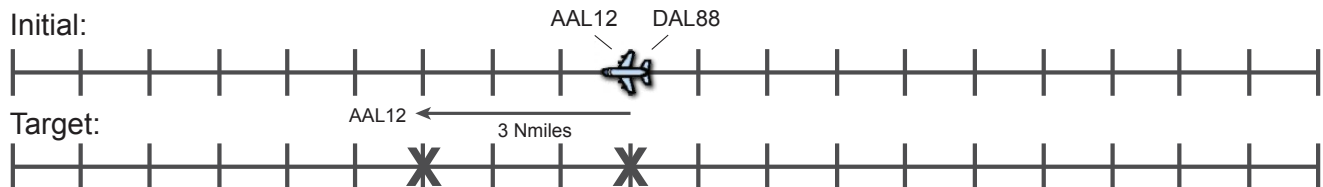


FLIGHT ANALYSIS

- **AAL12** and **DAL88** will arrive at MOD at the same time.
- **AAL12** must change route to avoid collision and achieve ideal spacing.

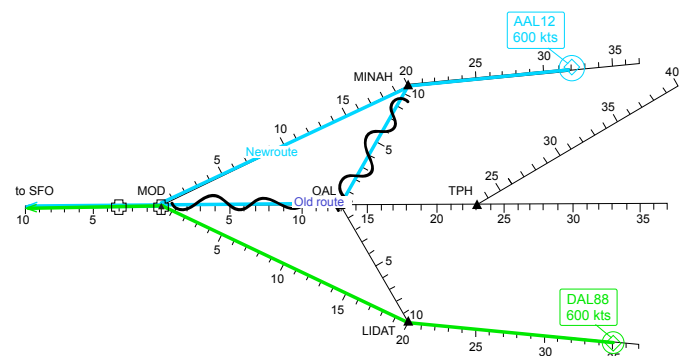
Projected Arrival	Plane	Distance Along Flight Plan	Initial Spacing
1st	AAL12	35	→ 0
1st	DAL88	35	

**Note: Ideal spacing could be achieved if DAL88 changes route, but the simulator does not recognize this as a solution.*



SOLUTION

- **AAL12:** Reroute direct to MOD through MINAH to move forward 3 nautical miles and achieve ideal spacing at MOD.
- **Target Time:** 3 minutes and 30 seconds.

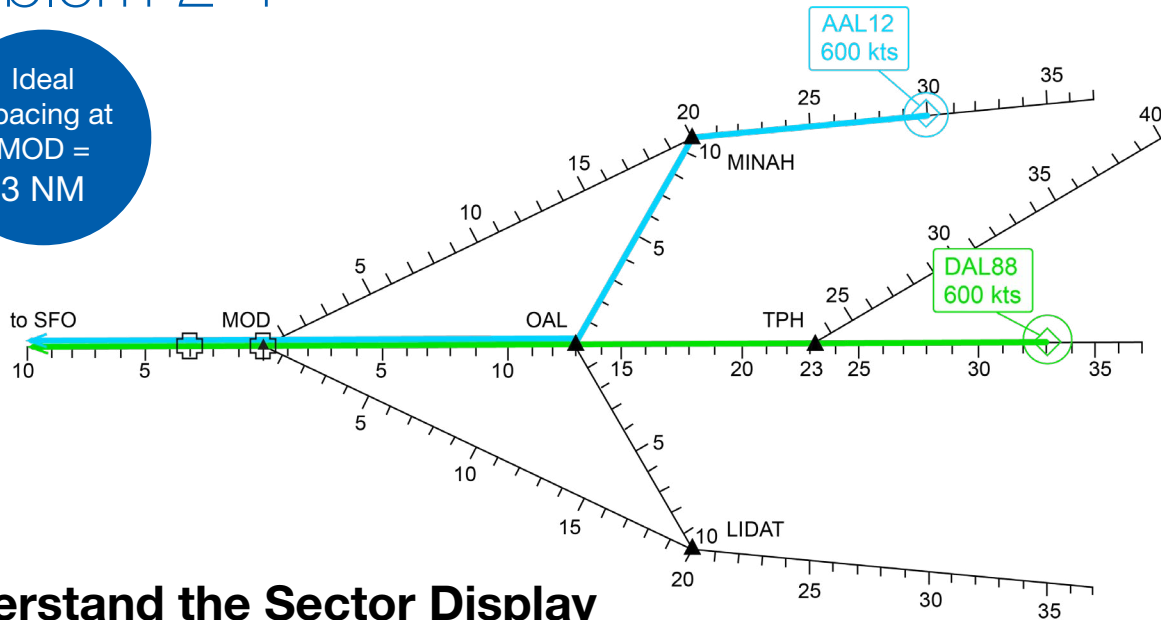


APPENDIX II

Answer Sheets

WORKSHEET #1

Problem 2-1



Understand the Sector Display

- The plane speeds are: ☒ Same ☐ Different
- The plane routes intersected first at: OAL

Predict Aircraft Positions

- Which plane is closer to OAL? Neither Headstart = $33-33=0$ nautical miles

This plane has a headstart.

- Which plane will arrive first at OAL? Both arrive at the same time Spacing = 0 nautical miles
- When that plane arrives at OAL, the spacing will be ☒ the **same as** or ☐ **different from** the headstart.

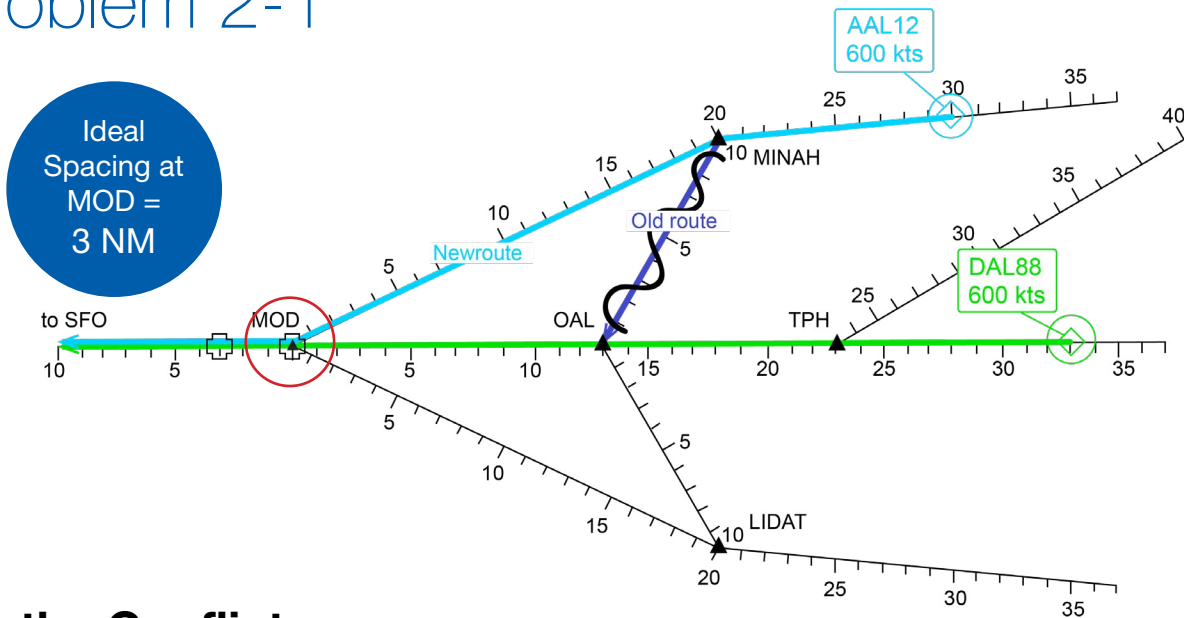
Check Separation

- Will the spacing at OAL be at least minimum separation? ☐ Yes ☒ No
- How much extra spacing is needed to have ideal spacing? 3 nautical miles **$(3-0=3)$**
- What could the controller do to achieve at least ideal spacing?

Change the route of AAL12.

WORKSHEET #1 continued

Problem 2-1



Fix the Conflict



To achieve ideal spacing, reroute AAL-12 directly from MINAH to MOD as shown above.

9. On the diagram above, circle the intersection where the new AAL12 route meets the DAL88 route.

Predict Aircraft Positions

10. Which plane now has a headstart? AAL12 New Headstart = 3 nautical miles
11. Which plane will arrive first? AAL12 New Spacing = 3 nautical miles
12. Why does the new route provide additional spacing? The new route to MOD will shorten the travel distance to give AAL12 a 3 NM headstart. (or something similar)

Check New Separation

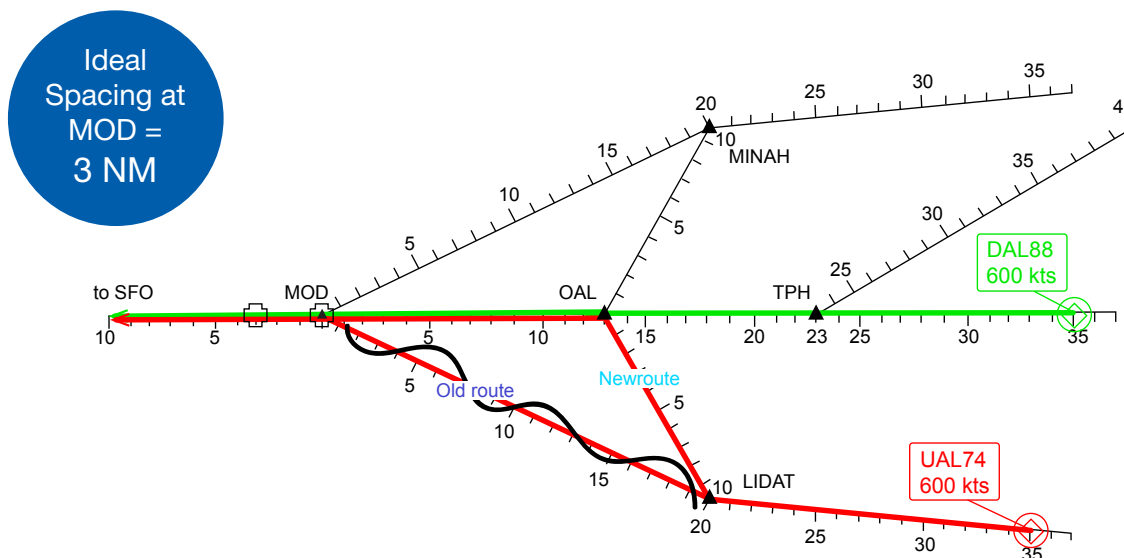
13. Is the new spacing at least minimum separation? ☒ Yes ☐ No If No, try again!
14. Does the new spacing equal ideal spacing? ☒ Yes ☐ No

Route changes don't always give Ideal Spacing

WORKSHEET #2

Problem 2-2

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



- Fill in the blanks to determine if the 2 planes have ideal spacing where the routes meet.

Where do the routes meet? MOD Headstart (NM) 35-35=0 Spacing at MOD (NM) 0

Ideal spacing at MOD? ☐ Yes ☒ No Additional spacing required for ideal spacing? 3 NM

- If spacing is **NOT** ideal, enter the flight plan change needed to add more spacing at MOD.

Plane: UAL74 Route Change: LIDAT To: OAL To: MOD

- Check the new route by filling in the table below.

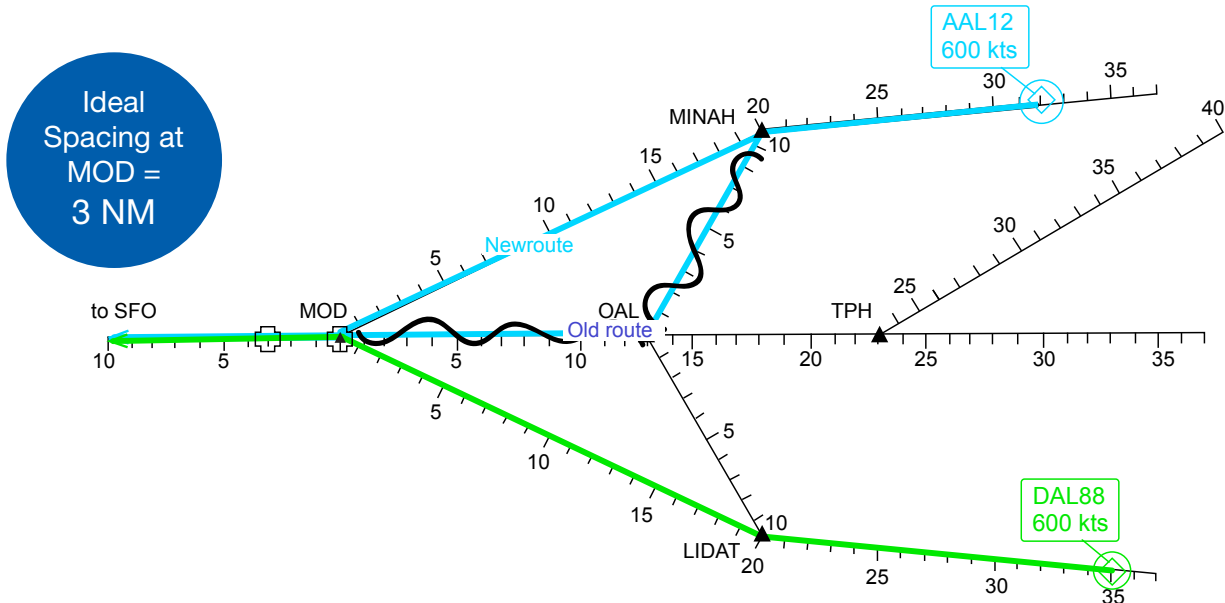
Where do the routes meet?	Lead Plane?	Headstart (NM)	Spacing at OAL (NM)	Is Spacing at MOD Ideal?
<u>OAL</u>	<u>DAL88</u>	<u>25-22=3</u>	<u>3</u>	<u>Yes</u>

→ **Does the route change work?** If Yes, Congratulations! If no, try again!

→ **Mark out the old route and darken the new route change on the diagram above.** Be sure to use the correct route when checking the solution with the ATC simulator.

WORKSHEET #3

Problem 2-3



1. What is the spacing at MOD? 35-35=0 nautical miles
2. Is this ideal spacing? ☐ Yes ☒ No
3. Why or why not? The route lengths and plane speeds are the same, so they will arrive at MOD at the same time. (35 nautical miles / 600 kts) (or something similar)
4. If the flight plan does **NOT** give ideal spacing, enter the flight plan change to solve the problem.

Plane: AAL12 New Route: MINAH to MOD

Note to Facilitator: If UAL74 is rerouted the long way, both planes will be delayed.

- **Mark out the old route and darken the new route change on the diagram above.** Be sure to use the correct route when checking the solution with the ATC simulator.

5. What is the new spacing at MOD? 35-32=3 nautical miles
6. Is the new spacing now ideal?
☒ Yes ☐ No
7. Why or why not? The new route will shorten the travel distance to give AAL12 a 3 NM lead. (or something similar)

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