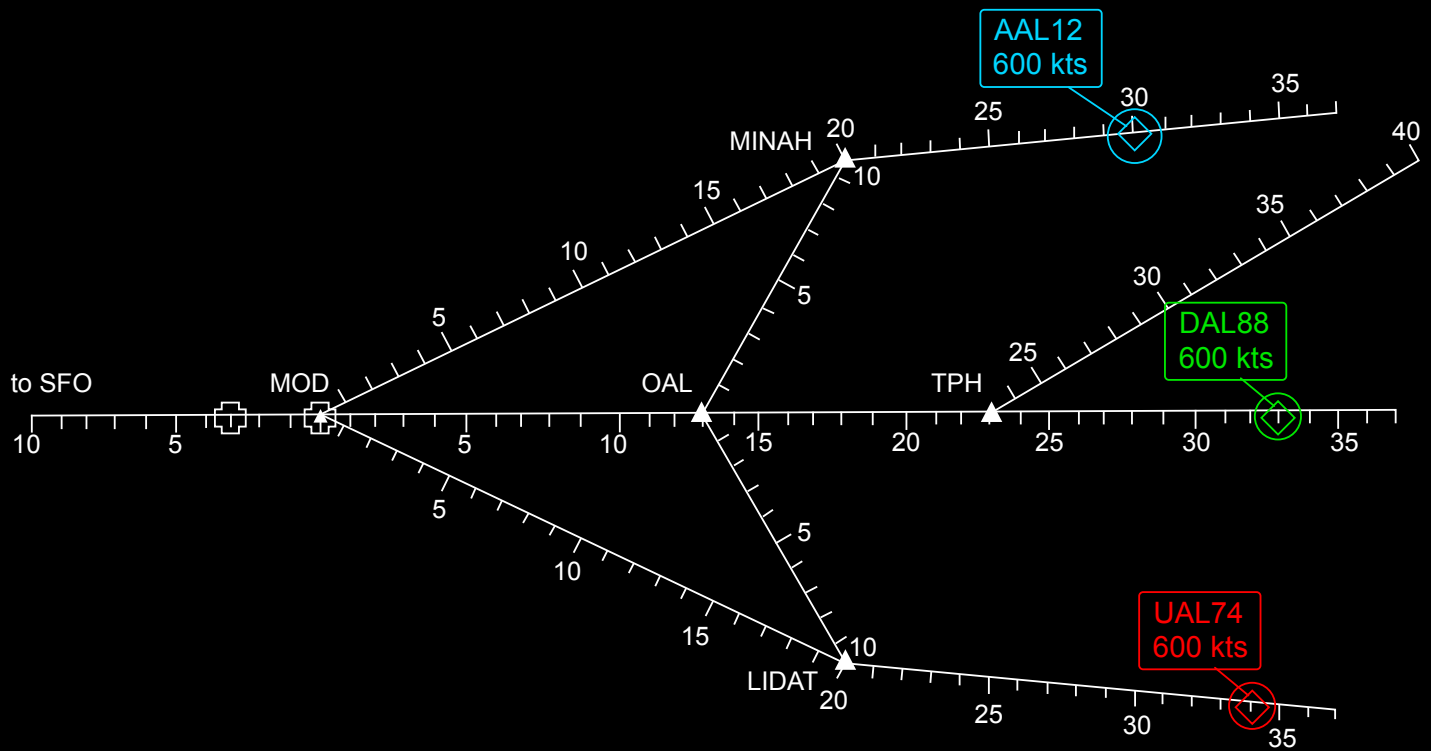




LineUp with Math

Math-Based Decisions in Air Traffic Control

FACILITATOR GUIDE C

Facilitator Guide with Answer Sheets

Resolving 3-Plane Air Traffic Conflicts by Changing Route

Simulator at: <https://atcsim.nasa.gov/simulator/sim2/sector33.html>

Facilitator Guide with Answer Sheets

Overview of Problem Set C

Estimated class time: 1 to 2 hours

In Problem Set C, students will determine whether three planes traveling on different merging routes will line up with ideal spacing at MOD (the last intersection before the planes leave the airspace sector). If the spacing is not adequate, students will use alternate routes for one or more planes to achieve ideal spacing.

Each problem will be explored with the interactive Air Traffic Control (ATC) simulator. One of the problems is recommended for guided learning (whole or small group). The two remaining problems are more closely examined with Student Workbook C.

Objectives

Students will:

- ➔ Analyze a sector diagram to identify spacing conflicts among three planes, each traveling at the same speed.
- ➔ Resolve spacing conflicts by changing the route for one or more planes.

Prerequisites

Complete Problem Set A and B, an introduction to essential air traffic control vocabulary, units of measurement, graphical representations, and the ATC Simulator.

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 C:
 - ➔ Fillable PDF versions
 - ➔ Printed copies

Facilitator Guide with Answer Sheets (cont'd)

ATC Simulator

Interactive Air Traffic Control Simulator

Each problem in this set features a 3-plane conflict that can be resolved by route changes. The simulator problems for Problem Set C are: 3-1*, 3-2*, and 3-7.

Problems with an asterisk (*) are supported by Student Workbook C. The remaining problem is recommended for guided learning (whole or small group).

Answer Sheets

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

Student Workbook

Student Workbook C consists of two worksheets, one for each problem: 3-1 and 3-2.

Worksheet #1: Problem 3-1

- On a number line, students plot each plane's travel distance from MOD to help picture the arrival order of planes at MOD, their relative spacing, and any spacing violations.
- On another timeline, students resolve spacing violation with a route change, to picture the planes' new arrival order and spacing.

Worksheet #2: Problem 3-2

- Students are expected to analyze and identify the conflict in the flight plan presented in the diagram.

APPENDIX I

Simulator Solutions for Problem Set C

3-1*, 3-2*, 3-7

Problems with an asterisk (*) are supported by Student Workbook C

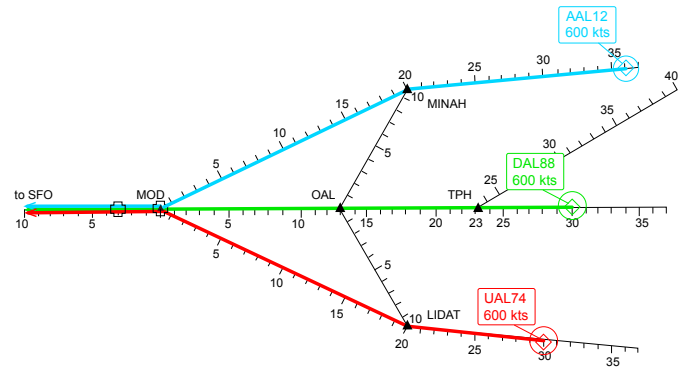
ANALYSIS OF WORKSHEET #1

Problem 3-1

STARTING CONDITIONS

Plane	From	Through	To	Distance	Speed
AAL12	MINAH		MOD	36	600
DAL88	TPH	OAL	MOD	30	600
UAL74	LIDAT		MOD	30	600

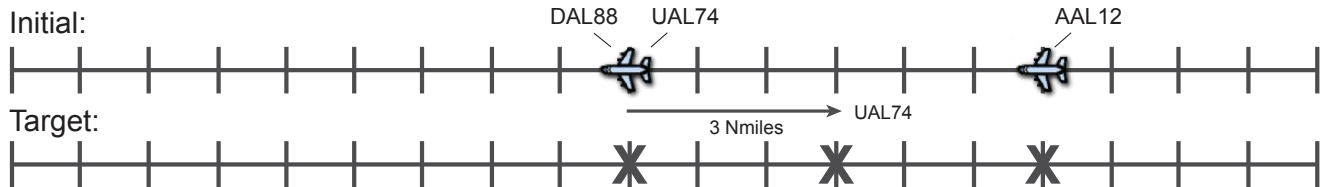
Ideal spacing at **MOD** is 3 nautical miles.
Minimum separation is 2 nautical miles.



FLIGHT ANALYSIS

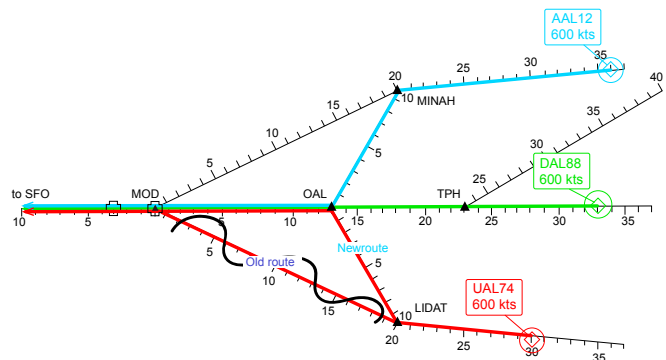
- DAL88** and **UAL74** will arrive at MOD at the same time.
- One** of the planes must reroute to avoid a collision and accomplish ideal spacing.

Projected Arrival	Plane	Distance Along Flight Plan	Initial Spacing
1st	DAL88	30	0
1st	UAL74	30	
3rd	AAL12	36	6



SOLUTION

- UAL74:** Reroute through OAL to lengthen travel distance to fall behind 3 nautical miles and achieve ideal spacing at MOD.
- Target Time:** 3 minutes and 36 seconds.



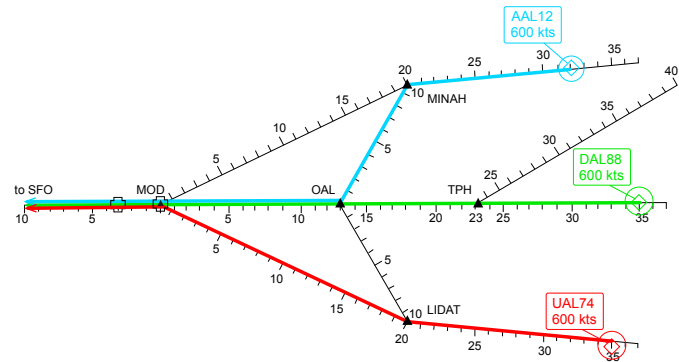
ANALYSIS OF WORKSHEET #2

Problem 3-2

STARTING CONDITIONS

Plane	From	Through	To	Distance	Speed
AAL12	MINAH	OAL	MOD	35	600
DAL88	TPH	OAL	MOD	35	600
UAL74	LIDAT		MOD	35	600

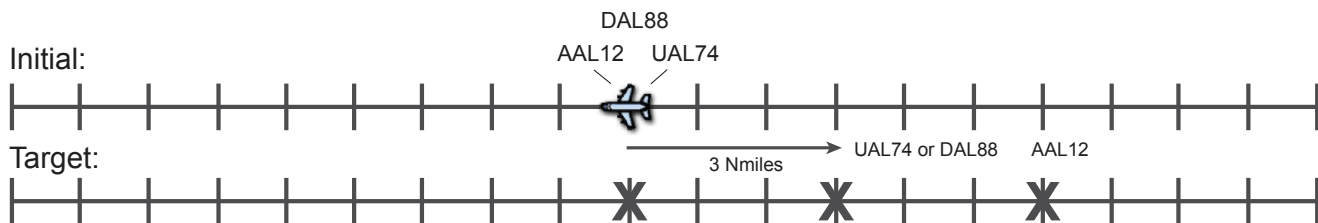
Ideal spacing at **MOD** is 3 nautical miles.
Minimum separation is 2 nautical miles.



FLIGHT ANALYSIS

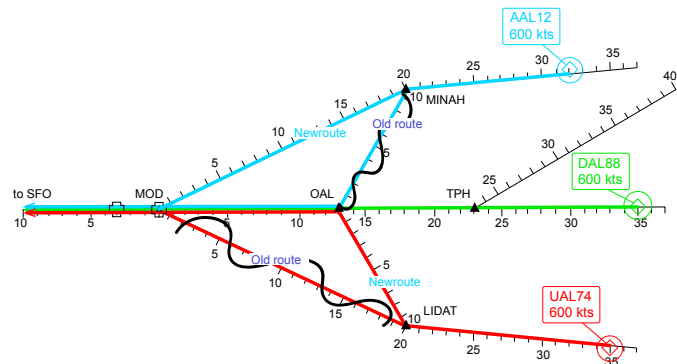
- **All three** planes will arrive at MOD at the same time.
- **Two** planes will need to reroute to avoid a collision and accomplish ideal spacing.

Projected Arrival	Plane	Distance Along Flight Plan	Initial Spacing
1st	AAL12	35	→ 0
1st	DAL88	35	
1st	UAL74	35	→ 0



SOLUTION

- **AAL12:** Reroute direct to MOD through MINAH to shorten travel distance to move ahead 3 nautical miles to achieve ideal spacing
- **UAL74:** Reroute through OAL to lengthen travel distance to fall behind 3 nautical miles to achieve ideal spacing.
- **Target Time:** 3 minutes and 48 seconds.

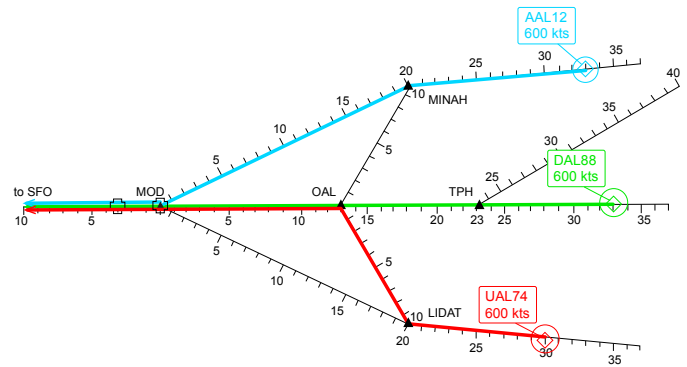


Problem 3-7

STARTING CONDITIONS

Plane	From	Through	To	Distance	Speed
AAL12	MINAH		MOD	33	600
DAL88	TPH	OAL	MOD	33	600
UAL74	LIDAT	OAL	MOD	33	600

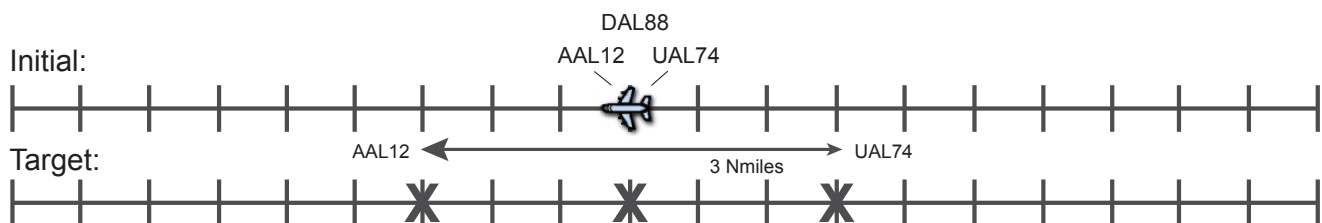
Ideal spacing at **MOD** is 3 nautical miles.
Minimum separation is 2 nautical miles.



FLIGHT ANALYSIS

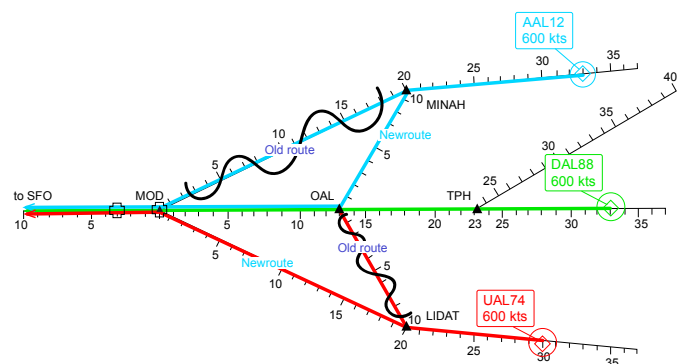
- **All three** planes will arrive at MOD at the same time.
- **Two** planes will need to reroute to avoid a collision and accomplish ideal spacing.

Projected Arrival	Plane	Distance Along Flight Plan	Initial Spacing
1st	AAL12	33	0
1st	DAL88	33	
1st	UAL74	33	0



SOLUTION

- **AAL12:** Reroute through MINAH to OAL to lengthen travel distance to fall back 3 nautical miles to achieve ideal spacing.
- **UAL74:** Reroute direct through LIDAT to MOD to shorten travel to move ahead 3 nautical miles to achieve ideal spacing.
- **Target Time:** 3 minutes and 36 seconds.



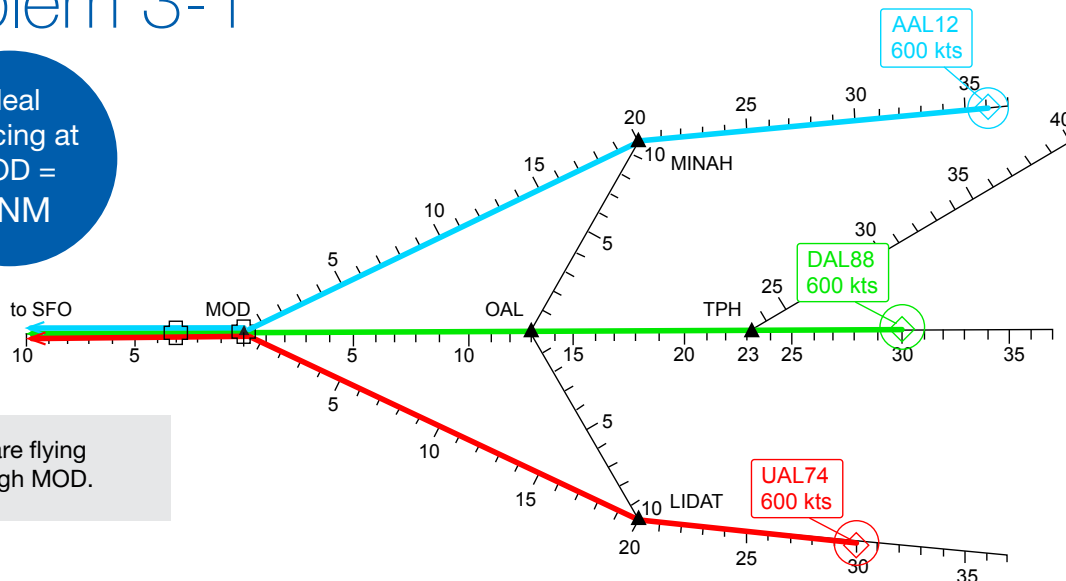
APPENDIX II

Answer Sheets

WORKSHEET #1

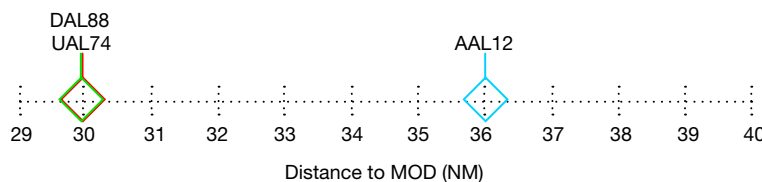
Problem 3-1

Ideal
Spacing at
MOD =
3 NM



All 3 planes are flying
to SFO through MOD.

- Use the diagram above to find each plane's travel distance to MOD. On the number line below, use a $\diamond$ to plot the travel distance to MOD for each plane. Label each plane.



- Fill in the table below using the number line above to analyze arrival order and spacing to MOD. Take note of any spacing less than minimum separation and extra spacing needed to get ideal spacing.

Arrival Order at MOD	1st	2nd	3rd
Plane Call Sign	<u>DAL88</u>	<u>UAL74</u>	<u>AAL12</u>
Projected Spacing at MOD	<u>0</u> NM	<u>6</u> NM	
Ideal Spacing at MOD	☒ No ☐ Yes	☐ No ☒ Yes	
Needed Spacing at MOD	<u>+3</u> NM	<u>-3</u> NM	

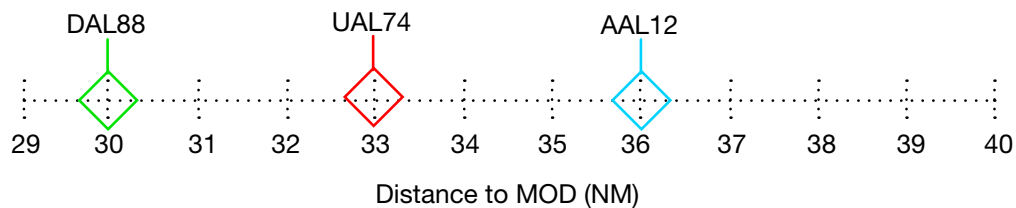
WORKSHEET #1 continued

Problem 3-1

3. What route changes are needed to solve any spacing problems?

Arrival Order	Plane	New Route (if needed)	New Distance to MOD	New Spacing at MOD
1st	<u>DAL88</u>	<u>No Change</u>	<u>30</u> NM	<u>3</u> NM
2nd	<u>UAL74</u>	<u>LIDAT to OAL to MOD</u>	<u>33</u> NM	
3rd	<u>AAL12</u>	<u>No Change</u>	<u>36</u> NM	<u>3</u> NM

4. To picture the **NEW** arrival order and spacing, use a $\diamond$ to plot the new distances to MOD for each plane on the number line below. Label each plane.



• With the new routes, do spacings meet at least minimum separation?

☐ No ☒ Yes

→ If Yes, Congratulations! If no, try again!

5. With the new routes, is spacing equal to ideal spacing?

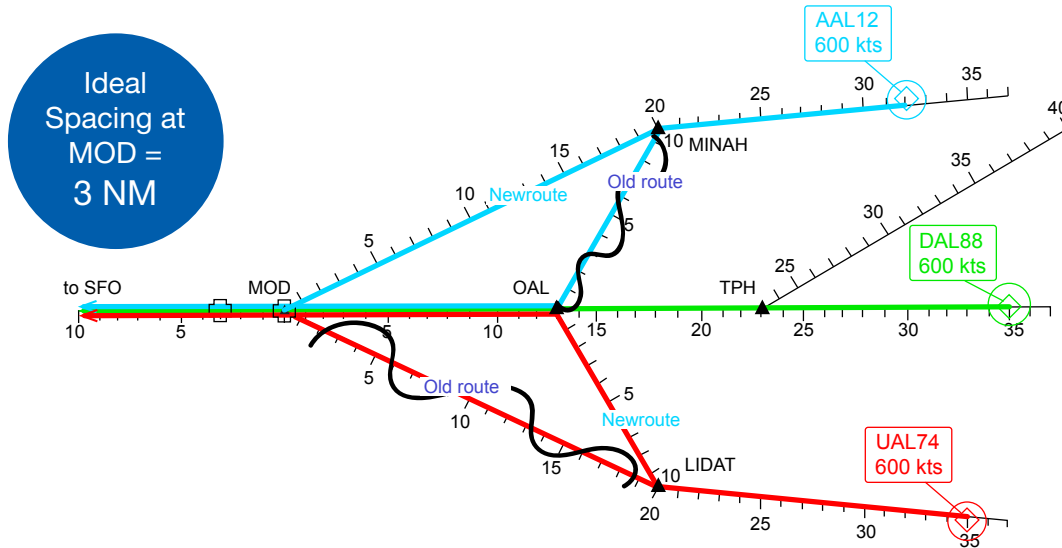
☐ No ☒ Yes

→ If Yes, Congratulations! If no, try again!

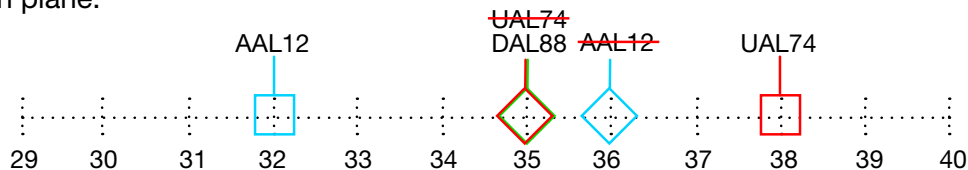
WORKSHEET #2

Problem 3-2

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



- Use the diagram above to find each plane's travel distance to MOD.
On the number line below, use a $\diamond$ to plot the travel distance to MOD for each plane.
Label each plane.



- Are all the spacings at least minimum separation? ☒ No ☐ Yes
 - Which plane needs extra spacing to have ideal spacing? All
 - How much extra spacing is needed? 3 nautical miles
 - On the diagram above, show the changes needed to reroute air traffic to achieve ideal spacing.
- 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.
- Using the number line in Question 1, plot a $\square$ for the **NEW** distances to MOD and label each $\square$ with the plane's call sign. Cross out the call sign at the starting distance.
 - Are all spacings now ideal? ☐ No ☒ Yes
- If Yes, Congratulations! If no, try again!

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