National Aeronautics and Space Administration

Smart Skies™

Distance-Rate-Time Mathematics In Air Traffic Control

Grades 6-7

Standards-Based

Free!

Rebecca Green

NCTM Regional Conference - Richmond, VA

13-Nov-2014

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NASA: With You When You Fly

2

NASA and the NextGen ATS

NASA plays a major role in NextGen research.

3

Agenda

- Introduction to Air Traffic Control
- LineUp With Math Training
  - Sector 33 air traffic control simulator
  - Math strategies
  - Practice with worksheets
- How to access the classroom materials

4

Challenges of Air Traffic Control

During the busiest travel times, about how many commercial planes are flying in the US?

5

World's Largest D-R-T Problem

Smart Skies™

24 Hours Of Flight

A 60-Second Animation

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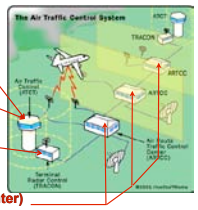
Air Traffic Control 101

Ground Control (tower)
- from gate to runway

Local Control (tower)
- takeoff & landing

Terminal Radar Approach Control (TRACON)
- ascending & descending

En-Route Traffic Control (center)
- high cruising altitude



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Air Traffic Control 101

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Air Traffic Control 101

How do ATCs maintain safety & efficiency?

Analyze the situation.

Detect potential conflicts.

Resolve the problem.

Communicate the solution.

…and they use a little math along the way.

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Two Classroom Activity Sets

FlyBy Math: Gr. 5-8

Pre-algebra to Algebra

- Scenarios involving 2 planes
- Hands-on physical experiment
- Multiple representations (six math methods)
- Graphing simulator

LineUp With Math: Gr. 6-7

Pre-algebra

- Scenarios involving 2 to 5 planes
- Realistic air traffic control simulator
- Proportional reasoning

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www.smartskies.nasa.gov/lineup

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Standards Based & Classroom Tested

- Aligned with both Common Core and State Standards:

- Distance = rate • time
- Proportional reasoning
- Problem solving
- Decision making

- Tested with 4,500 students nationwide

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LineUp with Math

Math-Based Decisions in Air Traffic Control (ATC)


Workbooks


Web-based ATC simulator

- Act as an Air Traffic Controller
- Use a simulator and math
  - to change plane routes and speeds
  - to keep planes safely separated and on time

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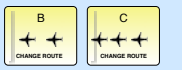
6 Workbook Problem Sets

Introduction to ATC

Speed Changes

Route Changes



4-plane and 5-plane challenge problems are available (without workbooks).

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Welcome to Sector 33

Introductory video for students available on student website: www.atcsim.nasa.gov

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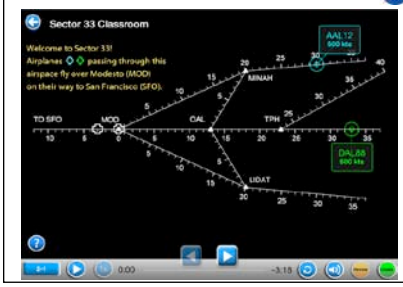
Intro to the Simulator



ATC Simulator Problem 3-8

Line up 3 planes over MOD, 3 Nmi apart.

- Change route
- Change speed
- Match the target time.
- Requires math!

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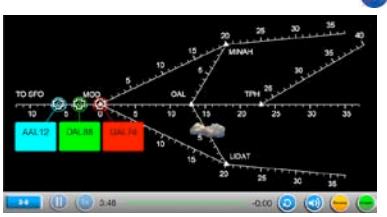
The Goal Over MOD



The planes must be spaced 3 Nmi apart over MOD.
The last plane must arrive in 3 min and 48 sec.

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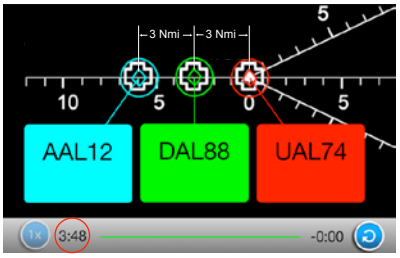
A Closer Look at the Goal



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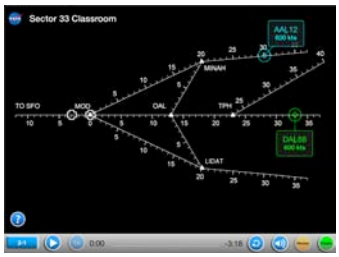
The Sector 33 ATC Simulator



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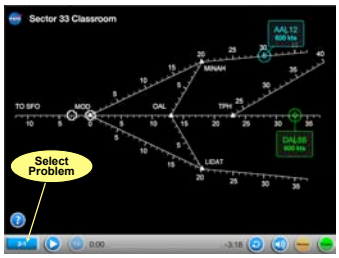
Select Problem 3-8



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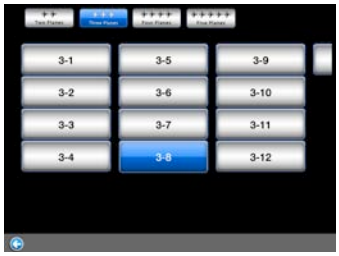
Select Problem 3-8



LineUp With Math™ x

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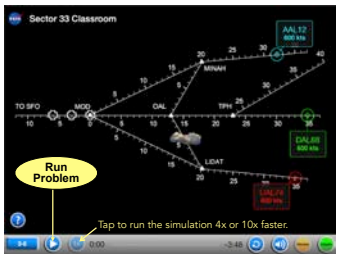
Run Problem 3-8 Without Changes



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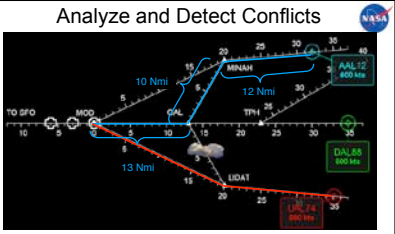
Analyze and Detect Conflicts



	UAL74	DAL88	AAL12
Speed:	600 kts	600 kts	600 kts
Distance to MOD:	35 Nmi	35 Nmi	35 Nmi

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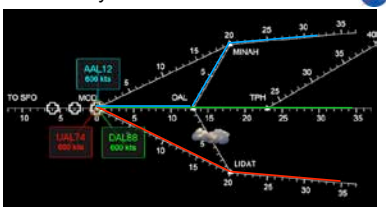
Analyze and Detect Conflicts



All 3 planes: Are the same distance, 35 Nmi, from MOD.
Are flying at the same speed, 600 kts.
Arrive over MOD at the same time!!!

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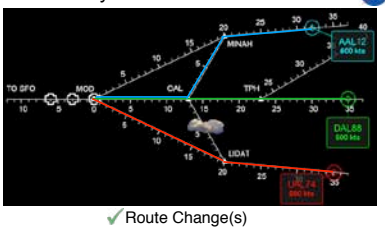
Ways to Resolve Conflicts



✓ Route Change(s)
✓ Speed Change(s)
⊘ Altitude Change(s)

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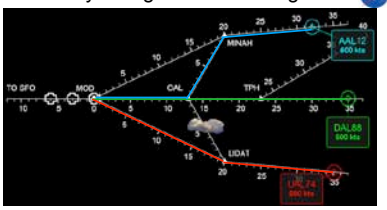
Try Using a Route Change



Can you change the route for:

UAL74?	DAL88?	AAL12?
No	No	Yes

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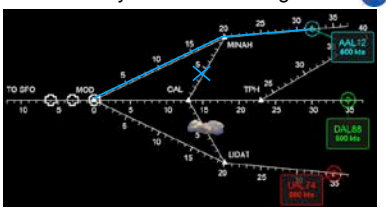
Verify the Route Change



Let's change the route for AAL12.
What's its new flight distance to MOD? 32 Nmi

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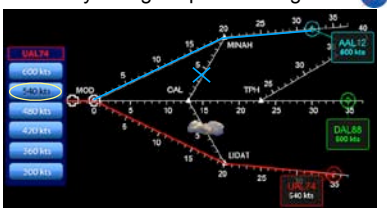
Try Using a Speed Change



Let's reduce the speed of UAL74.
Try 540 knots (smallest reduction).

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Communicate the Strategy

- "AAL12 cleared direct MINAH to MOD."
- "UAL74 reduce speed to 540 knots."

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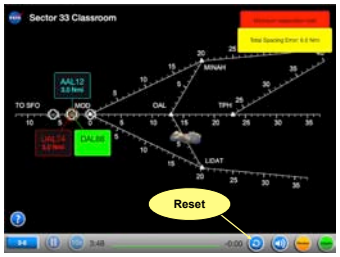
Reset Problem 3-8



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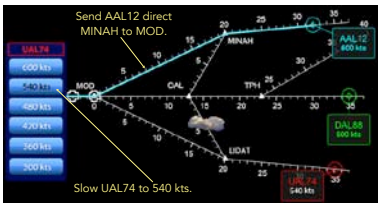
Apply the Route & Speed Changes



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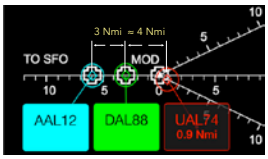
Result of Route & Speed Changes

Note the spacing at the target time:

3 Nmi between AAL12 & DAL88

≈ 4 Nmi between DAL88 & UAL74



How can you keep UAL74 from falling so far behind?

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Review & Fine Tune the Solution

- Investigate the problem in Review mode.
- Pause at 1, 2, and 3 minutes.
- Note the plane spacing each minute.

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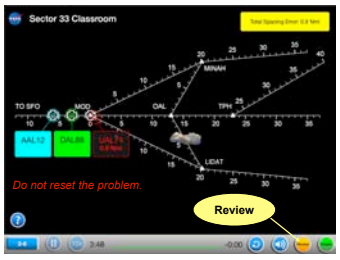
Review the Problem 3-8 Solution



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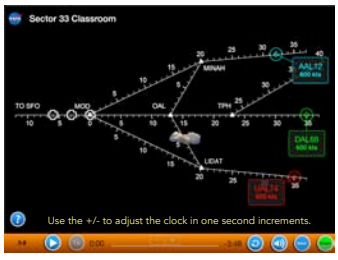
Using Review Mode



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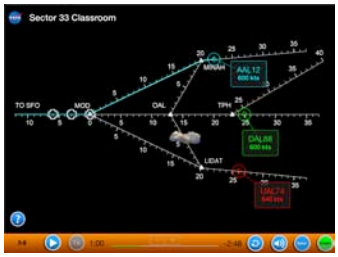
At One Minute



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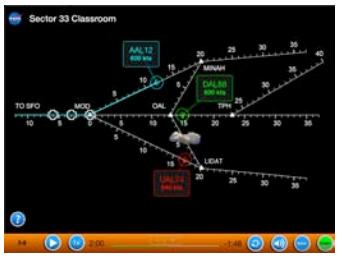
At Two Minutes



LineUp With Math™ x

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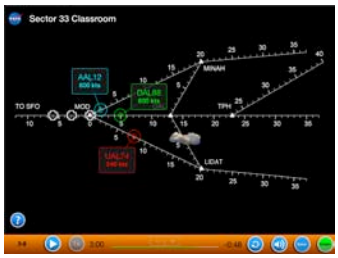
At Three Minutes



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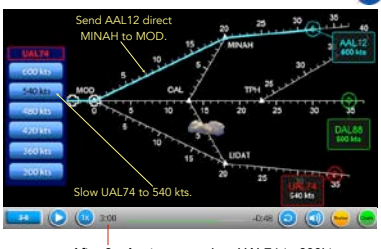
Fine Tune the Solution



After **3 minutes**, speed up UAL74 to 600kts.

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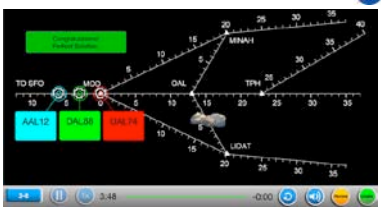
Goal Achieved!



The planes are spaced 3 Nmi apart over MOD.
The last plane arrived in 3 min and 48 sec.

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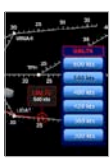
Understanding Speed Change

- We changed a plane's speed to achieve Ideal Spacing and meet the Target Time.
  - How did we know which speed to select?
  - Why is the speed menu in 60-knot increments?
    600 kts, 540 kts, 480 kts …



- To explain, we begin with 2 walkers.

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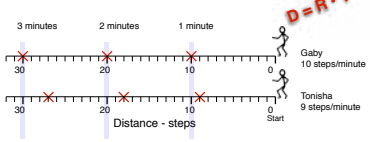
The Math Behind Speed Changes



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Connect Knots & Steps Per Minute

- How do walker speeds (steps per minute) relate to plane speeds (nautical miles per hour)?
- Controllers make decisions in minutes, not hours. So controllers use speed in miles per minute.

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Minute by Minute

A plane's speed is **600** knots:
In 1 hour, it flies 600 Nmiles.
In 60 minutes, it flies 600 Nmiles.
In 1 minute, it flies **10** Nmiles.

1 hr = 60 minutes

A plane's speed is **540** knots:
In 1 hour, it flies 540 Nmiles.
In 60 minutes, it flies 540 Nmiles.
In 1 minute, it flies **9** Nmiles.

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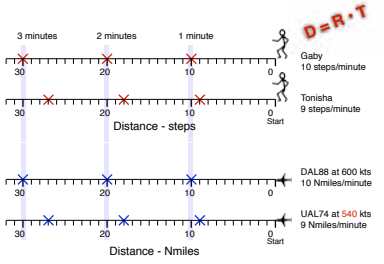
Plane Spacing Each Minute



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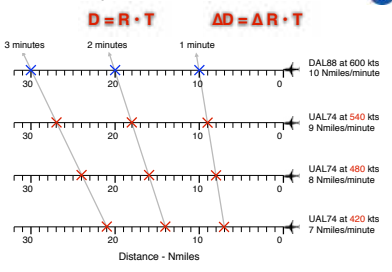
Reduce Speed in 60-Knot Increments



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Solution Strategy

Determine:

1. The order of plane arrival and spacing at MOD
2. How much each plane must fall back
3. If you can use a route change
4. The degree of speed change and duration

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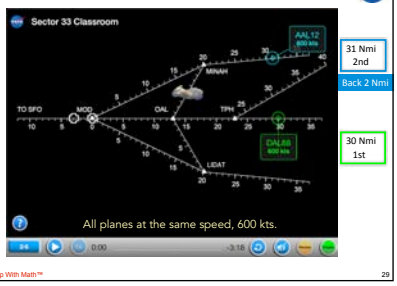
Analyze Problem 2-6



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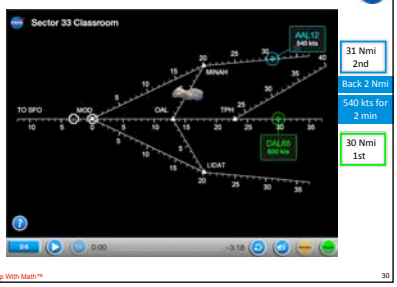
Solve Problem 2-6



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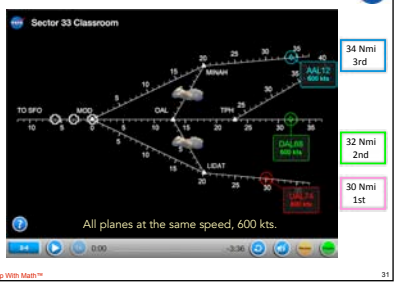
Analyze Problem 3-4



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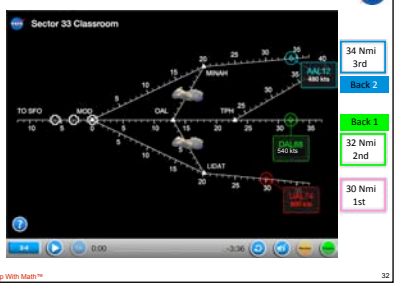
Solve Problem 3-4



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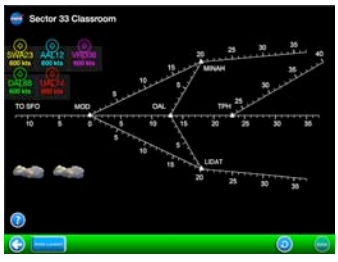
Create Your Own ATC Problems



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Classroom Implementation

Explore with the Simulator.

Do the math in a Workbook.

Meet the time challenge.

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LineUp With Math™ Materials

Free Online!

Educator Materials
Quick Start Guide
Educator Guide
Teacher Guide for each problem set with solutions
Answers and solutions to all simulator problems

Student Materials
Workbook for each problem set
Air Traffic Control simulator
Movies: 24-Hours of Flights, Welcome to Sector 33, and I'm an Air Traffic Controller

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Smart Skies home page

For Teachers

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www.smartskies.nasa.gov/lineup

LineUp With Math home page

For teachers

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Materials for Teacher Workshops
www.smartskies.nasa.gov/trainer

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LineUp With Math Video Workshop
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Expert Instruction

Watch anytime from anywhere!

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Simulator home page

For students & teachers

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Interagency Partnership

- Partnership in education with the FAA
  - Classroom visits from air traffic controllers
  - Student visits to air traffic control facilities

www.faa.gov/education

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Sector 33 Mobile Game

www.nasa.gov/sector33

A real-world extension to *LineUp With Math:*

- No pause button
- No review mode
- Student performance is scored
- Designed to further challenge students in a more realistic setting

for Apple & Android mobile devices

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Recent Recognition

The National Coalition for Aviation and Space Education (NCASE) awarded Smart Skies the:

2013 Dr. Mervin K. Strickler Award for Aerospace Education Leadership

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Contact Us

- By email: smartskies@mail.nasa.gov
- On the web: www.smartskies.nasa.gov

Send an email to smartskies@mail.nasa.gov if you would like:

- *To be added to the Smart Skies email list*
- *To receive professional development for your dept/ district via distance learning*

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Please complete the presentation feedback form.

Thank you from

Smart Skies

What's on *your* radar screen?

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