ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL TWO

INSTRUCTIONAL GUIDE

SECTION 7

EO C240.04 – NAVIGATE WITH A GLOBAL POSITIONING SYSTEM (GPS)

Total Time: 90 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-802/PG-001, Chapter 4. Specific uses for said resources are identified throughout the Instructional Guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Prepare a 200 m route for the cadets to navigate.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for TP1 to introduce a new subject and give an overview of GPS navigation.

Demonstration and performance was chosen for TP2 as it allows the instructor to explain and demonstrate navigating with a GPS while providing an opportunity for the cadet to practice the skill under supervision.

A practical activity was chosen for TPs 3 and 4 as it is an interactive way to introduce cadets to navigating with a GPS. This activity contributes to the development of these skills and knowledge in a fun and challenging setting.

INTRODUCTION

REVIEW

N/A.

OBJECTIVES

By the end of this lesson and in a group of no more than five, the cadet shall be expected to navigate with a GPS on a field exercise.

IMPORTANCE

It is important for cadets to navigate with a GPS and to learn its uses and limitations for future navigation on a field exercise. GPS navigation is a valuable tool and will serve as an excellent resource for navigating to a specific location.

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Teaching point 1 **Describe the GPS**

Time: 5 min Method: Interactive Lecture

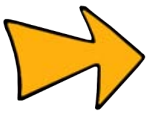
WHAT IS GPS

Global Positioning System (GPS) is a satellite system used to navigate. It enables anyone on the planet who owns a GPS receiver to know where they are 24 hours a day in any kind of weather.

A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude).

HOW ACCURATE IS GPS

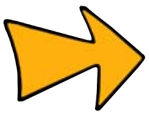
Today's GPS receivers are extremely accurate, thanks to their parallel multi-channel design. Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. GPS receivers are accurate to within 15 m on average.



In 1998, the Wide Area Augmentation System (WAAS) was added to provide increased accuracy for use by commercial airplane navigation systems. WAAS increases accuracy to better than 3 m.

GPS SATELLITE SYSTEM

GPS satellites are powered by solar energy. They have backup batteries onboard to keep them running in the event of a solar eclipse, when there is no solar power. Small rocket boosters on each satellite keep them flying in the correct path.



Here are some other interesting facts about the GPS satellites (also called NAVSTAR, the official U.S. Department of Defense name for GPS):

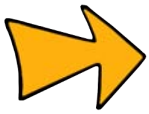
- The first GPS satellite was launched in 1978.
- GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use.
- A full constellation of 24 satellites was achieved in 1994.
- The 24 satellites that make up the GPS space segment are orbiting the Earth about 20 000 km above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are travelling at speeds of roughly 12 000 km/h.
- Each satellite is built to last about 10 years. Replacements are constantly being built and launched into orbit.
- A GPS satellite weighs approximately 900 Kg and is about 5 m across with the solar panels extended.
- Transmitter power is only 50 watts or less.
- There are no subscription fees or set-up charges to use GPS.

SOURCES OF GPS SIGNAL ERRORS

Factors that can degrade the GPS signal and thus affect accuracy include the following:

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- **Signal Multi-path.** This occurs when the GPS signal is reflected off objects such as tall buildings or large rock surfaces before it reaches the receiver. This increases the travel time of the signal, thereby causing errors.
- **Number of Satellites Visible.** The more satellites a GPS receiver can "see," the better the accuracy. Buildings, terrain, electronic interference, or sometimes even dense foliage can block signal reception, causing position errors or possibly no position reading at all. GPS units typically will not work indoors, underwater or underground.
- **Receiver Clock Errors.** A receiver's built-in clock is not as accurate as the atomic clocks onboard the GPS satellites. Therefore, it may have very slight timing errors.



Other factors that can degrade the GPS signal.

- **Ionosphere and Troposphere Delays.** The satellite signal slows as it passes through the atmosphere. The GPS system uses a built-in model that calculates an average amount of delay to partially correct for this type of error.
- **Orbital Errors.** Also known as ephemeris errors, these are inaccuracies of the satellite's reported location.
- **Satellite Geometry/Shading.** This refers to the relative position of the satellites at any given time. Ideal satellite geometry exits when the satellites are located at wide angles relative to each other. Poor geometry results when the satellites are located in a line or in a tight grouping.
- **Intentional Degradation of the Satellite Signal.** Selective Availability (SA) is an intentional degradation of the signal once imposed by the U.S. Department of Defense. SA was intended to prevent military adversaries from using the highly accurate GPS signals. The government turned off SA in May 2000, which significantly improved the accuracy of civilian GPS receivers.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. What is a GPS?

Q2. How accurate is a GPS?

Q3. How are GPS satellites powered?

ANTICIPATED ANSWERS

A1. A Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense.

A2. GPS receivers are accurate to within 15 m on average.

A3. GPS satellites are powered by solar energy and have backup batteries on board to keep them running in the event of a solar eclipse.

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Teaching point 2 **Explain What a GPS Tells the User**

Time: 10 min Method: Demonstration and Performance

WHAT A GPS TELLS THE USER

A GPS tells the user the following standard features:

- their position – coordinates and elevation;
- distance to a waypoint;
- speed of travel;
- direction of travel (may not work in low speeds);
- estimated time of arrival; and
- cross track error (lateral distance off a straight line course).

Some GPS models may have extra features, such as:

- built-in maps,
- sunrise/sunset,
- signal strength indicators,
- battery strength indicators,
- audible alarm, and
- course deviation errors.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS

Q1. What does a GPS tell the user?

Q2. Does a GPS tell the user the direction of travel at slow speeds?

Q3. What extra features can be found on some GPS models?

ANTICIPATED ANSWERS

A1. Any of the following answers are correct.

- their position – coordinates and elevation;
- distance to a waypoint;
- speed of travel;
- direction of travel (may not work in low speeds);
- estimated time of arrival; and
- cross track error (lateral distance off a straight line course).

A2. Yes and no.

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- Sometimes the direction of travel feature may not work in low speeds on a GPS.

A3. Any of the following answers are correct.

- built-in maps,
- sunrise/sunset,
- signal strength indicators,
- battery strength indicators,
- audible alarm, and
- course deviation errors.

Teaching point 3 **Operate the GPS**

Time: 20 min Method: Practical Activity

ACTIVITY

OBJECTIVE

The objective of this activity is for the cadets to become familiar with operating a GPS.

RESOURCES

GPS (one per five cadets) (Type TBD).

ACTIVITY LAYOUT

N/A.

ACTIVITY INSTRUCTIONS

Complete the following steps:

1. Divide the cadets into groups of no more than five.
2. Distribute one hand-held GPS to each group.
3. Turn on and initialize the GPS.
4. Review the various screens.
5. Identify battery strength.
6. Locate your current grid reference.
7. Identify your direction of travel.
8. Set your current waypoint.
9. Set a waypoint (not your current position).
10. Set the go-to to a preset waypoint.
11. Turn off the GPS.

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SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 3

The cadets' participation in the practical activity will serve as the confirmation of this TP.

Teaching point 4 **Navigate a Route**

Time: 50 min Method: Practical Activity

ACTIVITY

OBJECTIVE

The objective of this activity is for the cadets to become familiar with navigating with a GPS.

RESOURCES

GPS (one per five cadets) (Type TBD).

ACTIVITY LAYOUT

N/A.

ACTIVITY INSTRUCTIONS

1. In the same groups as TP3, have cadets turn on the GPS.
2. Using the bearing to the preset waypoint from TP3, have the cadets navigate the 200 m route (caution, waypoints too close together will not work; you will need approximately 200 m between waypoints).
3. Have the cadets identify when they have arrived at the preset waypoint.
4. Have the cadets turn off the GPS.
5. Have the cadets return the GPS to the instructor.

SAFETY

State the area boundaries for conducting this activity.

CONFIRMATION OF TEACHING POINT 4

The cadets' participation in the practical activity will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

The cadets' participation in the GPS navigation activity will serve as the confirmation of this lesson.

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CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

N/A.

CLOSING STATEMENT

A GPS is a valuable tool and serves as an excellent resource to find a specific place and navigate a route to that position.

INSTRUCTOR NOTES/REMARKS

This lesson will be presented during the field exercise associated with PO 290 (Participate in a Field Exercise).

REFERENCES

C3-117 (ISBN 0-96-522025-7) Ferguson, M. H. (1996). *GPS Land Navigation: A Complete Guide Book for Backcountry Users of the NAVSTAR Satellite System.* Calgary, AB: Glassford Publishing.

C3-132 (ISBN 1-894765-48-6) Letham, L. (2003). *GPS Made Easy.* Surrey, BC: Rocky Mountain Books.

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