## Handout 9:  The Gulf of Sidra Incident



Figure 1:  Libyan President
Colonel Muammar Abu
Minyar al-QADHAFI, better
known to the west as Gadaffi.

In 1981 Colonel Gadaffi (the President of Libya - see Figure 1[1]) claimed the entire Gulf of Sidra as Libyan territorial waters (see Figure 2[2]).



Figure 2:  Location of the Northern African nation of Libya and the Gulf of Sidra.

This action was not in accord with international laws, and President Reagan (see Figure 3[3]) challenged this position by conducting naval exercises in the Gulf[4].

The admiral commanding these naval forces ordered F-14's (see Figure 4[5]) to patrol at a distance of ten miles from the Libyan coast.  Any unidentified aircraft crossing the Libyan coast at a speed of greater than 500 miles per hour was to be treated as hostile.

Figure 5 (see next page) shows one of the situations that developed during this crisis.  An F-14 was circling (essentially remaining near the same spot) at an altitude of approximately 5.7 miles.  When the F-14 was 10 miles (diagonal distance) from the coast, its AWG-9 air search radar detected an object moving rapidly across the Libyan coastline.



Figure 3:  Former US President
Ronald Reagan.

[1] Image source:  http://www.goal.com/es/esp/
[2] Image sources:  CIA World Factbook, 2002.  and  http://www.africaguide.com/
[3] Image source:  http://reagan.webteamone.com/reagan_images.cfm
[4] Throughout these exercises, Libyan and US forces antagonized each other by approaching with every indication that they were preparing to attack. The most serious incident occurred on August 19, 1981, when a pair of Libyan Su-22 "Fitter" aircraft approached a pair of US Navy F-14's and fired an air-to-air missile.  Both F-14's easily evaded the missile and returned fire destroying both Libyan aircraft.
[5] Image source:  US Navy, http://www.navy.mil/

Figure 4: The F-14 Tomcat Fleet Defense Interceptor

The AWG-9 measures the rate at which the distance between the F-14 and the target changes. In this situation, the AWG-9 measured the rate of change of this distance to be 420 miles per hour.



F-14 Tomcat

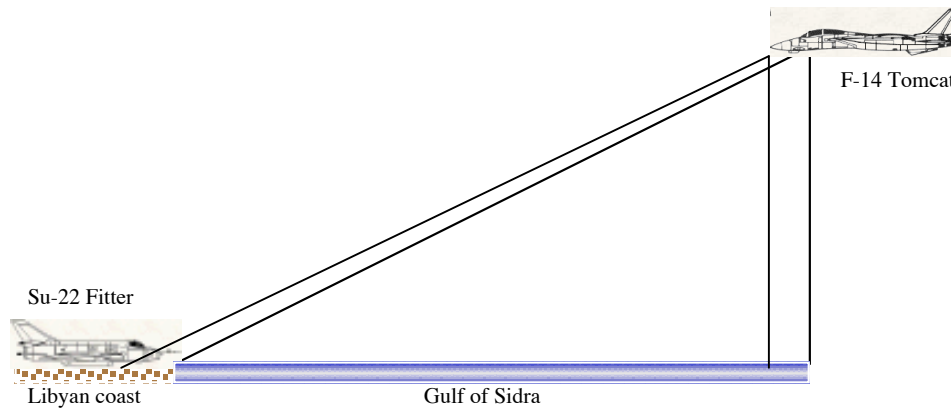Su-22 Fitter

Libyan coast        Gulf of Sidra

Figure 5: The situation at the start of the engagement.



Figure 6: A pair of Libyan Su-22 "Fitter" aircraft flying over a coastal region near the Gulf of Sidra.

In 1981, the Libyan airforce included a number of high performance Soviet made aircraft such as the Su-22 "Fitter" (see Figure 6[6]). The top speed[7] of the Su-22 was approximately 1380 miles per hour.

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[6] Image source: http://www.tbe.aims.on.ca/keele/emir/su-22.htm
[7] Source: http://www.aerospaceweb.org/

In this handout, you will analyze the mathematics that the computer on the F-14 performed to covert the information from the AWG-9 radar into information about the speed of the object that the F-14 detected. When you have finished doing this, you will be able to decide whether the radar contact should be classified as "hostile" or not.

Let $t$ represent the number of seconds that have elapsed since the F-14 first detected the target. Let $L(t)$ represent the diagonal distance (the length of the hypotenuse of the triangle in Figure 5) between the F-14 and the object. Let $R(t)$ represent the horizontal distance between the F-14 and the object (i.e. the length of the base of the triangle in Figure 5).

1.    Using the quantities defined above to express your answer, what rate of change does the AWG-9 radar measure?

2.    Using the quantities defined above to express your answer, what is the air speed of the object that the F-14 detected?

3.    Using Figure 5, find a relationship between the functions $R(t)$ and $L(t)$. Use this relationship to find a relationship between the derivatives $R'(t)$ and $L'(t)$.

**4.** This incident occurred when the diagonal distance between the F-14 and the Libyan cost was 10 miles. What was the horizontal distance between the F-14 and the object at the moment when the object crossed the Libyan coastline?

**5.** Use your answers to Questions 1-4, along with any other relevant information from the introduction, to calculate the air speed of the object as it crossed the Libyan coastline. In the actual incident, the F-14 crew classified the contact as hostile. Was their decision justified?