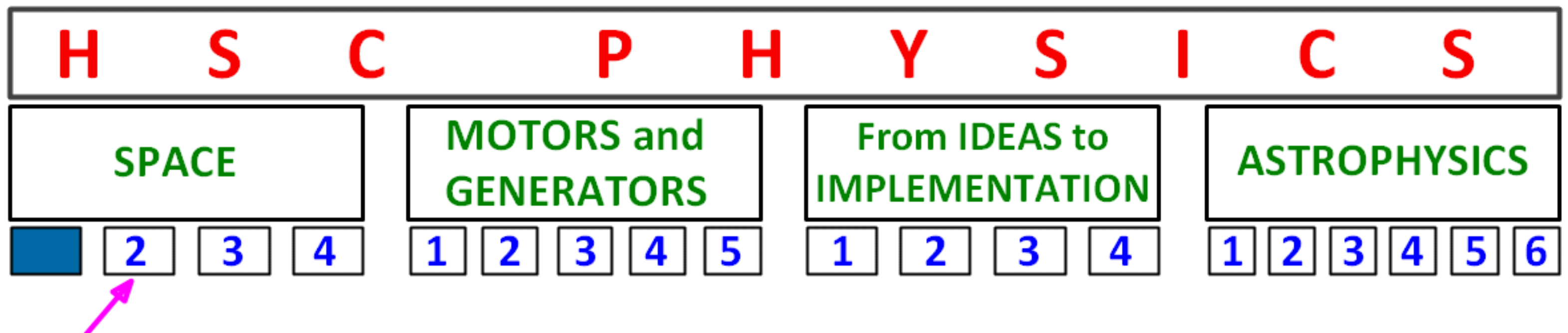


# SPACE

1<sup>st</sup> Quarter; Module 1

## PERIOD 10

"g" forces &  
Effects of Earth Motion on Rocket Launch



## SPACE 2

Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth

*Students learn to:*

- describe the trajectory of an object undergoing projectile motion within the Earth's gravitational field in terms of horizontal and vertical components
- describe Galileo's analysis of projectile motion
- explain the concept of escape velocity in terms of the:
  - gravitational constant
  - mass and radius of the planet
- outline Newton's concept of escape velocity
- identify why the term 'g forces' is used to explain the forces acting on an astronaut during launch
- discuss the effect of the Earth's orbital motion and its rotational motion on the launch of a rocket
- analyse the changing acceleration of a rocket during launch in terms of the:
  - Law of Conservation of Momentum
  - forces experienced by astronauts
- analyse the forces involved in uniform circular motion for a range of objects, including satellites orbiting the Earth
- compare qualitatively low Earth and geo-stationary orbits
- define the term orbital velocity and the quantitative and qualitative relationship between orbital velocity, the gravitational constant, mass of the central body, mass of the satellite and the radius of the orbit using Kepler's Law of Periods
- account for the orbital decay of satellites in low Earth orbit
- discuss issues associated with safe re-entry into the Earth's atmosphere and landing on the Earth's surface
- identify that there is an optimum angle for safe re-entry for a manned spacecraft into the Earth's atmosphere and the consequences of failing to achieve this angle



## SPACE 2

Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth

*Students:*

- solve problems and analyse information to calculate the actual velocity of a projectile from its horizontal and vertical components using:

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2} a_y t^2$$

- perform a first-hand investigation, gather information and analyse data to calculate initial and final velocity, maximum height reached, range and time of flight of a projectile for a range of situations by using simulations, data loggers and computer analysis
- identify data sources, gather, analyse and present information on the contribution of one of the following to the development of space exploration: Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun
- solve problems and analyse information to calculate the centripetal force acting on a satellite undergoing uniform circular motion about the Earth using

$$F = \frac{mv^2}{r}$$

- solve problems and analyse information using:

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

"g force"

for only rockets  
going up (launch)

The term 'g force' is used to express a person's apparent weight as a multiple of his/her normal true weight (that is, weight when standing on the surface of the Earth).

$$g-f = \frac{\text{Reaction Force}}{\text{true weight}} = \frac{R}{W} = \frac{g+a}{g}$$

most of the time (for you)  $g-f = 1$

"unitless number"

because  $R=W$

WHY DO WE USE THE TERM "g force"?

is to compare the conditions the astronauts  
with different weights experience

$$W_1 = 700N$$
$$R_1 = 1400N$$

$$W_2 = 1200N$$
$$R_2 = 2400N$$

$$g-f = 2$$



## WHAT DOES "g" FORCE OF 1 MEAN?

it means that  $R = W$

$g-f > 1$  when  $R > W$  "you feel heavier"

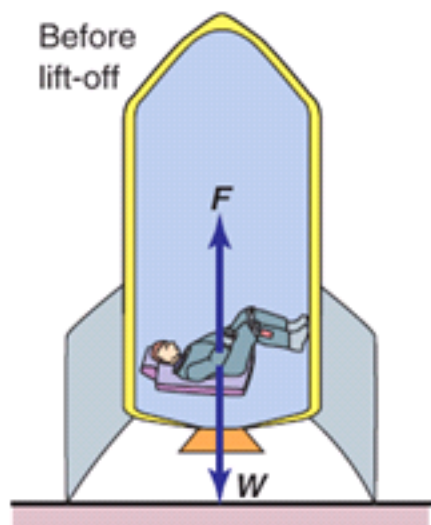
- level 1 and going up.
- at the bottom of the track in roller coaster.
- at the lowest point in a swing.

$g-f < 1$  when  $R < W$  "you feel lighter"

- level 10 and going down
- highest pt in a swing
- going over a speed hump.

$g-f = 0$  when  $R = 0$   $\frac{0}{W} = 0$

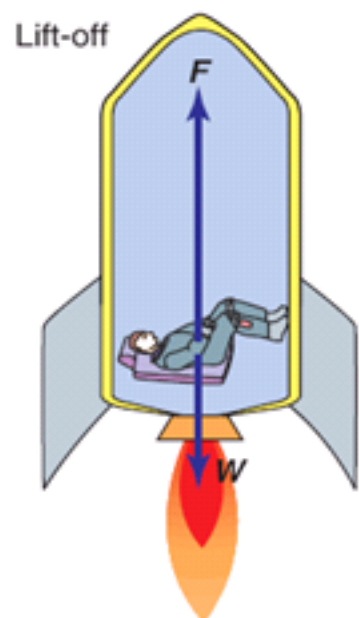
- free fall



$$F = W$$

$$\therefore g \text{ force} = 1$$

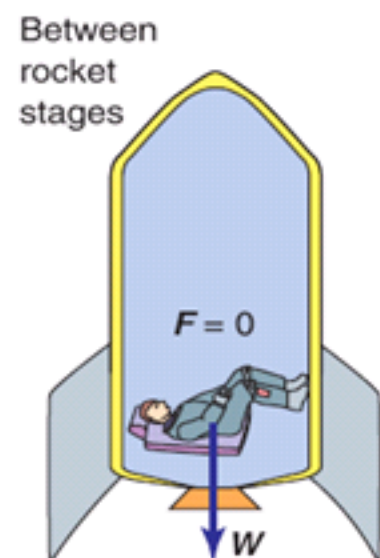
$$g - f = 1$$



$$F > W$$

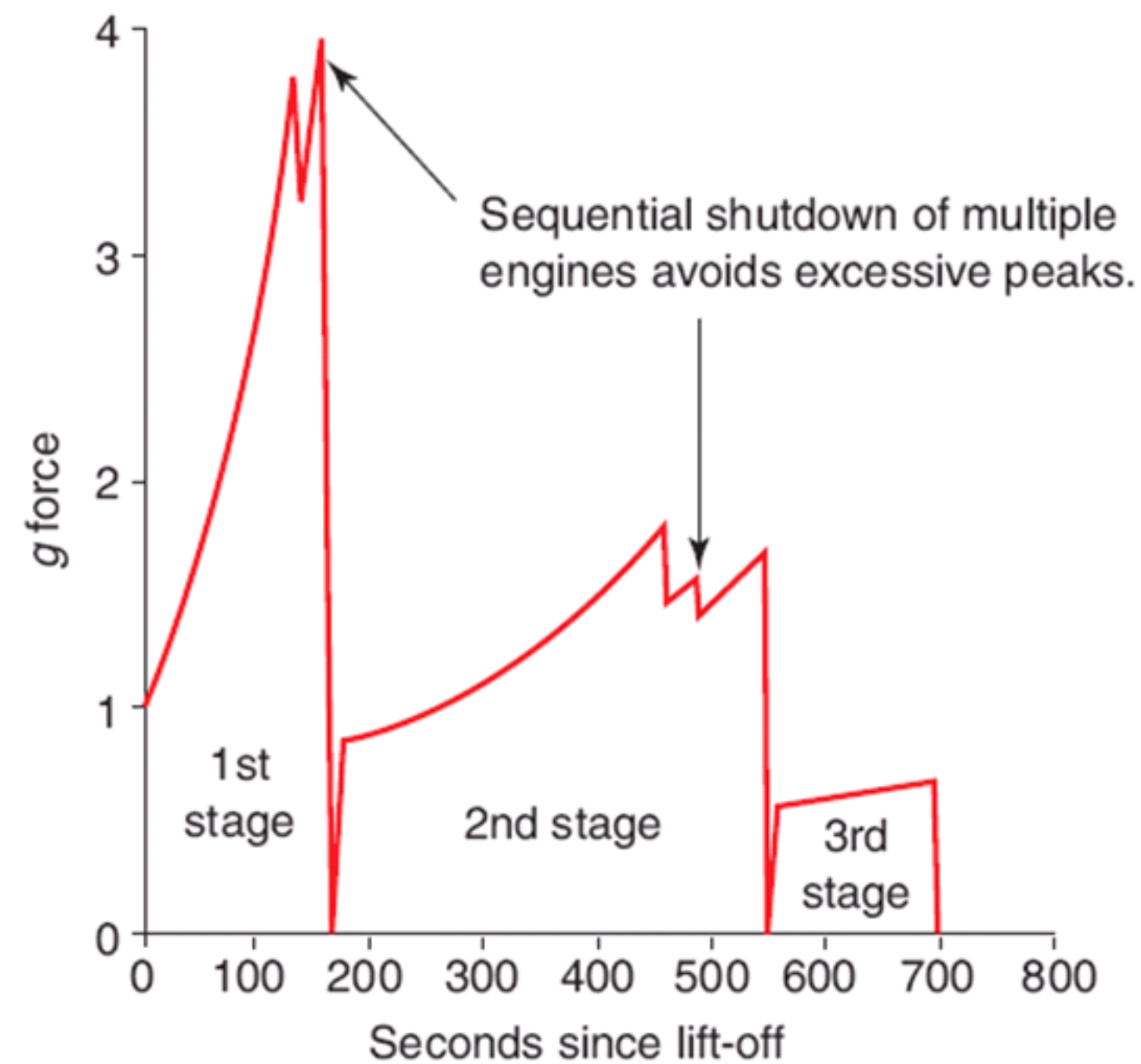
$$\therefore g \text{ force} > 1$$

$$g - f > 1$$



$$F = 0$$

$$\therefore g \text{ force} = 0$$



**Figure 2.22** Variations in g forces during an Apollo-Saturn V launch



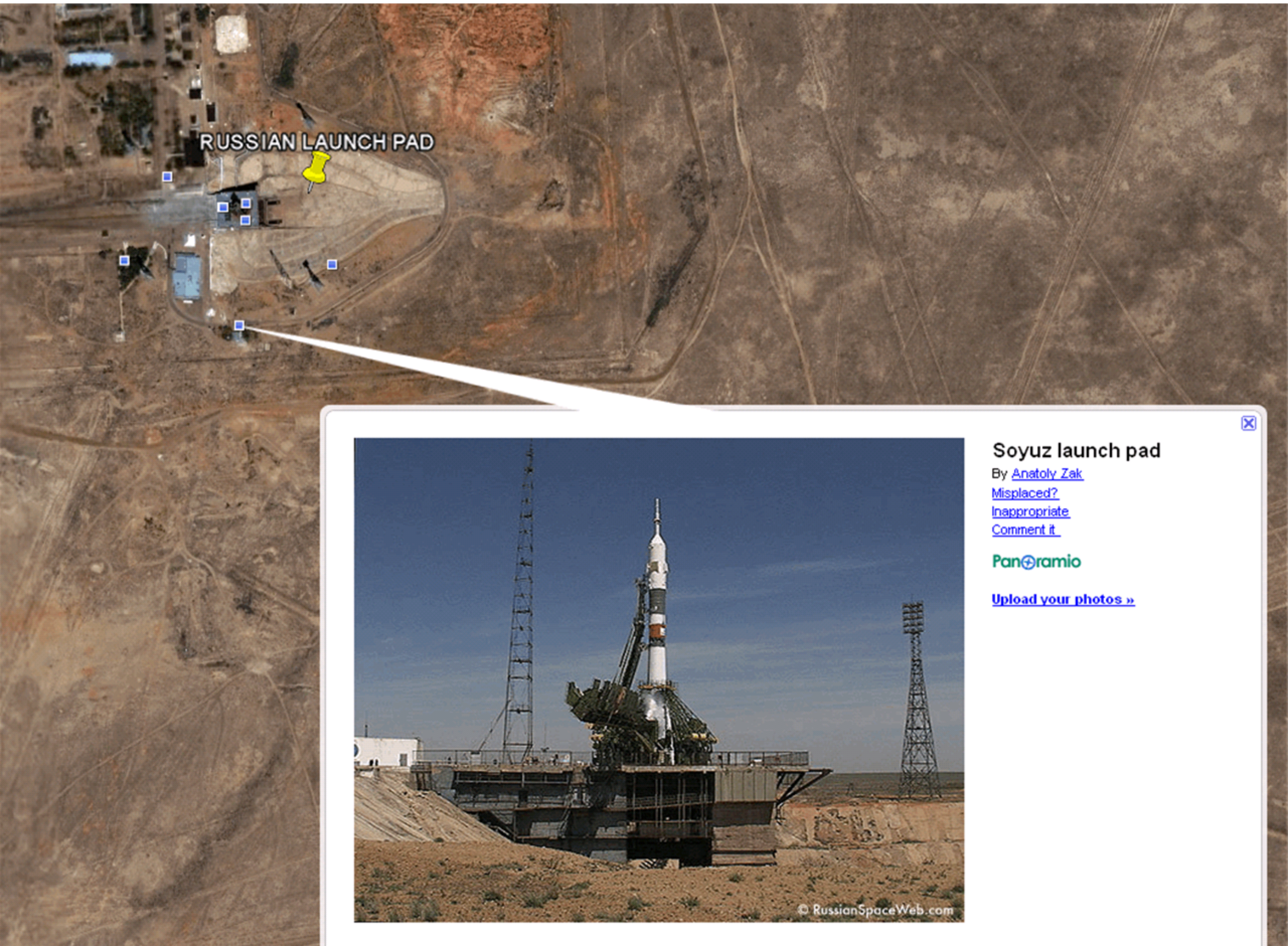
***Calculating the  $g$  force on a model rocket***

The model rocket has a pre-launch mass of 94.2 g, of which 6.24 g is solid propellant. It is able to deliver a thrust of 4.15 N for a period of 1.2 s. Assuming that the rocket is fired directly up, determine:

- (a) the initial rate of acceleration and  $g$  force
- (b) the final rate of acceleration and  $g$  force just prior to exhaustion of the fuel.



# RUSSIAN LAUNCH PAD



## Soyuz launch pad

By [Anatoly Zak](#)

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[Inappropriate](#)

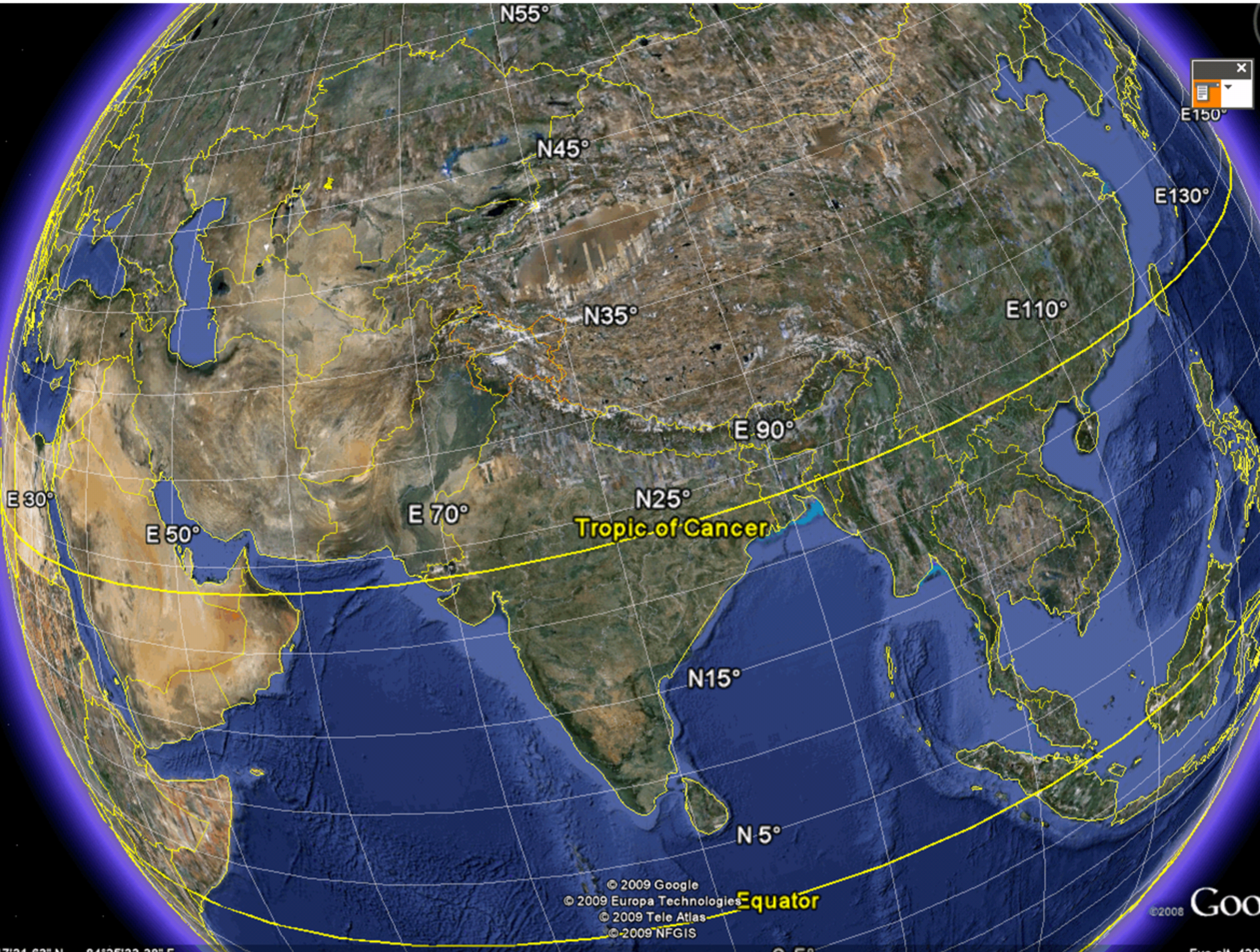
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RUSSIAN LAUNCH PAD



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# CHINEESE LAUNCH PAD

Jiuquan Satellite Launch Center  
腾飞中国



腾飞中国

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[Inappropriate](#)

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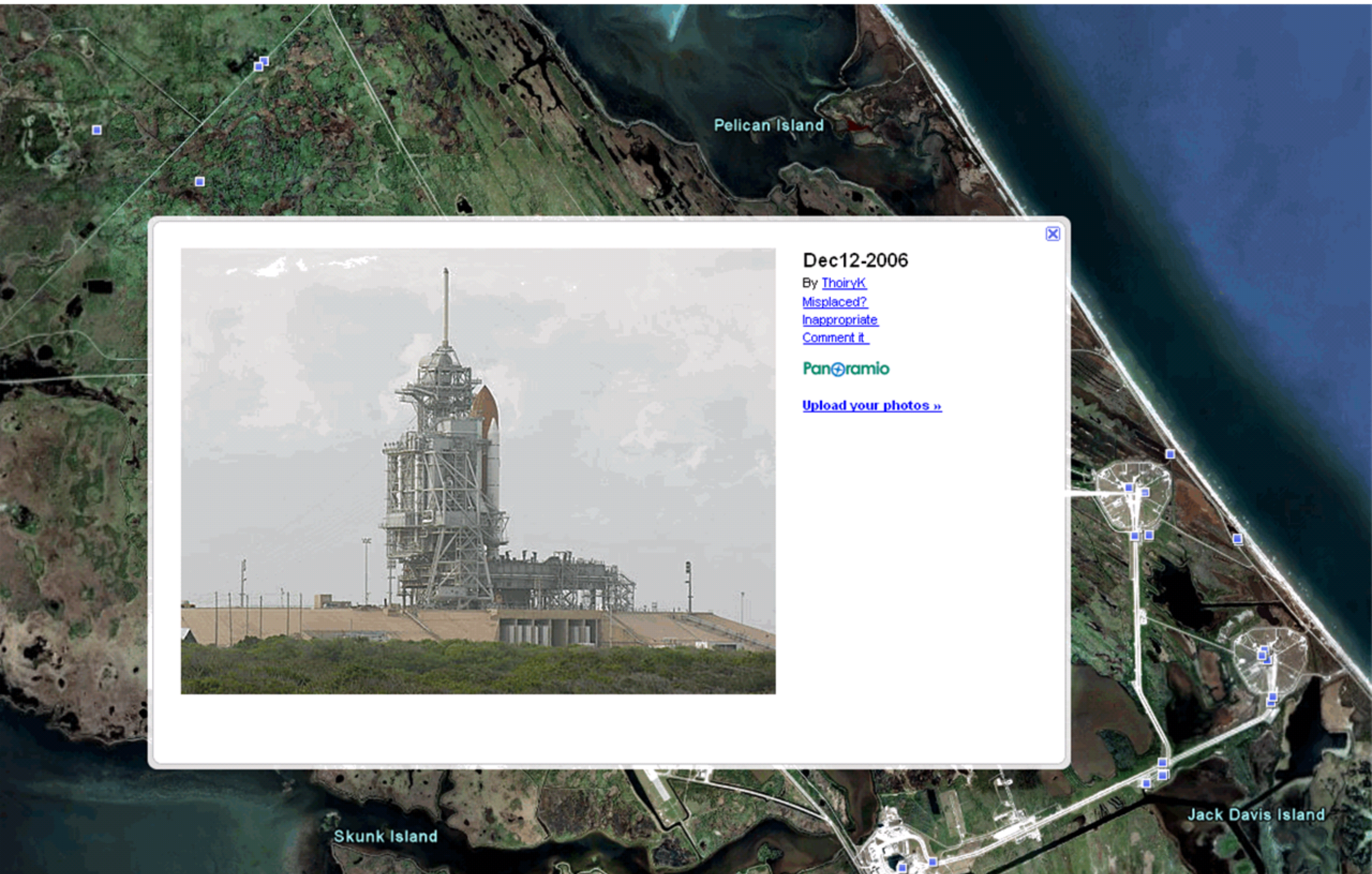


# CHINEESE LAUNCH PAD





# USA LAUNCH PAD



Pelican Island

Dec12-2006

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Skunk Island

Jack Davis Island

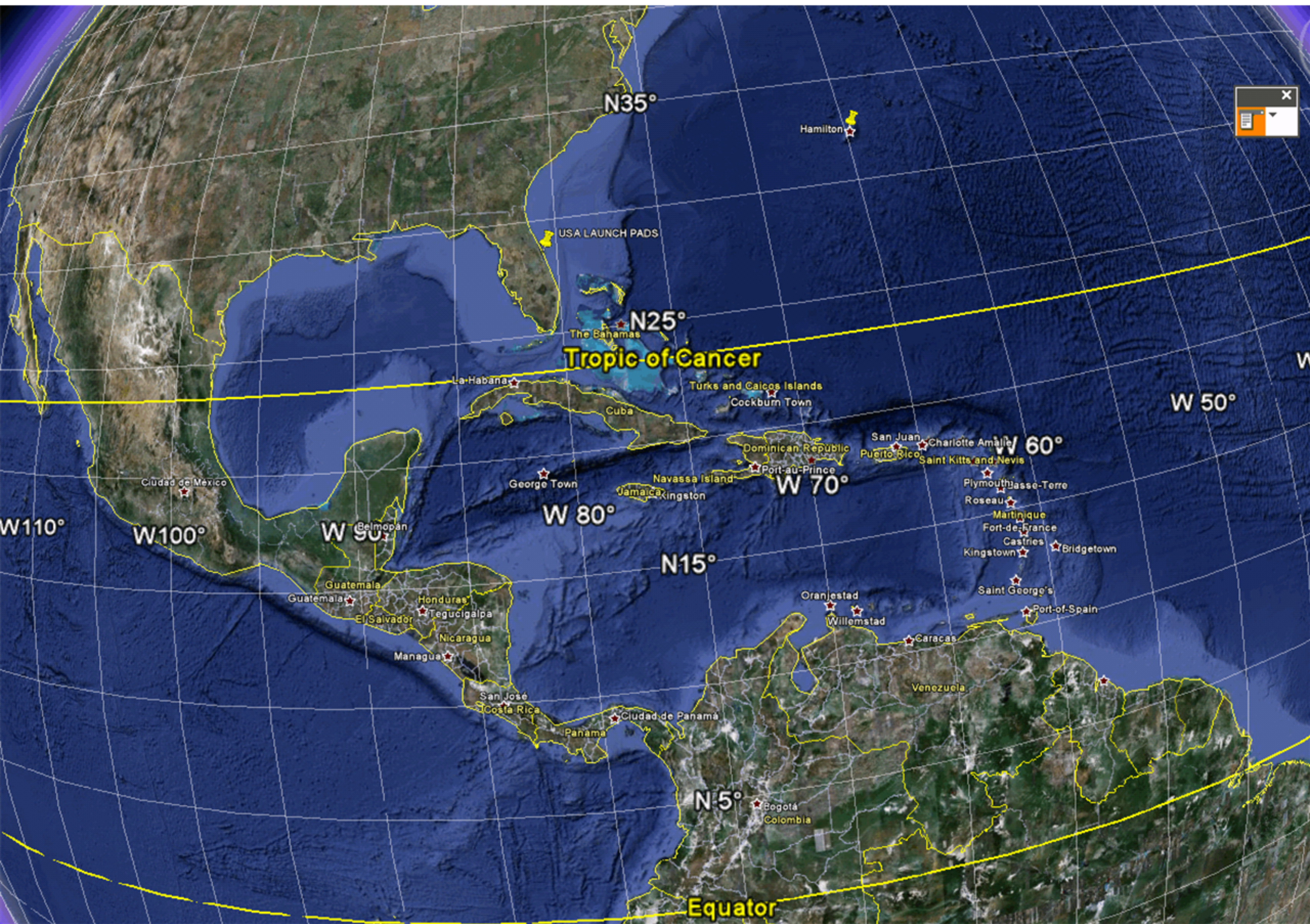


# USA LAUNCH PAD





# USA LAUNCH PAD





# INDIAN LAUNCH PAD

Satish Dhawan Space Center Launch Pad 2

Satellite Launch pad



斯里哈里柯塔岛发射站  
二号工位

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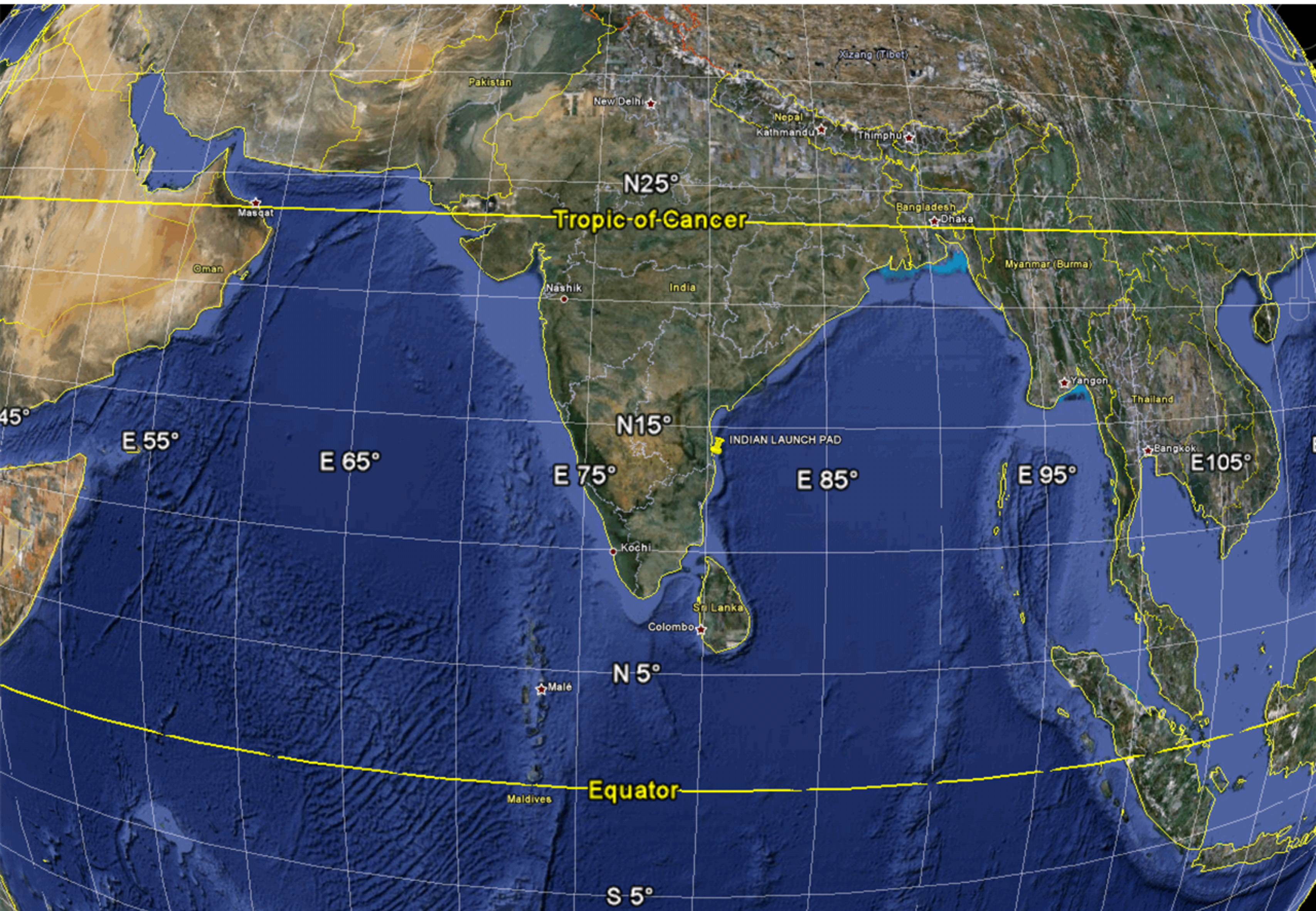
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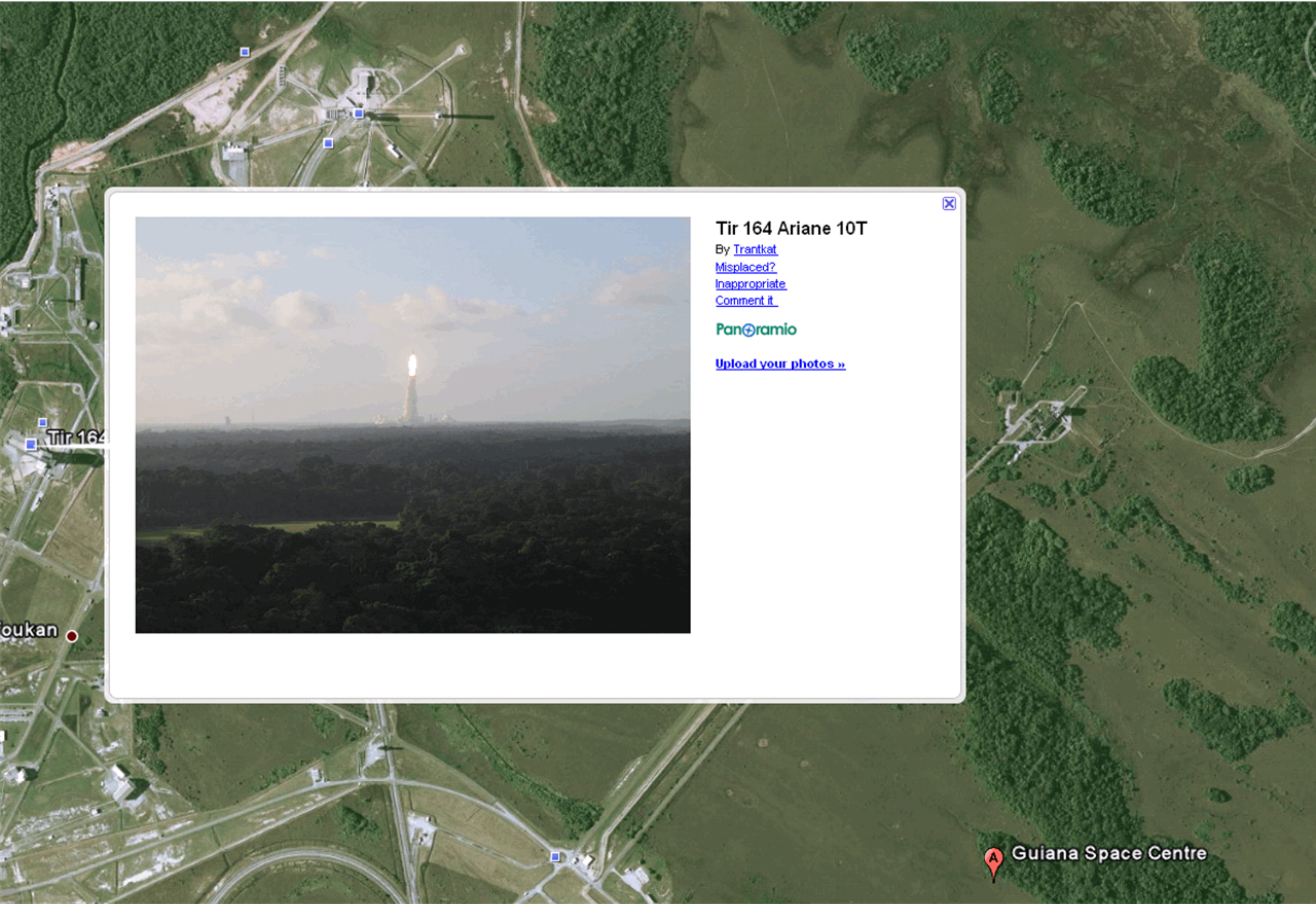


# INDIAN LAUNCH PAD





# EUROPEAN LAUNCH PAD



 Guiana Space Centre



# EUROPEAN LAUNCH PAD



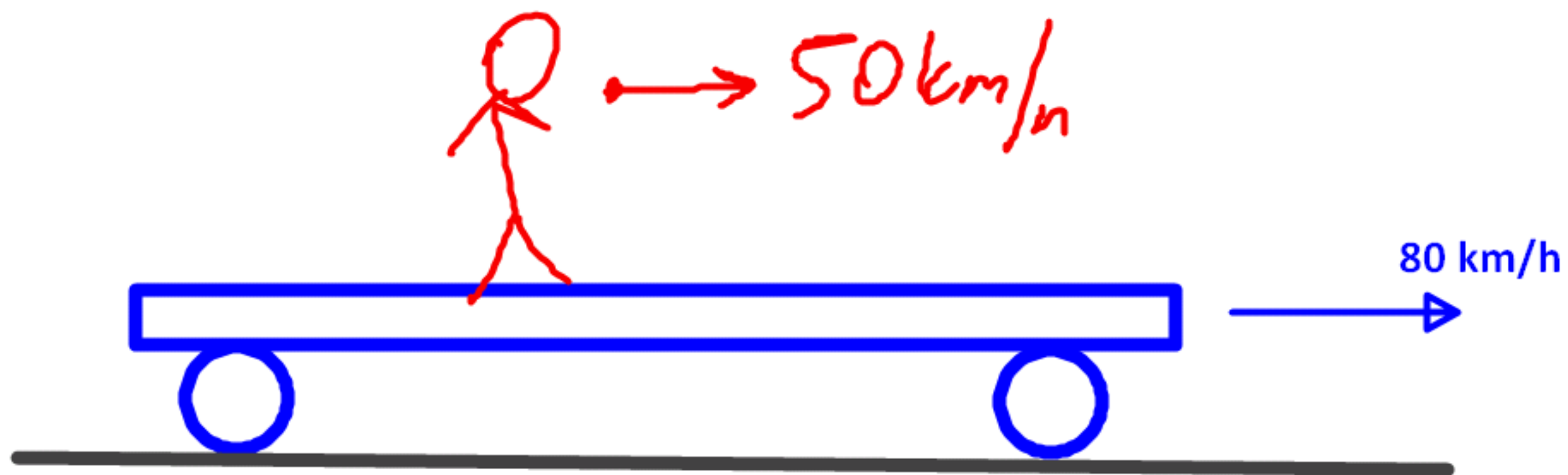


# EUROPEAN LAUNCH PAD





## FIRING PROJECTILES FROM A MOVING PLATFORM



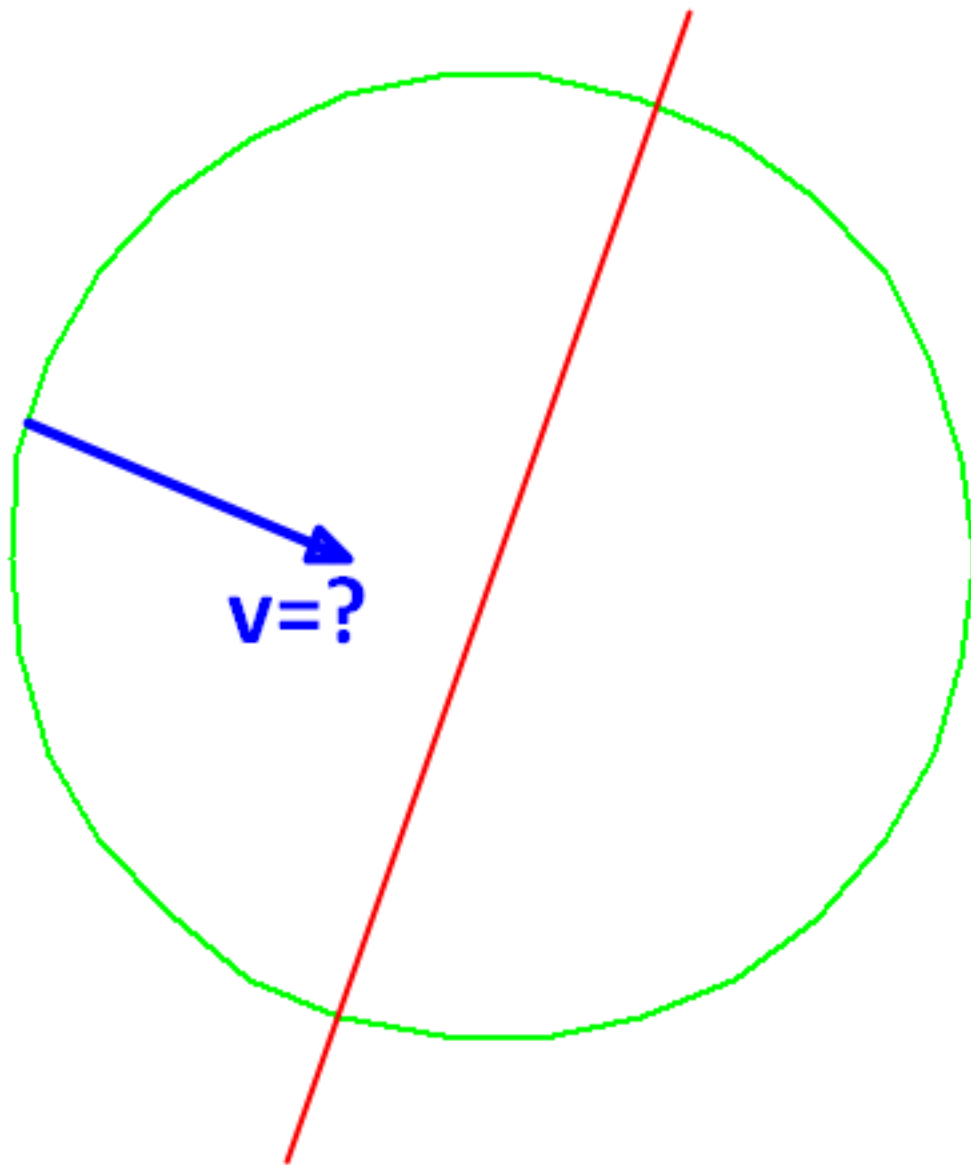


# EFFECTS OF EARTH'S MOTION ON THE LAUNCH OF ROCKETS

## EARTH HAS TWO TYPES OF MOTION

### 1. ROTATIONAL; ROTATING ON ITS OWN AXIS

What is the speed of a point on the equator due to Earth's rotation on its axis?



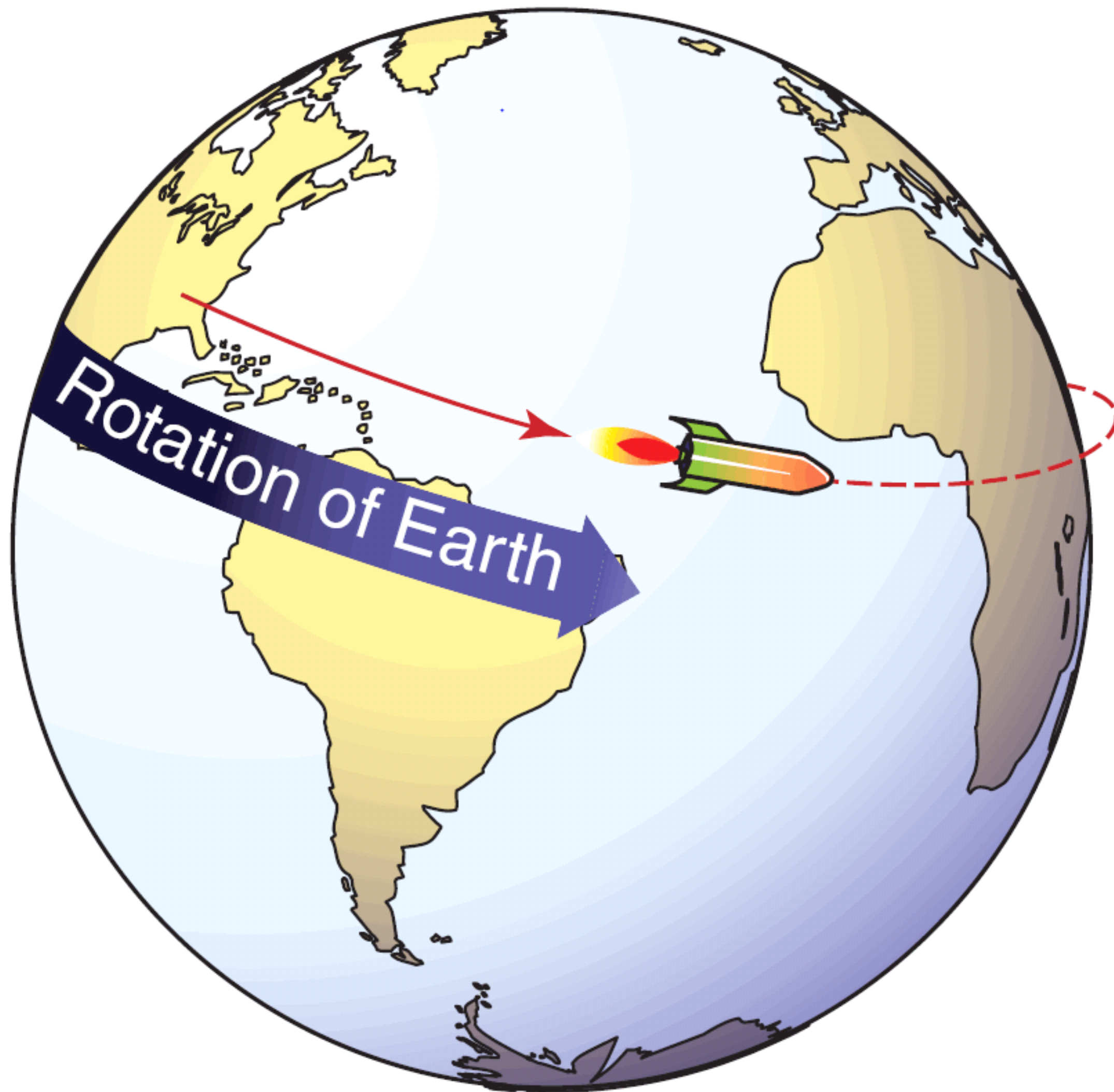
$$v = \frac{2\pi R}{24 \text{ hours}}$$

$R_e$

### 2. ORBITAL; ORBITTING AROUND THE SUN

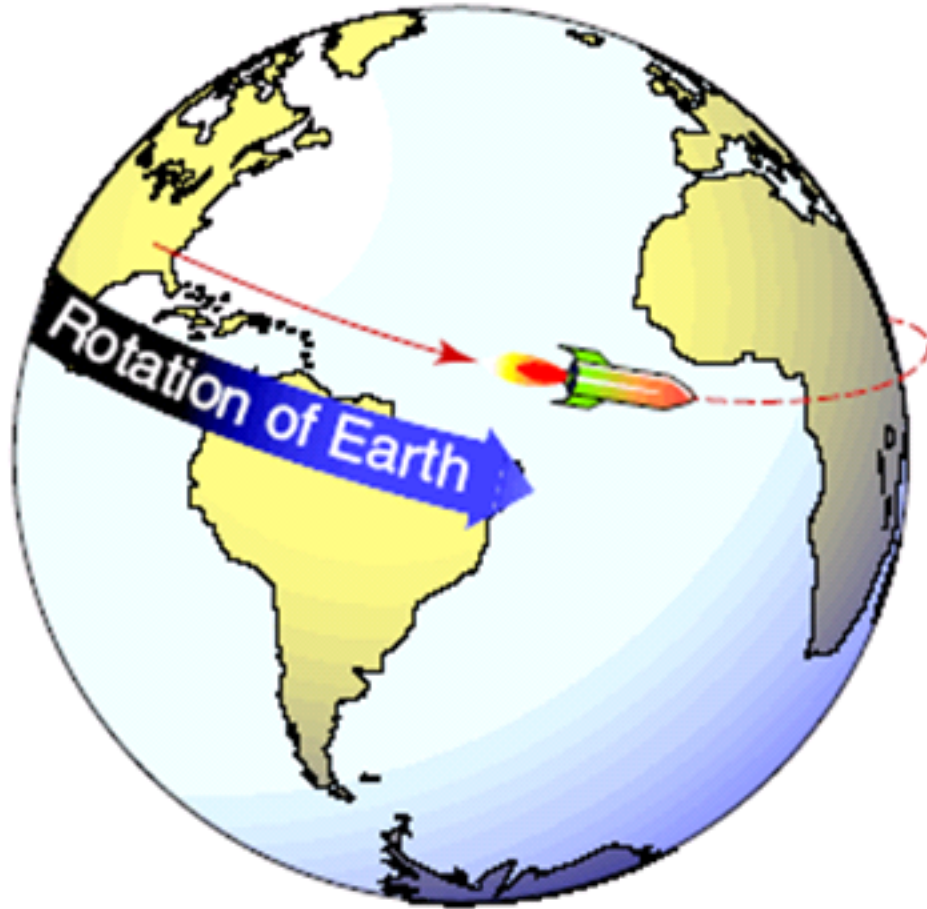


# 1. ROTATIONAL; ROTATING ON ITS OWN AXIS





# 1. ROTATIONAL; ROTATING ON ITS OWN AXIS



**Figure 2.23** *A rocket heading into orbit is launched to the east to receive a velocity boost from the Earth's rotational motion.*

Engineers planning to launch a rocket into orbit can exploit the Earth's rotation in order to achieve the velocity needed for a stable orbit.

This is done by launching in the direction of the Earth's rotation; that is, by launching toward the east.

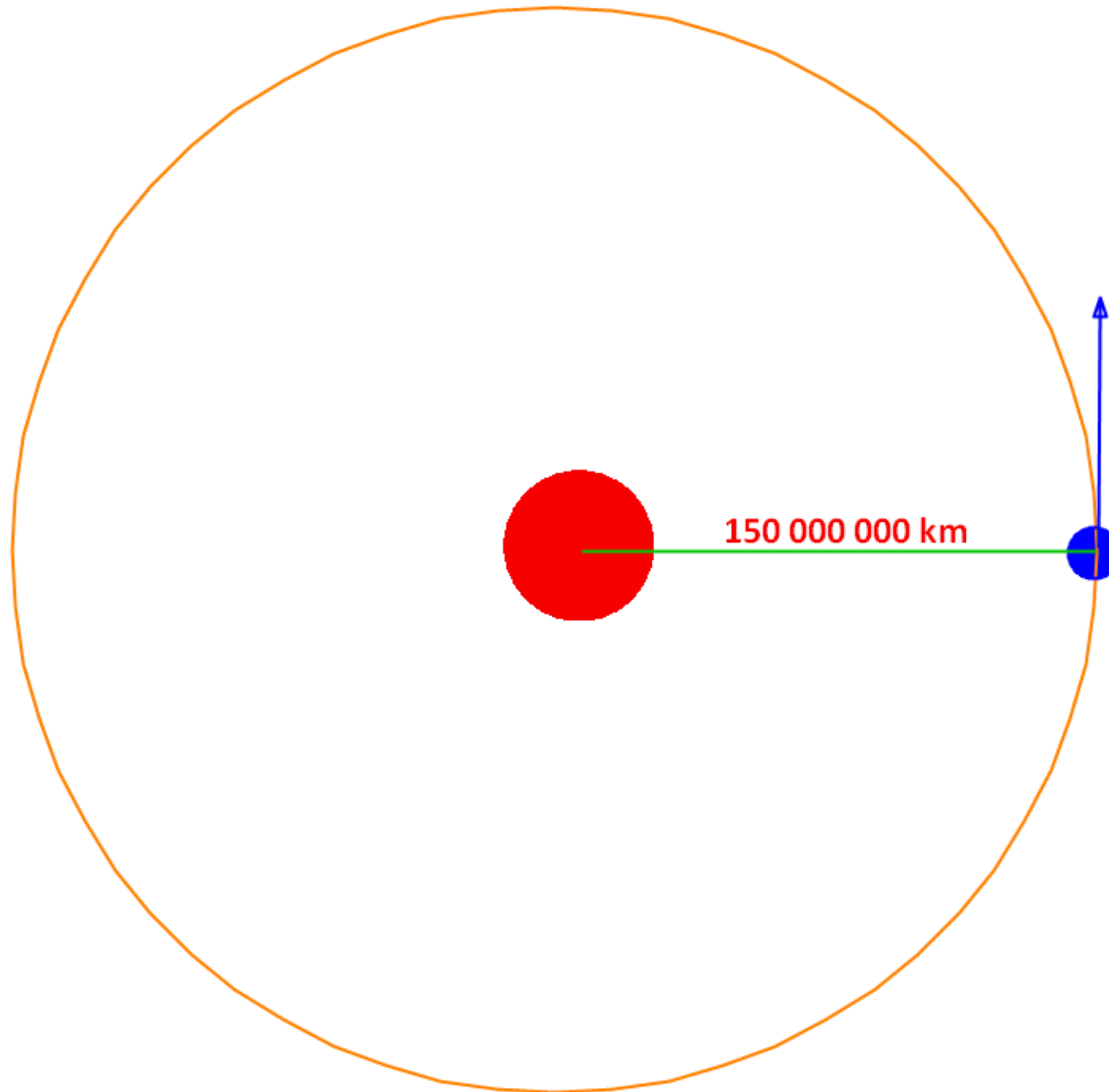
In this way, the rotational velocity of the launch site relative to the Sun will add to the orbital velocity of the rocket relative to the Earth, to produce a higher orbital velocity achieved by the rocket relative to the Sun.



## 2. ORBITAL; ORBITTING AROUND THE SUN

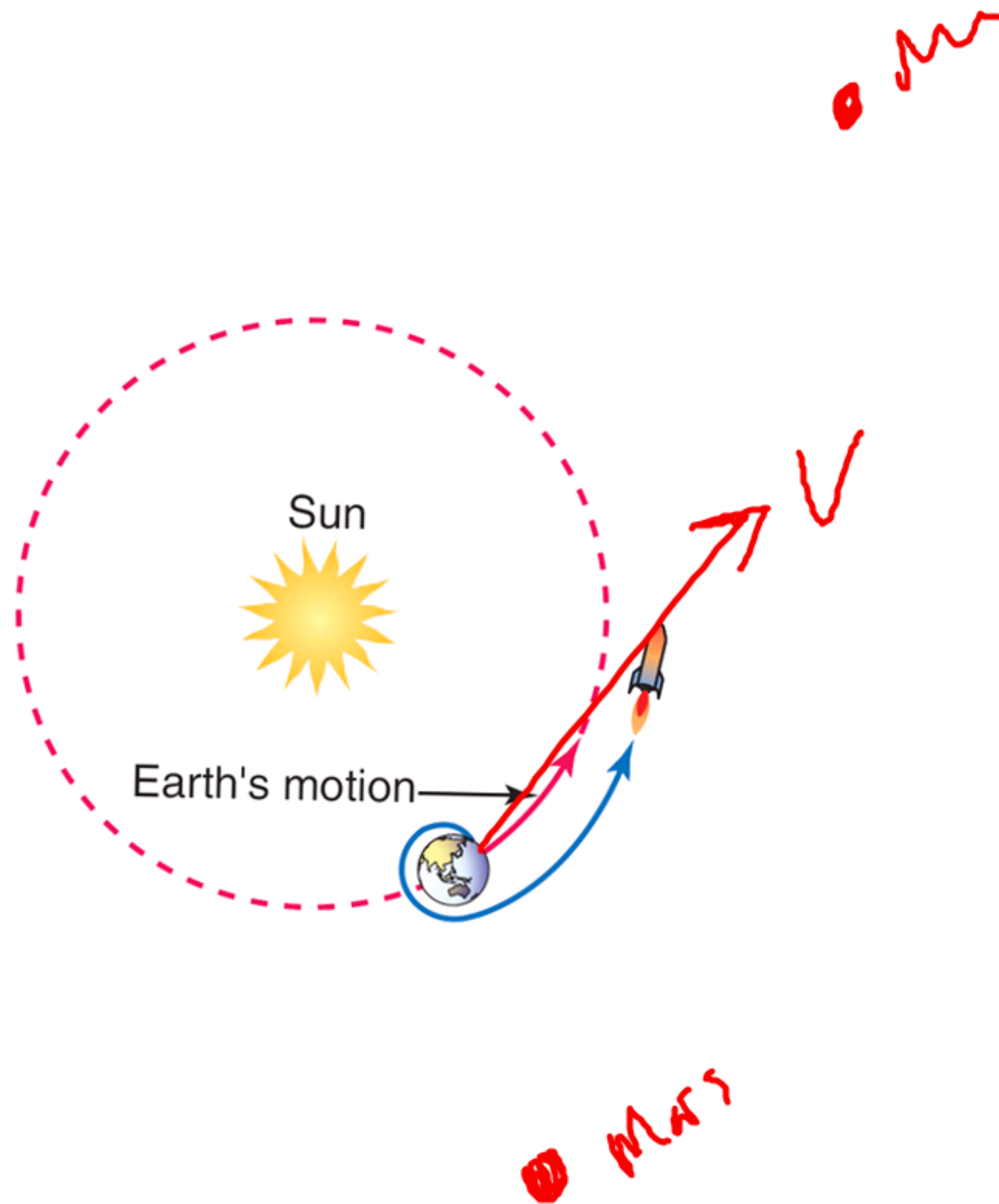
What is the Earth's speed due to its orbit around the Sun?

$$v = \frac{2\pi R}{T}$$



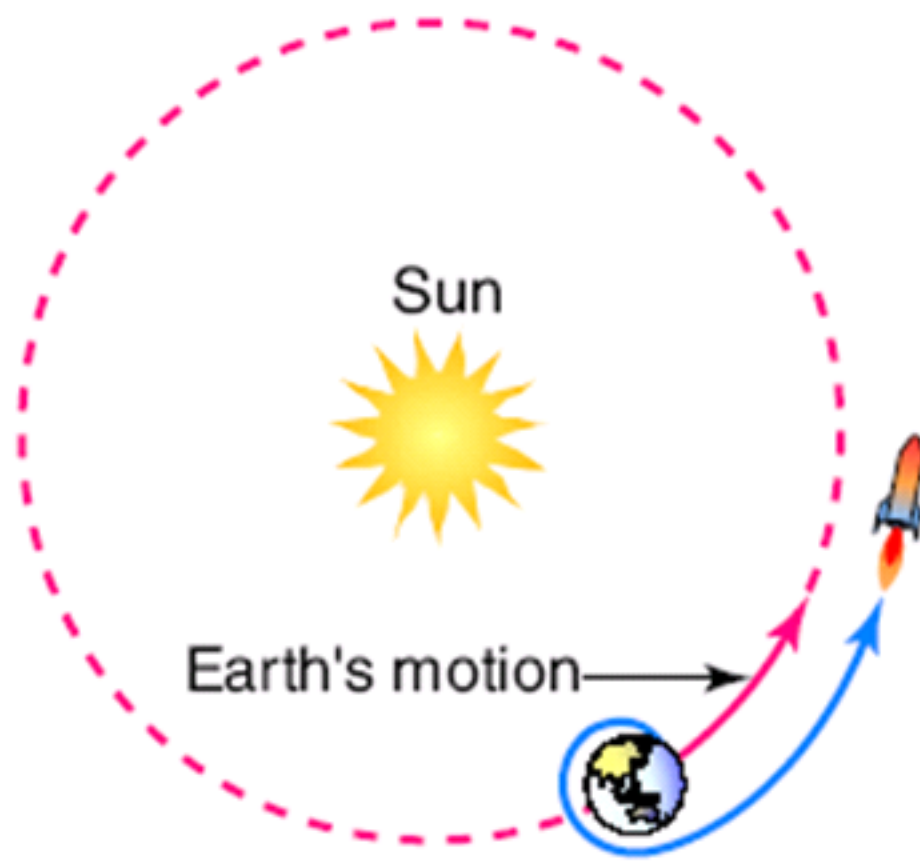


## 2. ORBITAL; ORBITTING AROUND THE SUN





## 2. ORBITAL; ORBITTING AROUND THE SUN



**Figure 2.24** *The flight of a rocket heading into space is timed so that it can head out in the direction of the Earth's motion and thereby receive an extra boost.*

Engineers planning a rocket mission heading further into space can exploit the Earth's revolution around the Sun by planning the launch for a time of year when the direction of the Earth's orbital velocity corresponds to the desired heading.

Only then is the rocket launched up into orbit.

The rocket is allowed to proceed around its orbit until the direction of its orbital velocity corresponds with the Earth's, and then its engines are fired to push it out of orbit and further into space.

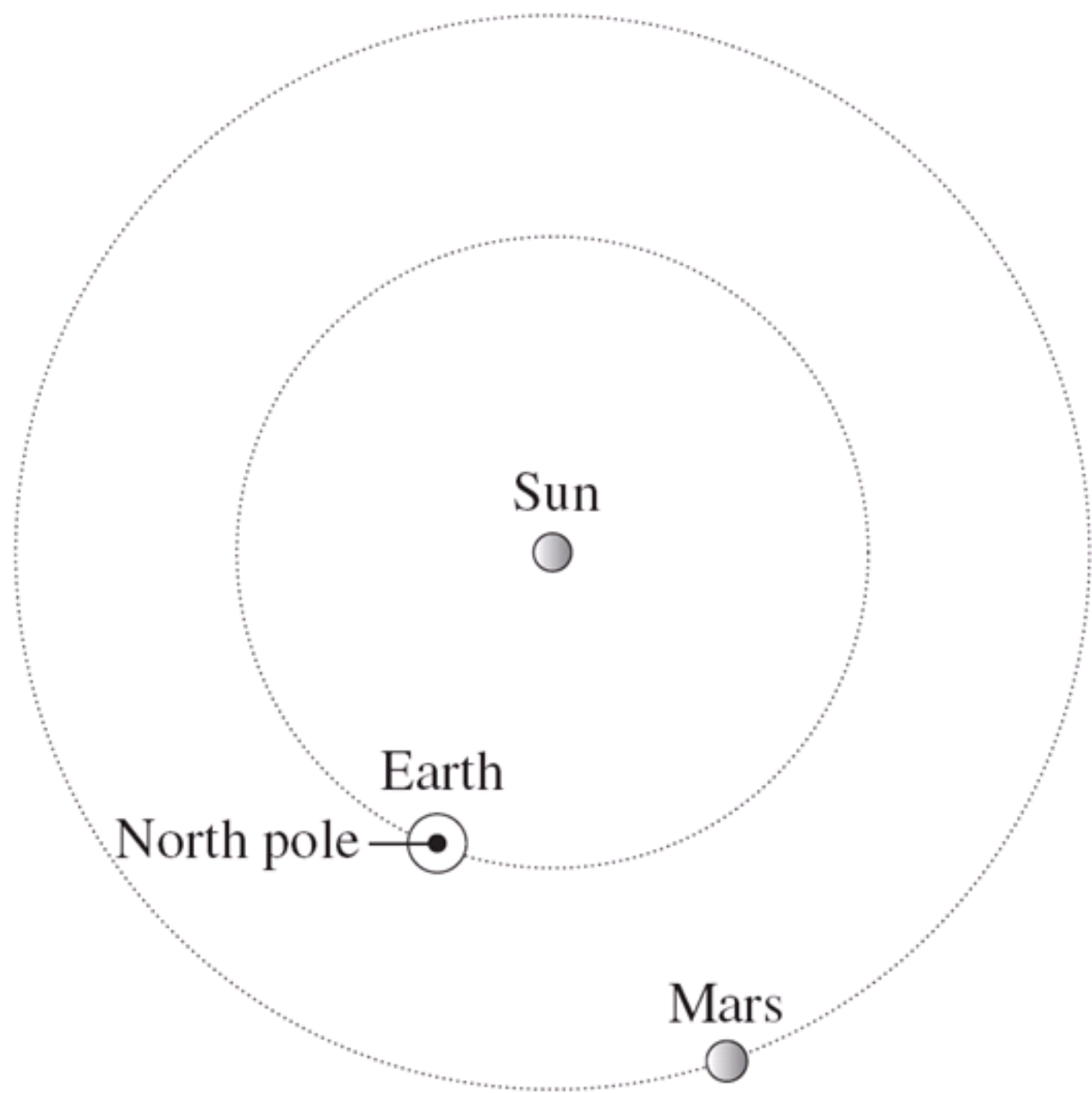
In this way the Earth's orbital velocity relative to the Sun adds to the rocket's orbital velocity relative to the Earth, to produce a higher velocity achieved by the rocket relative to the Sun.



2004 HSC PAPER

Question 19 (6 marks)

On 11 June 2003 the Mars Rover called Spirit was launched on a satellite from Earth when the planets were in the positions shown in the diagram below. The satellite arrived at Mars on 3 December 2003.



- (a)

Indicate on the diagram the approximate positions of Earth and Mars on 3 December 2003 and show the satellite's trajectory to Mars.

3
- (b)

Discuss the effect of Earth's motion on the launch and trajectory to Mars of this satellite.

3



# HOMEWORK

- ✦ Homework is an integral part of your "Learning Curve", take it seriously!
- ✦ Target minimum 1 hour of Physics everyday
- ✦ Divide your physics home study in three segments;
  - ✓ Revision (past)
  - ✓ Homework (present)
  - ✓ Tomorrow (future)
- ✦ Homework is due next period, unless otherwise stated
- ✦ If you cannot do all, at least do a few from each piece

*Apart from **reading the relevant pages from the textbook and solving the rest of the questions in this booklet**  
your homework is:*

1. Space 2 CSU notes
2. Chapter 2 Questions 1-20

Also

PM Practice Booklet

All Questions in Period 7 & 8 Booklets

Experiment 4 Report

**NEXT PERIOD >**

**ROCKETS, HOW DO THEY MOVE?**