Satellite Simulation Workshop

Introduction

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Aims of this Workshop

Computer Science in related disciplines & domains

Appreciate the complexity of Computer Systems

Understand role of human factors in such systems

Achieved through the use of software simulation

And investigation of historical case study

Interpreting findings of academic publications

Computer Science

With many complex applications, Computer Science often works in collaboration with other disciplines

Computers are SO useful, everyone is using them
However this requires knowledge of BOTH disciplines (Computer Science AND the Application Domain)
Not just two separate people - but people with both

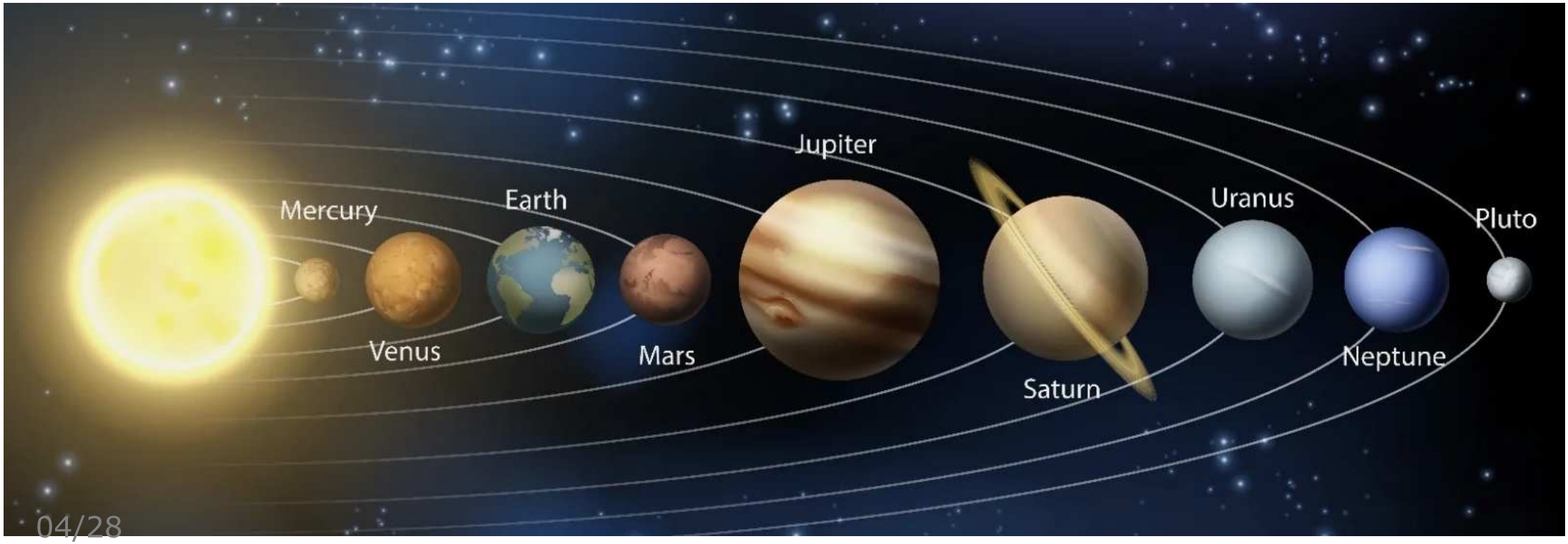
Let's look at just one application...

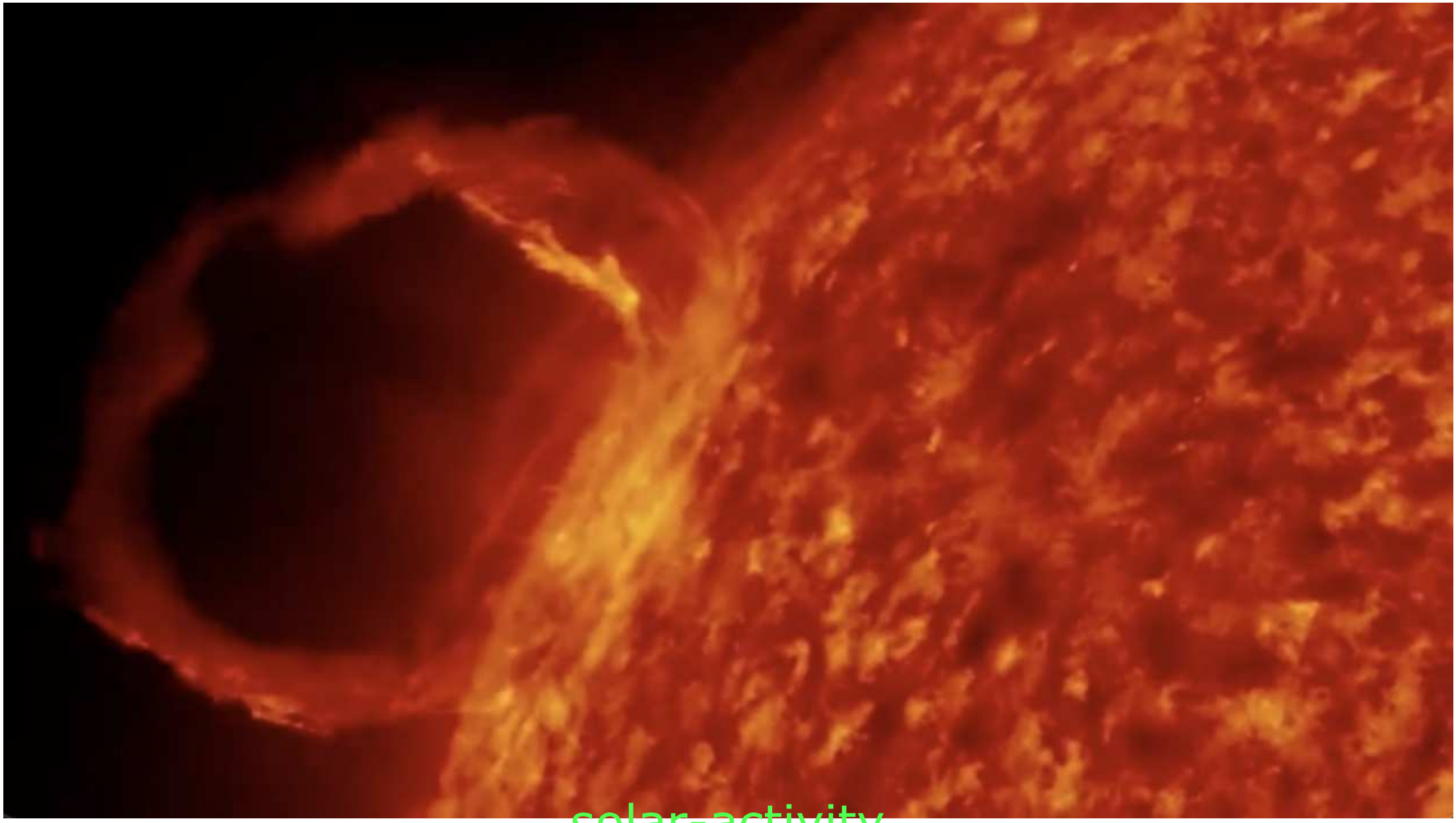
Our Solar System

Let's test your knowledge of our solar system

How many planets are there (8/9/10) ?

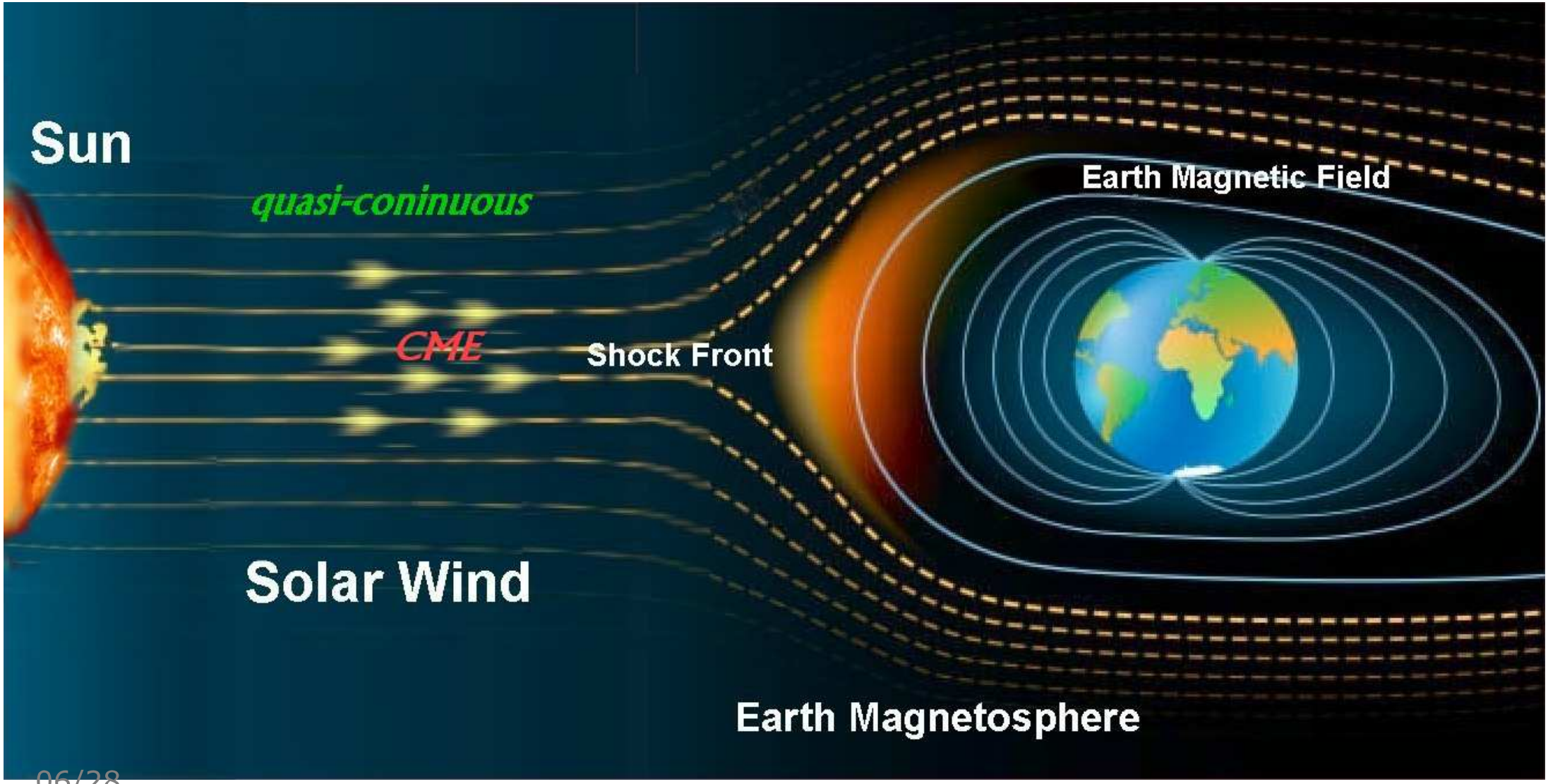
WhichOrbitsWhich





solar-activity

Solar Wind


Sun
quasi-coninuous
CME
Shock Front
Earth Magnetic Field
Solar Wind
Earth Magnetosphere

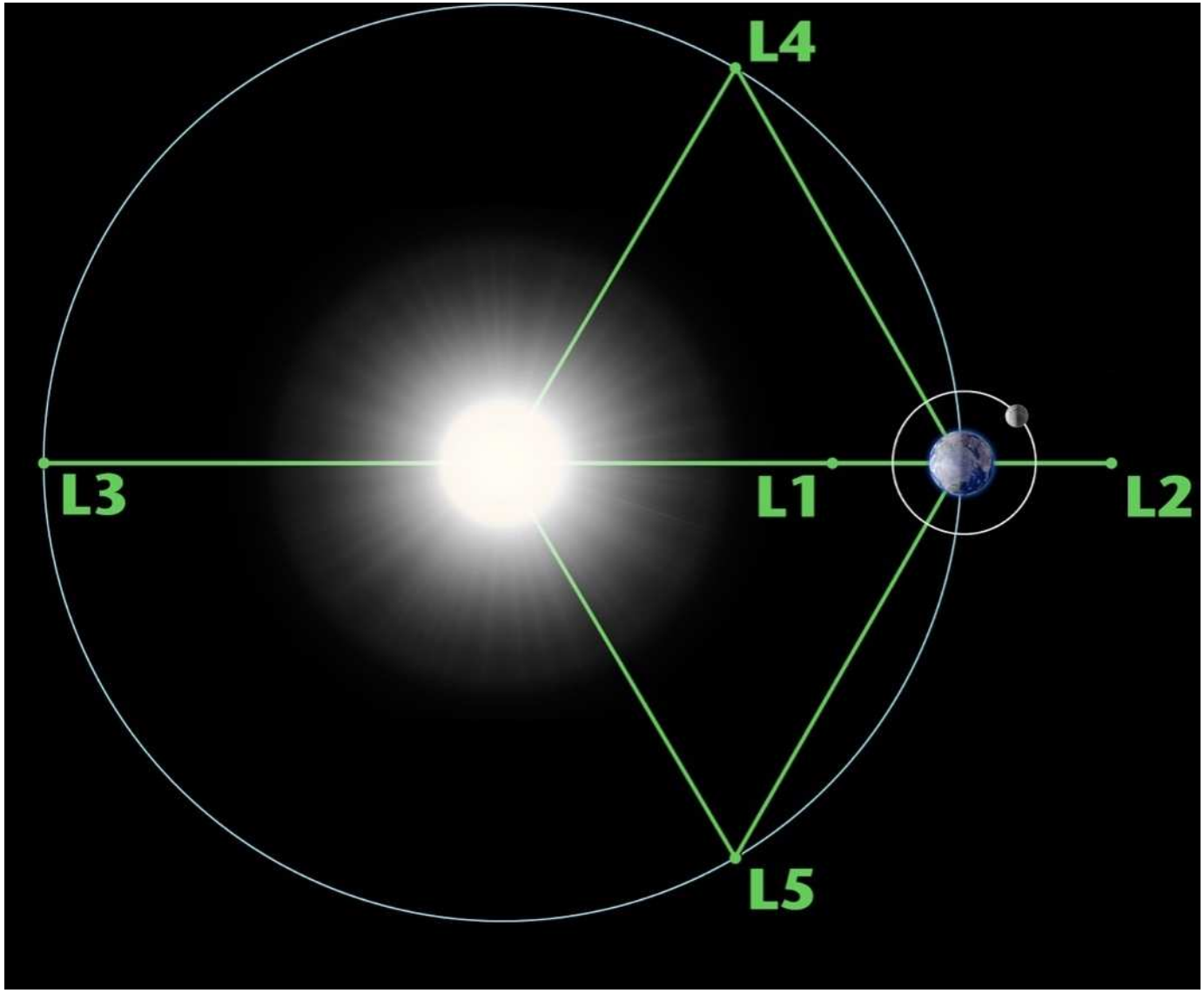
Solar Wind

Travels at around 400 km/s (~1.5 million km/h)
(takes three or four days to reach Earth)

When it strikes the Earth, solar wind can:

- cause power outages on the ground
- inferrer with communication networks
- disrupt operation of satellites
- interfere with navigation systems
- injure astronauts in space !

Lagrange Points



Lagrange Point "L1"

This is an ideal location for a solar observatory
Good for assessing impact of solar wind on Earth !

L1 is 1.5 million km from the Earth

For reference, Earth is approx.
150 million km from Sun

Takes 4 about months to travel
from Earth to L1 (at 500 km/h)

Satellites currently at L1

Solar and Heliospheric Observatory (SOHO)

Aditya-L1 (arrived in January 2024 !)

Global Geospace Science "Wind" satellite

Deep Space Climate Observatory (DSCOVR)

Advanced Composition Explorer (ACE)...


http://services.swpc.noaa.gov/text/ace-swepam.txt

Graphing

It can be hard to interpret raw numerical data

But we can pull the live feed from the satellite

And represent the numerical data visually:

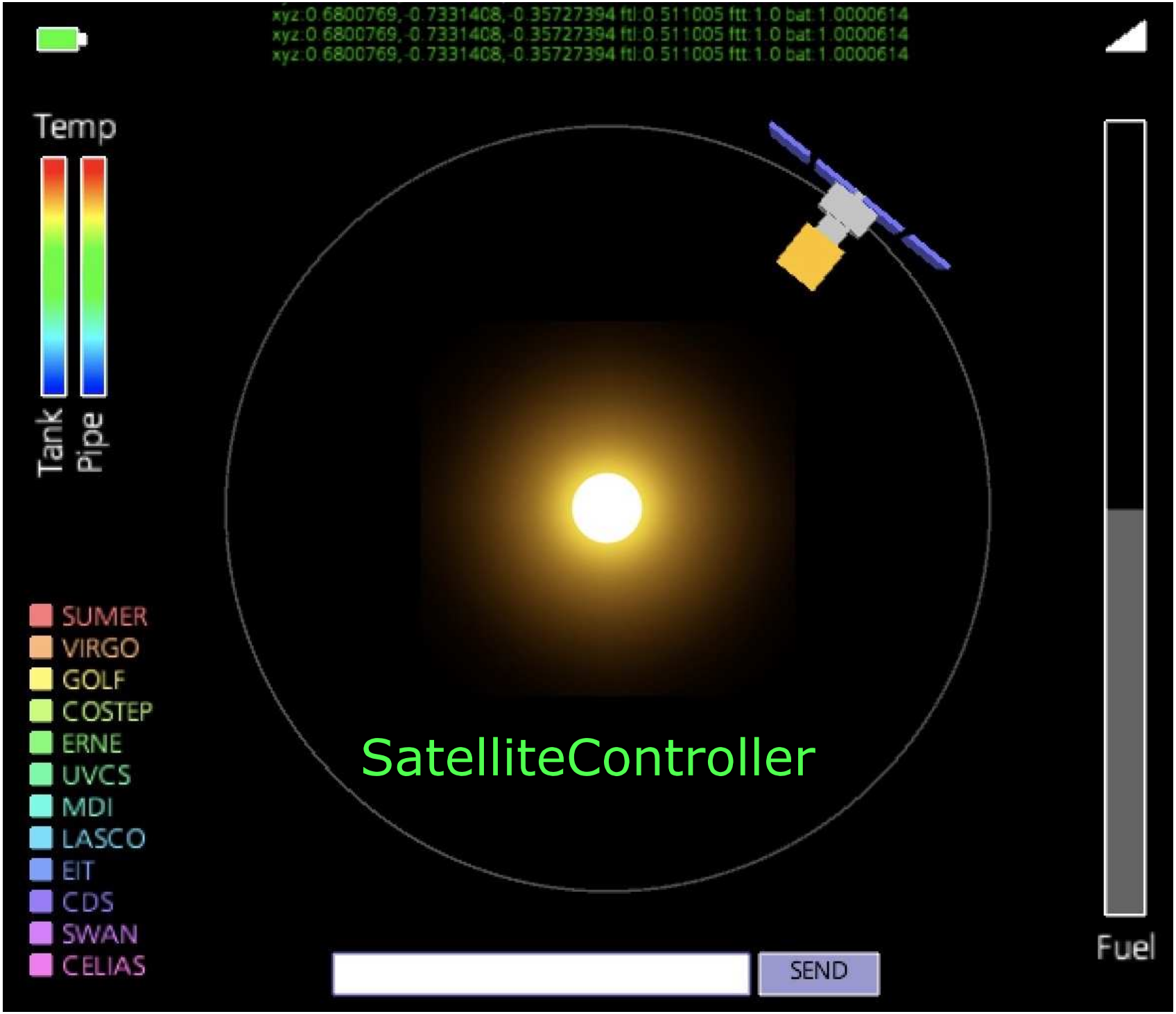
ACEGrapher

Practical Activity

Enough theory and high-level discussion
Let's get hands-on with a practical activity

UNFORTUNATELY
We don't have a real satellite to play with :o(

FORTUNATELY
However, since we are Computer Scientists...
We can build a simulator to experiment with !


xyz:0.6800769, -0.7331408, -0.35727394 ftl:0.511005 ftt:1.0 bat:1.0000614
xyz:0.6800769, -0.7331408, -0.35727394 ftl:0.511005 ftt:1.0 bat:1.0000614
xyz:0.6800769, -0.7331408, -0.35727394 ftl:0.511005 ftt:1.0 bat:1.0000614
Temp
Tank
Pipe
SUMER
VIRGO
GOLF
COSTEP
ERNE
UVCS
MDI
LASCO
EIT
CDS
SWAN
CELIAS
SatelliteController
SEND
Fuel

Features - Clockwise from top

- Telemetry Feed
- Radio Signal Strength
- Hydrazine Fuel Level
- Command Prompt
- Science Experiments
- Temperature Values
- Battery Power

Warning

Note that this simulation is an *approximation*
(not everything is scientifically accurate)

We've made some compromises to make is usable:

- Scale: can't fit 150 million km on the screen
- Time: sped up animation to reduce waiting time
- Dimensions: 2D rather than 3D for easier interaction
- Commands Simplified: to make more understandable

Simulator can be downloaded from here:

http://people.cs.bris.ac.uk/slock/solar

Written in Processing
But exported as an application !

Download, unzip it and get it running

We will explore the command set
(when everyone is ready)

Control Commands

Science Experiments

Satellite carries a range of scientific experiments
We won't explore the nature of these experiments
They are space science, this is computer science

We switch ON/OFF all science experiments using:

```
SCI1
SCI0
```

Useful if we need to save some power, however...
Scientists won't be very happy if we leave them off

WARNING

We are about to see some navigation commands
It is ESSENTIAL that we are VERY careful with these
We MUST NOT let satellite get out of alignment
Move too much and we will lose solar power
As well as radio signal antenna alignment

Be careful
Only move by small amounts
Always move back again afterwards

Navigation

Before navigation, we MUST switch on Gyroscope

```
GYR1
```

We can then change the "pitch" of the satellite

```
PIT15
PIT-5
```

As well as the "yaw"

```
YAW-20
YAW10
```

Why not try it now ?

Careful with fuel consumption!

Sun Reacquisition

Due to all our previous manual navigation
The satellite can quickly become out of alignment:

- Alignment with the Sun (for solar power)
- Alignment with the Earth (for radio control signals)

Luckily satellite provides an "auto pilot" feature:
"Emergency Sun Reacquisition"

ESR

Resets the satellite to the correct orientation
Why not try it now !