StellarXplorers

Sample Scenario #2
Mission Requirements
"Ruler Not Required"

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Sample Exercise Synopsis

Teams will be required to select a mission orbit for a satellite to measure the height of the Washington Monument by using its shadow. Teams whose orbits successfully collect significant amounts of this imagery and transmits it to a ground station will achieve high scores in this exercise.

Disclaimer: Information in this briefing was developed specifically for use during the StellarXplorers Challenge Summer Exercise. Although some information was collected from publically available sources, any similarity between items in this presentation and real world events is purely coincidental.

Mission Briefing

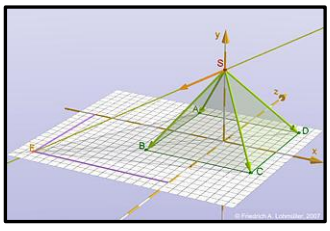
Surveying from Space

The Situation:

Surveying is the profession and science of determining the terrestrial or three-dimensional position of points and the distances and angles between them. These points are on the surface of the Earth, and they are often used to establish maps and boundaries for ownership, locations like building corners or the surface location of subsurface features, or other purposes required by government or civil law, such as property sales. Surveyors determine the position of objects by measuring angles and distances. The factors that can affect the accuracy of their observations are also measured. They then use this data to create vectors, bearings, coordinates, elevations, areas, volumes, plans and maps. Measurements are often split into horizontal and vertical components to simplify calculation.

The National Society of Processionals Surveyors (NSPS) is an organization that strives to establish and further common interests, objectives, and political effort that would help bind the surveying profession into a unified body in the United States. Among the Society's objectives, they strive to advance the sciences and disciplines within the profession, advance the protection of public welfare relative to surveying and mapping issues, and support new practical methods of surveying, promoting good business practice.

NSPS is hoping to further the profession by employing space systems to assist the ground-based survey teams that work around the United States and the world. They are planning to place a proof-of-concept satellite on orbit to see if it can be used to accurately measure the heights of buildings, towers and land masses by measuring the length of their shadows. By correlating the shadow lengths with the time of day, it is believed that precise, accurate measurements can be attained. For this initial proof-of-concept demonstration, NSPS will be using the Washington Monument as their initial target.



The effort began with NSPS issuing a contract to Surrey Satellite Technology Limited (SSTL) of Guildford, England to design and build this first-of-its-kind satellite. In the late 1970s, a group of highly-skilled aerospace researchers working at the University of Surrey, decided to experiment by

creating a satellite using commercial off-the-shelf components. The results were surprising. The team showed that relatively small and inexpensive satellites could be built rapidly to perform successful and sophisticated missions. In 1985, the University formed SSTL to transfer the results of its research into a commercial enterprise. The growth of the company has accelerated, and their innovative approach to the design, build, test and operation of spacecraft has propelled SSTL to the forefront of the small satellite industry. Today, they have built 40% of the world's small satellites.

To test the ability to collect imagery of the Washington Monument's shadow, SSTL is building a small, low-cost, imaging satellite that can be placed into a low earth orbit using a small launch vehicle. Utilizing state-of-art electronic systems, SSTL is designing and building the spacecraft. NSPS has named it **L'Enfant** in honor of Pierre Charles L'Enfant, the original architect of Washington, DC.

Since NSPS has so satellite operations capabilities of its own, they are relying on SSTL to provide all the satellite on-orbit services. This includes tracking **L'Enfant**, maintaining the satellite's health, downloading its collected imagery data, and shipping the imagery to NSPS's Headquarters in Frederick, Maryland for analysis. To meet this requirement, SSTL will use their Satellite Operations Center located in their Guildford headquarters. It houses a control center linked to two offsite ground stations. The facility contains the entire infrastructure to command, control and downlink telemetry and payload data from SSTL orbiting satellites. The ground station has of a row of computer terminals, a TV monitor showing a live camera feed of the antenna dishes, a screen showing the current satellite position, and a compact set of equipment contained in a rack, processing data 24/7.

For the **L'Enfant** mission, SSTL will be using the Rutherford Appleton Laboratory (RAL) Satellite Ground Station. The RAL Ground Station is used for both uplink commanding and downlink telemetry reception. The station has four antennas positioned across two sites. The Rutherford Appleton Laboratory at Harwell has a 2.4 meter and a 12 meter antenna. At Chilbolton, Hampshire there are both a 4.5 meter and 25 meter antennae. The two sites are separated by 40 km thus providing operational redundancy. The ground station serves the scientific community and undertakes work for commercial clients. The 12 meter antenna at Harwell will be used to receive the **L'Enfant** data. The imagery will be shipped in real-time from RAL to the NSPS analysis team in Maryland.

The Washington Monument photos taken by **L'Enfant's** camera are stored on board the satellite until it is in direct line-of-site with the RAL Ground Station. All the images can be quickly download over the station. By using the satellite's high speed

transmitters, only fifteen minutes of contact with the ground station is needed to completely download of all imagery taken during the day.

SSTL has hired the new launch service provider Virgin Orbit of Long Beach, California to launch **L'Enfant** with their *LauncherOne* vehicle. *LauncherOne* is a small-class, two-stage launch vehicle capable of placing a 500 kilogram payload into low-earth orbit. Since the *LauncherOne* is launched from a Boeing 747, it can place **L'Enfant** into any orbit between a 0° and a 180° inclination. The **L'Enfant** spacecraft weights 436 kilograms, so *LauncherOne* can easily place the satellite on orbit. However, the maximum operational altitude (Apogee) is 600 kilometers due to the focal length of the spacecraft's camera. The minimum operational altitude (Perigee) for **L'Enfant** is 300 kilometers due to concerns with atmospheric drag degrading the orbit.

SSTL has hired your team to determine the best orbit to place **L'Enfant** that will provide the most opportunities to collect imagery of the Washington Monument shadow and download it to the Rutherford Appleton Laboratory Satellite Ground Station.

The Task:

Select an orbit between 300 kilometers and 600 kilometers with an orbital inclination between 0º to 180º that collects the most imagery of the Washington Monument's shadow and can download that data to the RAL Ground Station over a 14-day span.

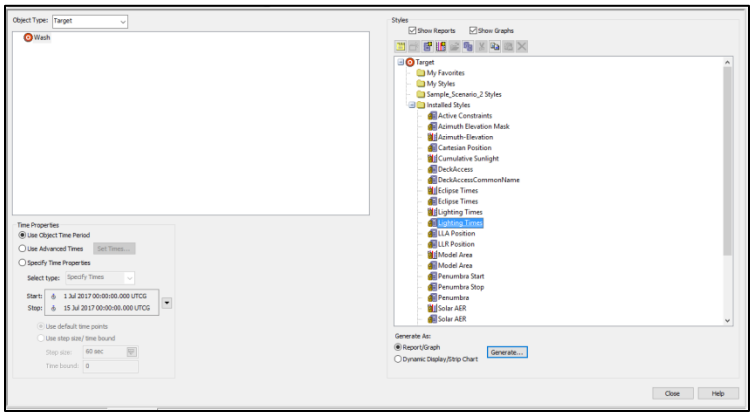
To perform its imagery collection, **L'Enfant** must be within direct line-of-sight of the Washington Monument during daylight hours. The Washington Monument is located at 40° 45' 32.83" N; 73° 58' 46.20" W. The antenna at the RAL Ground Station in Harwell, England is located at 51° 34' 19.74" N; 1° 18' 45.648" W at an altitude of 174 meters. To determine the effectiveness of the selected satellite orbit, the team must evaluate satellite-to-ground station performance during the 14-day period from July 1, 2017; 0000 UCTG to July 15, 2017; 0000 UCTG.

To reduce the workload on your team, the StellarXplorers Staff has provided an STK VDF file (Sample2_STLX04-0xxx.vdf) that contains many elements of the scenario preloaded. The STK file includes the following data:

- Scenario Timeline (July 1, 2017, 00:00 UCTG to July 15, 2017, 00:00 UCTG)
- Washington Monument (**Wash_Mon**) Location
- RAL Ground Station (**RAL_Gnd_Stat**) Location
- **L'Enfant** Satellite in Orbit (300 kilometers X 300 kilometers, 0º Inclination)

The team will not need to load these items into the STK scenario. Just click on Sample2_STLX04-0xxx.vdf to launch STK and begin your evaluation.

Of course to see the monument's shadow, it must be in sunlight. Any images collected after the sun sets will be of no use to the NSPS analysis team. Teams can determine if the monument is in sunlight by using STK's "Analysis", "Report & Graph Manager" function. Just select "Target" as the "Object Type", then select "Wash", then "Lighting Times" from the "Installed Types" on the right, and finally "Generate…". This will produce a report showing all the times the Washington Monument is in "Sunlight." Do not use the Penumbra (monument is in partial shadow) and Umbra (monument is in total shadow) times. Sunlight is too weak or blocked during those periods to produce a distinct shadow.



SUMMARY:

The National Society of Professional Surveyors is pioneering a new method of determining the height of structures on the earth. Let's find the best orbit to support this ground-breaking concept. Good luck!

Team Data Presentation

At the end of the exercise, each team will produce the following information for the **L'Enfant** spacecraft:

1. An STK VDF file with the team's final solution.
   Note: Teams must save the VDF with the following unique file name: STLX_Sample_Scenario_2_STLX04-0xxx.vdf where "xxx" is replaced with the team's number, i.e. STLX_Sample_Scenario_2_STLX04-0123.vdf

2. Mission Orbital Elements in text format containing the following data:
   a. Semi-Major Axis (in kilometers)
   b. Eccentricity
   c. Inclination (in degrees)
   d. Argument of Perigee (in degrees)
   e. Right Ascension of the Ascending Node (in degrees)
   f. True Anomaly (in degrees)
   g. Orbit Epoch (in UTCG)

   During a competition round, the Staff would use the team's vdf file to score their solution and to verify that none of the **L'Enfant** altitude restrictions for Apogee, Perigee or Inclination were violated. If a violation is discovered, the staff would enter the correct altitude or inclination limitation and rerun the scenario, the team would receive a **5% penalty** deducted from their scenario score.

An example of the required document is shown in Appendix I of this package.

Teams will be provided a blank template of this document.

StellarXplorers Sample Scenario #2 Scoring

Teams will receive a score in this exercise based on their ability to collect imagery of the Washington Monument's shadow using the **L'Enfant** spacecraft and download those images to the RAL Ground Station.

Mission Orbit Determination Data

Each team will be evaluated on their ability to provide **L'Enfant** coverage of the Washington Monument during daylight hours from the start of July 1, 2017 until the end of the day on July 14, 2017. During this 14-day period, NSPS needs the most imagery coverage possible. Teams will receive one point for every 5 minutes of Washington Monument daylight coverage. The score will be based on total coverage time achieved. For example: if a team collects 453.235 minutes of daylight imagery over the 14-day period, they would score 90.647 points. (453.235 ÷ 5).

Note: **L'Enfant** must also be within line-of-sight of the RAL Ground Station at least 15 minutes every day to download all the collected imagery. Failure to meet this requirement would result in a **20%** penalty to the team's Mission Orbit score.

Final Score

The team's final score will be based on the total number of points accumulated from their Mission Orbit.

Appendix I

Practice Scenario #2
Mission Orbital Elements

Team: STLX04-1234

Organization: Smallville High School

a.	Semi-Major Axis:	6778.14	Kilometers
b.	Eccentricity:	0.0147533	
c.	Inclination:	28.54	Degrees
d.	Argument of Perigee:	15.32	Degrees
e.	RAAN:	85.1	Degrees
f.	True Anomaly:	132.25	Degrees
g.	Orbit Epoch:	1 Dec 2017 00:00:00.000	UTCG