StellarXplorers

Sample Exercise #3
Mission Requirements
"How's the Old Ticker?"

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Scenario Synopsis

Teams will be required to select components for a commercial satellite that must meet strict spacecraft mass and cost requirements while still meeting all mission objectives. A team whose satellite meets the launch weight and budget limitations and optimally completes the customer's requirements will achieve high scores in this sample exercise for the StellarXplorers Challenge.

Mission Briefing

Real-Time Stock Exchange Updates from Space

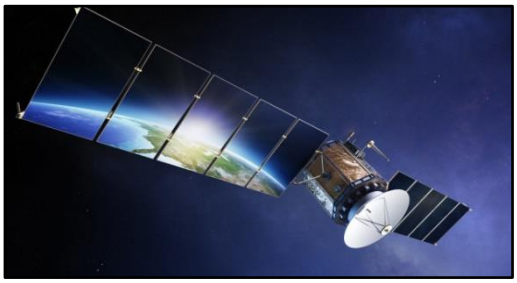
Note: The StellarXplorers Staff highly recommends that teams read the entire scenario before beginning their analysis.

The Situation:

Stock Exchanges are some of the most important parts of today's global economy. Countries around the world depend on Exchanges for economic growth. Although the Exchanges are a relatively new phenomenon, they have become the driving economic force. Today, virtually every country in the world has its own Stock Exchange. In the developed world, major Exchanges typically emerged in the 19th and 20th centuries soon after the London Stock Exchange and New York Stock Exchange were first created. From Switzerland to Japan, all of the world's major economic powers have highly-developed Stock Exchanges which are still active today.

The Exchange is a facility where stock brokers and traders can buy and sell securities, such as shares of stock and bonds and other financial instruments. Stock Exchanges often function as "continuous auction" markets where buyers and sellers finalize transactions at a central location such as the floor of the Exchange. Many Exchanges today use electronic trading, in place of the traditional floor trading.

The speed and the volume of these transactions continues to increase. And it has created a demand for fast, accurate and complete information on all the security trading activity occurring at all the Stock Exchanges around the World. To meet this demand, the leaders of the world's largest Exchanges have formed a consortium called the **World Financial Systems, Inc.** Their goal is to develop a space-based satellite system that will distribute data from the major Stock Exchanges to users all over the globe. The satellite is called **TICKER** and is named after the stock market ticker tape machine that was one of the earliest methods of sending stock information to the World. In fact, the continuous stream of Exchange data is still called the "Ticker."



The concept of operations for **TICKER** is that as it circles the globe and makes line-of-sight contact with each of the major Stock Exchanges, each Exchange will rapidly uplink all its current market information to the satellite. **TICKER** will store all this data onboard its solid state data recorders. Simultaneously, **TICKER** will download all the information that it has received from the other Exchanges to the location that is up-linking its own data. Therefore, each Exchange will have all the data from the World's Exchanges that it can distribute to its customers.

Initially, **TICKER** will communicate with ten of the World's largest Stock Exchanges. The Exchange Abbreviation, Exchange Name, Location and the Capital Value of all the securities marketed at each Exchange are listed in the following chart:

Abbv.	Name	City	Nation	Capital
NYSE	New York Stock Exchange	New York, NY	United States	$23,139 B
JPX	Japan Exchange Group	Tokyo	Japan	$6,288 B
SSE	Shanghai Stock Exchange	Shanghai	China	$5,023 B
Euronext	European Stock Exchange	Amsterdam	Netherlands	$4,649 B
HKEX	Hong Kong Stock Exchange	Hong Kong	China	$4,443 B
BSE	Bombay Stock Exchange	Bombay	India	$2,298 B
ASX	Australian Securities Exchange	Sydney	Australia	$1,442 B
JSE	Johannesburg Stock Exchange	Johannesburg	South Africa	$1,165 B
B3	Brasil Bolsa Balcão	São Paulo	Brazil	$1,073 B
ADX	Abu Dhabi Securities Exchange	Abu Dhabi	United Arab Emirates	$ 135 B

The satellite will operate in a circular orbit at an altitude of 1,000 kilometers (621 miles) and an Inclination of 50°. **TICKER** will have an orbital period of 105.119 minutes, so it will orbit the Earth 13.7 times in 24 hours. This orbit allows the satellite to contact each of the ten Stock Exchange locations several times each day. This will allow a significant amount of data to be received from and shipped to each of the ten Exchanges.

World Financial Systems, Inc. has hired **Expanse Space Systems** of Ceres, Illinois to build **TICKER.** The contract calls for the satellite to cost no more than $550,000,000. The satellite is in its final assembly phase. Most components of the spacecraft have been selected and are being installed on the vehicle. However, three vital components have yet to be chosen. They are the Spacecraft Computer, the Data Transmitter, and the Attitude Control System. A decision on which version of these vital spacecraft sub-system elements needs to be made as soon as possible so that work can proceed on final assembly.

TICKER will be launched from Cape Canaveral Air Force Station, Florida as soon as the satellite has completed assembly and testing at the **EXPANSE** factory. It will be launched on the new *Rocinante* launch vehicle. *Rocinante* is capable of launching a satellite with a mass of 1,600 kilograms (3,527 pounds) into **TICKER's** 50° inclination, 1,000 km circular orbit. This weight must not be exceeded or the satellite will not be able to achieve its mission requirements.

EXPANSE SPACE SYSTEMS has hired your team to select the best combination of computer, transmitter and attitude control system for **TICKER** so that it can download the most information to the ten Stock Exchanges around the Earth while simultaneously meeting the stringent *Rocinante* launch vehicle mass limitations and the satellite's construction budget. All the components already assembled on the satellite weigh 1,391 kilograms and cost a total of $348,000,000. Therefore, there is only a 209 kg weight allowance for the remaining components and only $202,000,000 ($202M) left in the satellite's construction budget. As your team reviews this equipment, you will discover that each component has its own unique capabilities and constraints.

The Task:

Select the best set of satellite components to maximize the transmission of financial data to and from the ten Stock Exchanges while meeting the launch vehicle's liftoff capability and the program's budget requirements.

Spacecraft Computer

The heart, or brain, of the satellite is its Computer. This piece of equipment controls all systems on board the spacecraft. It manages the electrical power subsystem, thermal control systems, compresses at stores information on the solid state data recorders, and then schedules its transmission to the ground Exchanges. It must work flawlessly in the harsh vacuum of space and must self-correct if it discovers an internal error in its processor. Needless to say, selection the Computer for **TICKER** is one of the most critical equipment selections.

The computers for **TICKER** are built by the Scopuli Corporation of Pallas, Oregon. They have four models available and all have the speed and capability to perform the **TICKER** mission. They are space-qualified and have been used on other **EXPANSE** satellites. The models with their capabilities are listed in the following chart:

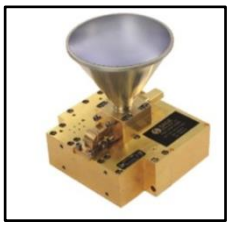
Scopuli Spacecraft Computers		
Model	**Weight (kg)**	**Price ($1M)**
FastByte 120	49.8	51.2
FastByte 125	44.5	60.4
FastByte 130	39.4	72.6
FastByte 135	32.4	84.9

Your team should select the computer that can best meet *all* mission objectives.

Data Transmitter

Once **TICKER** is within line-of-sight of one of the Stock Exchanges, it will download all the financial information it has received from the nine other Exchanges. There is a significantly large amount of data that must be sent to the ground. **TICKER** will continuously send this information to the ground as long as it is still within line-of sight of the Exchange's ground station. The transmitter must provide a strong enough signal to make sure that all the financial data is successfully received at the Exchange. **EXPANSE** has conducted an extensive analysis and determined that an output power at or above 52 decibel watts (dBW) by the transmitter would be sufficient to insure that 100% of **TICKER**'s data can be received. A decibel watt is a unit for the measurement of the strength of a signal expressed in decibels relative to one watt.

However at lower output power levels, the percentage of data received at the Exchange drops significantly. Analysis has determined that for every 1 dBW below 52 dBW, the percentage of data received at the Exchange falls by 2.5%. For example, a transmitter with an output power of only 42 dBW (10 dBW below 52 dBW) would only have 75% of its data [100% - (10 ✕ 2.5%)] received at the Exchange.



Note: **TICKER** can simultaneously transmit up to four data streams of financial data to four separate Stock Exchanges. It can also receive four separate streams of financial data sent from the individual Stock Exchanges at the same time. **TICKER** can do this because it has four separate transmit/receive antennae located around the perimeter of the spacecraft.

For this mission, the satellite manufacture, **EXPANSE SPACE SYSTEMS**, will be using Data Transmitters built by the Donnager Electronics Corporation of Vesta, New Mexico. Donnager has a new line of space-qualified transmitters which will provide the high speed downlink necessary for this mission. The models with their capabilities are listed in the following chart:

Donnager Data Transmitters			
Model	**Power (dBW)**	**Weight (kg)**	**Price ($1M)**
Validium 2300	45	15.4	30.9
Validium 2400	48	18.3	32.6
Validium 2500	50	21.6	34.7
Validium 2600	52	24.5	36.2

Your team should select the data transmitter that can best meet *all* mission objectives.

Attitude Control System

To insure that **TICKER** successfully transmits and receives data from the ten Stock Exchanges, the satellite must maintain a very stable and precise orientation. The spacecraft accomplishes this by using control moment gyroscopes to keep the satellite

transmitters and receivers pointed at each Stock Exchange's ground station. Therefore, the pointing accuracy of the Attitude Control System is critical to the success of **TICKER**'s mission. **World Financial Systems, Inc.** requests that **Expanse** place special emphasis on this critical spacecraft system.

For this mission, **Expanse** will use the SurePoint Attitude Control System (ACS) built by Canterbury Electronic Works of Ganymede, New Jersey. They have provided ACS for a number of government and commercial satellites which have proven to be highly reliable and accurate. Canterbury has identified four of their space-qualified SurePoint ACS that can provide the accuracy needed for **TICKER**. The four systems and their capabilities are listed below:

Canterbury Attitude Control Systems			
Model	**Accuracy**	**Weight (kg)**	**Price ($1M)**
SurePoint 350	20°	121.6	83.4
SurePoint 360	15°	132.0	86.2
SurePoint 370	10°	143.2	92.3
SurePoint 380	5°	153.1	98.4

Your team should select the Attitude Control System that can best meet *all* mission objectives.

At the completion of the satellite's assembly and testing at **Expanse**, **TICKER** will be shipped to Cape Canaveral and mated to the *Rocinante* launch vehicle. *Rocinante* is capable of a quick reaction time to a launch request. Therefore, **TICKER** should be on-orbit shortly after leaving the factory. *Rocinante* will launch **TICKER** into this orbit:

Semi-major Axis:	7378.14 km
Eccentricity:	0
Inclination:	50°
Argument of Perigee:	0°
Right Ascension of Ascending Node:	0°
Mean Anomaly:	0°
Orbit Epoch:	1 Jan 2016 00:00:00.000 UTCG
Coord Epoch:	1 Jan 2000 11:58:55.816 UTCG

To evaluate the effectiveness of the selected satellite components, the team must determine satellite-to-ground performance during the period from October 1, 2018, 00:00:00 UTCG to October 15, 2018, 00:00:00 UTCG.

SUMMARY:

World Financial Systems, Inc. is pioneering a new concept in space-based Stock Exchange data transmission by designing and launching the **TICKER** spacecraft into low earth orbit. Let's make sure that they get the most capable satellite design possible. Good luck!

Team Data Presentation

At the end of the practice period, each team should have developed the following information in electronic formats for the **TICKER** spacecraft:

1. Satellite Components Chosen in spreadsheet format (STLX Sample #3 Solution.xlsx) containing the following data:
    a. Spacecraft Computer
    b. Data Transmitter
    c. Attitude Control System

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

Teams will be provided a blank template of this document.

StellarXplorers Sample Exercise #3 Scoring

Teams will receive a score in Sample Exercise #3 based on the following:

Their selection of the **TICKER** satellite components to meet the *Rocinante* launch vehicle weight requirements while delivering the most data to the ten Stock Exchange locations.

Mission Orbit Determination Data

Each team will be evaluated on their ability to select a Spacecraft Computer, a Data Transmitter, and an Attitude Control System for the **TICKER** spacecraft that meets the mass requirements for launch on the *Rocinante* launch vehicle while simultaneously transmitting the most data to the ten Stock Exchanges around the World. Teams score a point for every 180 minutes of data transmitted to the ten Exchanges from October 1, 2018, 00:00:00 UCTG until October 15, 2018, 00:00:00 UCTG. Since **World Financial Systems, Inc.** has placed special emphasis on the pointing accuracy of the Attitude Control System, teams will receive a bonus factor for their score based on the accuracy achieved by the Attitude Control System. The bonus factor is based on the following chart:

ACS Pointing Accuracy	Bonus Factor
20°	0%
15°	5%
10°	10%
5°	20%

For example, a team that successfully transmitted 14,400 minutes of data to the Markets would score 80 points (14,400 ÷ 180). If the ACS accuracy was only 20°, then they would receive no bonus points (80 × 0%). However if the accuracy was 15°, then they would receive 4 bonus points (80 × 5%). If 10°, 8 points (80 × 10%). If 5°, 16 points (80 × 20%).

On the other hand, teams will lose points if they allow the satellite to exceed the *Rocinante* maximum launch weight of 1,600 kilograms. For each 0.5 kilogram over the launch weight, the team will lose 1 point.

Based on the output power of their chosen Data Transmitter, teams could lose points based on the percentage of data received at the ten Stock Exchanges. Note: The percentage decreases 2.5% for every 1 dBW below the output power level of 52 dBW.

Finally, teams will lose points if they allow the price of the satellite to exceed the budget set by **World Financial Systems, Inc.** for construction of the satellite. For every $200,000 over the **TICKER** budget of $550,000,000, the team will lose 1 point.

Final Score

The team's final score will be based on the total number of points accumulated from their Satellite Design & Mission Accomplishment tasks.

Appendix I

Sample Exercise #3
Satellite Components Chosen

Team: STLX0X-0123

Organization: Main Street High School

Satellite: **TICKER**

Satellite Components Chosen

Spacecraft Computer: Enter One of the Following: FastByte 120, FastByte 125, FastByte 130, or FastByte 135	FastByte	120
Data Transmitter: Enter One of the Following: Validium 2300, Validium 2400, Validium 2500 or Validium 2600	Validium	2300
Attitude Control System: Enter One of the Following: SurePoint 350, SurePoint 360, SurePoint 370 or SurePoint 380	SurePoint	350