A Quest for Knowledge: Role-playing and Researching the MMS Mission

ISTE/NASA Collaborative Project

Teacher Guide

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INTRODUCTION: Welcome to what is hoped to be a *fun* and *exciting* collaborative student project based on both the current solar activity Earth is experiencing, and the Magnetosphere Multi-Scale Mission (MMS Mission) that NASA plans to lanuch in 2014. The "Quest for Knowledge" project presented here allows students to explore the main MMS ideas through participating in a set of missions for one of three roles: Engineers, Researchers, or Marketing Specialists. Each role will engage in a variety of projects in small groups, and create their own artifacts to celebrate their accomplishments. Students earn badges after each mission by scanning a QR code when they are completed.

TARGET AUDIENCE: We have tried to make this project flexible depending on technology availability and authorized use policy of particular schools or school districts. "A Quest for Knowledge" is primarily intended for Grades 7-12.

ORGANIZATION OF MATERIALS:

- The entire "Quest for Knowledge" activity can be found on Wordpress: http://nasa.wirededucator.org.
- Teacher materials will also include descriptions, resources, NETS, MMS Key Messages, and goals for completing the missions for each role.

INTRODUCTION TO THE QUEST:

- Once logged into Wordpress, access the Welcome Introduction Video. This is an approxmately 1-minute machinima introduction to the Quest.
- Student roles will need to be determined per teacher evaluation.

MMS MISSION INTRODUCTORY VIDEOS: Videos describing the background of the MMS mission can help provide teachers with information. Access the MMS Youtube page at http://www.youtube.com/user/nasamms. If school permits, students and teachers can also keep updated on the MMS mission on Twitter: http://twitter.com/NASA_MMS or on Facebook: http://www.facebook.com/MagMultiScale

INTRODUCTION: NETS Standards and MMS Key Messages

NETS STANDARD 2A: *Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.*

NASA MMS Key Introductory Messages:

MMS investigates how the Sun's and Earth's magnetic fields connect and disconnect, explosively transferring energy from one to the other - - a process that occurs throughout the universe, known as magnetic reconnection.

MMS reveals, for the first time, the small- scale 3D structure and dynamics of the key reconnection regions where the most energetic events originate.

By observing magnetic reconnection, MMS studies the ultimate driver of space weather, which affects modern technological systems such as communications networks, GPS navigation, and electrical power grids.

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ENGINEER MISSIONS

INTRODUCTION: Students who are working in the role of Engineer are responsible for learning about the design of the MMS satellites and associated launch for the MMS Mission. There are 2 missions within this role: "Mission to Volume" and "Mission to Launch". Each mission will be described below, along with corresponding NETS and MMS Key Messages. The missions are followed by a table listing useful web resources or required links.

MACHINIMA INTRODUCTION: http://www.youtube.com/watch?v=6TeBmegG2JY

"MISSION TO VOLUME" #1. This mission contains 3 activities. They are:

1. Volume of a Cube: Students are asked to cut out, fold, and calculate a paper cube (l x w x h). They should scan the QR code on the cube when they are completed. There they will receive a badge for accomplishing this activity. A good appplication for Ipod or Ipad is: http://itunes.apple.com/us/app/qr-scanner/id377643590?mt=8.
Alternatively, the website for the badge for the Volume of a Cube can be found at: http://www.mrochsner.com/NASA/Volume/cubevolume.badge.htm

2. Volume Design Mission: Students are asked to determine how the 4 MMS satellites will each act as a vertice to measure magentic reconnection in Earth's orbit. Students must create a shape that will capture volume with only 4 vertices points. The goal is for students to design a trangular pyramid from these 4 vertices.

3. Volume of a Triangular Pyramid: Students are guided through how to calculate the volume of the triangular pyramid that will be created by the formation of the 4 MMS satellites.

4. MMS Triangular Pyramid Flight Pattern: Students explore the 3D Photographic monitoring of reconnection will take place within the volume of the triangular pyramid satellites.

"MISSION TO LAUNCH" #2. This mission contains 2 activities. They are:

1. Students should first watch the Newton's Law (Action and Reaction) video from: http://www.youtube.com/watch?v=cP0Bb3WXJ_k&feature=player_embedded

2. After watching the video, encourage students to engage in the Orbital Velocity Mission. In this mission, they will use their knowledge of Newton's laws to successfully launch a rocket into Earth's orbit. The goal of the mission to apply the concepts of thrust, angle, and action/reaction to the orbital launching of the 4 MMS satellites.

3. Lastly, engineers are asked to write a reflection on the practice launches, and on orbital velocity, thrust, and angle, in Edmodo. Reflection question: What made a successful launch and return in your practice? They should click on the badge link when they are completed. There they will receive a badge for accomplishing this activity.

MMS ENGINEERING MISSION RESOURCES: Resources describing the concepts within each engineering mission can help provide teachers with information.

MISSION	TOPICS	WEB RESOURCES
Mission to Volume #1	Volume of a cube, Volume design for MMS satellites, Volume of a triangular pyramid, and MMS Triangular Flight Pattern.	http://www.wolframalpha.com/input/?i=volume+cube http://mathworld.wolfram.com/TriangularPyramid.html http://mms.gsfc.nasa.gov/mission_details.html
Mission to Launch	Newton's Laws of Motion: Action and Reaction, Orbital Velocity.	Youtube Video: http://www.youtube.com/watch?v=cP0Bb3WXJ_k&feature=player_embedded (Action and Reaction) Orbital Velocity Mission: http://sciencenetlinks.com/interactives/Gravity%20Launch2.6.swf Reflection Journal for Collaborative Sharing: What made a successful launch and return in your practice? http://www.edmodo.com/ Badge: http://www.mrochsner.com/NASA/Launch/VelocityBadge.htm

ENGINEERING: NETS Standards and MMS Key Messages

NETS STANDARD:

1. Creativity and Innovation
a. Apply existing knowledge to generate new ideas, products, or processes
b. Use models and simulations to explore complex systems and issues
d. Identify trends and forecast possibilities

2. Communication and Collaboration
a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats
d. Contribute to project teams to produce original works or solve problems

3. Research and Information Fluency
a. Plan strategies to guide inquiry
d. Process data and report results

5. Digital Citizenship
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity

6. Technology Operations and Concepts
a. Understand and use technology systems

NASA MMS Key Engineering Messages:

1. MMS reveals, for the first time, the small-scale 3D structure and dynamics of the key reconnection regions where the most energetic events originate.

2. The four identically instrumented MMS spacecraft fly in an adjustable pyramid-like formation that enables them to observe the 3-D structure of magnetic reconnection. Use of four spacecraft endows MMS with the multipoint measurements needed to determine whether reconnection events occur in an isolated locale, everywhere, or within a larger region at once, or traveling across space.

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RESEARCHER MISSIONS

INTRODUCTION: Students who are working in the role of Researcher are responsible for building a library of resources and concurrently answering 6 main research questions: What is solar wind? What is the magnetosphere? What is magnetic reconnection and how does it convert and harness energy? How do day and night-side reconnection differ? How does reconnection get measured accurately and with high resolution? How do the three processes of reconnection, energy particle acceleration, and turbulence occur in the plasma?

- Each research question will be listed below, along with sample answers taken mainly from http://www.nasa.gov/mission_pages/sunearth/index.html
- The missions are followed by a list of web resources or hyperlinks that will get students started in their research. It is recommended that students also build their own list of research links as well.
- Following the descriptions of each research question and the resources table will be the corresponding NETS and MMS Key Messages.
- Researchers will likely need to share their knowledge via edmodo (http://www.edmodo.com) with marketing specialists.

The researcher mission is introduced with a Machinima introduction that can be found at: http://www.youtube.com/watch?v=85y-s-BvxUQ

RESEARCHER MISSION QUESTIONS

1. What is solar wind?

Students should be able to describe the sun cycle, the resulting solar winds and coronal mass ejections (CME's) which affects modern technological systems such as communications networks, GPS navigation, and electrical power grids. The MMS mission seeks to understand these fundamental physical processes of the space environment from the sun to Earth, to other planets, and to the extremes of the solar system boundary.

2. What is the magnetosphere?

We call Earth's magnetic field and the particles and space within this field Earth's "magnetosphere. Students should be able to define the layer of the atmosphere called the magnetosphere. This will aid them in their subsequent research questions.

3. What is magentic reconnection and how does it convert and harness energy?
Magnetic reconnection is a process that happens throughout the entire universe. It is a process in which the Sun and Earth's magnetic fields are connecting and disconnecting, explosively releasing energy from one to the other. Magnetic reconnection taps the energy stored in a magnetic field and converts it rapidly into heat and kinetic energy in the form of individual charged particle acceleration and large- scale flows of ionized gas.

4. How do day and night-side reconnection differ?
MMS probes both the dayside and nightside of Earth, each with its own reconnection characteristics. The solar wind streams towards Earth until it hits our planet's magnetic field, says Tom Moore, the project scientist for MMS at Goddard. "The solar wind comes flying in and the terrestrial stuff is like molasses – slow, cold and reluctant to do whatever the solar wind wants. So there is a contest of wills whenever the two fields connect up via reconnection.That's what happens on the sun side of Earth. On the other side, the night side, magnetic reconnection in Earth's magnetic tail causes a geometry change in the shape of the field lines. Portions of the magnetic field get disconnected from the rest of the tail and shoot away from Earth. The orbit for MMS will be tailored to hit these spots of magnetic reconnection on a regular basis. The first year and a half will be spent in the day side and the last six months in the night side. In the case of both day- and night-side reconnection, the changing magnetic fields also send the local ionized gas, or plasma, off with a great push. Measuring that plasma – a concrete, physical entity unlike the more abstract magnetic fields themselves – is one way to learn more about what's happening in that process.

5. How does reconnection get measured accurately and with high resolution?
At NASA's Goddard Space Flight Center in Greenbelt, Md., a team of scientists and engineers are working on a crucial element of the MMS instrument suite: the Fast Plasma Instrument (FPI). Some 100 times faster than any previous similar instrument, the FPI will collect a full sky map of data at the rate of 30 times per second – a necessary speed given that MMS will only travel through the reconnection site for under a second. The FPI instrument will measure the plasma in these small regions using electron and ion spectrometers. In order to capture as much as possible in the second-long journey through a magnetic reconnection site, each detector will be made of two spectrometers whose field of view is separated by 45 degrees, each of which can scan through a 45-degree arc for a larger panorama. There will be four dual electron spectrometers and four dual ion spectrometers onboard each MMS spacecraft. In combination, the ion spectrometers will produce a three-dimensional picture of the ion plasma every 150 milliseconds, while the electron spectrometers will do the same for the electrons every 30 milliseconds.
Not only is this approach an improvement of 100 times over previous plasma data collection, it's an advancement in terms of instrument building. For those doing the math: there are four plus four instruments plus one data processing unit on each of four spacecraft, which equates to 32 sensors and four data processing units, 36 boxes total.

6. How do the three processes of reconnection, energy particle acceleration, and turbulence occur in the plasma?

In the case of both day- and night-side reconnection, the changing magnetic fields also send the local ionized gas, or plasma, off with a great push. Measuring that plasma – a concrete, physical entity unlike the more abstract magnetic fields themselves – is one way to learn more about what's happening in that process. Previous spacecraft, such as Cluster and THEMIS have helped narrow down the regions near Earth where magnetic reconnection happens. The solar wind streams towards Earth until it hits our planet's magnetic field, says Tom Moore, the project scientist for MMS at Goddard. "The solar wind comes flying in and the terrestrial stuff is like molasses – slow, cold and reluctant to do whatever the solar wind wants. So there is a contest of wills whenever the two fields connect up via reconnection." That's what happens on the sun side of Earth. On the other side, the night side, magnetic reconnection in Earth's magnetic tail causes a geometry change in the shape of the field lines. Portions of the magnetic field get disconnected from the rest of the tail and shoot away from Earth.

MMS RESEARCH MISSION GUIDING RESOURCES from NASA:
http://sunearthday.gsfc.nasa.gov/2010/multimedia/index.php
http://www.youtube.com/user/nasamms

RESEARCHERS: NETS Standards and MMS Key Messages

NETS STANDARD:

2. Communication and Collaboration
a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats

3. Research and Information Fluency
b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media
c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks
d. Process data and report results

5. Digital Citizenship
a. Advocate and practice safe, legal, and responsible

use of information and technology
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity
c. Demonstrate personal responsibility for lifelong learning
d. Exhibit leadership for digital citizenship

NASA MMS Key Research Messages:

1. MMS investigates how the Sun's and Earth's magnetic fields connect and disconnect, explosively transferring energy from one to the other - - a process that occurs throughout the universe known as magnetic reconnection.

2. Magnetic reconnection taps the energy stored in a magnetic field and converts it rapidly into heat and kinetic energy in the form of individual charged particle acceleration and large- scale flows of ionized gas.

3. MMS probes both the dayside and nightside of Earth, each with its own unique reconnection characteristics.

4. Instruments on MMS will measure charged particle velocities, as well as electric and magnetic fields, with unprecedentedly high (milliseconds) time resolution and accuracy.

5. MMS examines the microphysics of three fundamental space processes: magnetic reconnection, energetic particle acceleration, and turbulence. These processes occur universally in plasmas, the electrically conducting material that accounts for an estimated 99% of the observable universe made of positively and negatively charged particles.

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MARKETING SPECIALIST MISSIONS

INTRODUCTION: Students who are working in the role of Marketing specialists are responsible for the technical marketing and public relations roles of the MMS mission. They will work, in person and through edmodo http://www.edmodo.com, with both Engineers and Researcher roles. Marketing Specialist responsibility may be shared with both of these roles if the roles complete their missions. They will be asked to create activities, artifacts, and multimedia presentations at teacher discretion. Some ideas include:

- Fun Games to Play: to help show understanding of the MMS mission
- Social Marketing: to become engaged in how research and ideas can be communicated socially.
- PSA Videos: to inform the public, both in and out of schools, about the MMS mission
- Print/Web Ads: to illustrate and advertise the MMS mission
- Mission Patch Design: a student-designed project completion patch to be distributed to each member of the group upon completion of the project.

The marketing mission is introduced with a Machinima introduction that can be found at: http://www.youtube.com/watch?v=4xLh95fc724

MMS MARKETING SPECIALIST RESOURCES:

MISSION	POSSIBLE RESOURCES and WEB 2.0 TOOLS
Fun Games to Play	Alice: http://www.alice.org/ STEM http://www.stemchallenge.org/ Gamemaker: http://www.yoyogames.com/ Kodu: http://research.microsoft.com/en-us/projects/kodu/ (Runs on X-Box) Scratch: http://scratch.mit.edu/ StarLogo: http://education.mit.edu/projects/starlogo-tng
Social Marketing	Share information on Facebook: http://www.facebook.com/MagMultiScale Twitter: http://twitter.com/NASA_MMS YouTube: http://www.youtube.com/user/nasamms Facebook Fan page: http://www.facebook.com/SunEarthDayFan YouTube: http://www.youtube.com/sunearthday

PSA Videos	Windows Movie Maker IMovie: http://www.apple.com/ilife/imovie/ Animoto Photostory: http://microsoft-photo-story.en.softonic.com/
Print/Web Ads	Aviary: http://advanced.aviary.com/tools/vector-editor
Mission Patch Design	www.weebly.com

MARKETING SPECIALISTS: NETS Standards and MMS Key Messages

NETS STANDARDS:

1. Creativity and Innovation
a. Apply existing knowledge to generate new ideas, products, or processes
b. Create original works as a means of personal or group expression

2. Communication and Collaboration
a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats
d. Contribute to project teams to produce original works or solve problem

4. Critical Thinking, Problem Solving, and Decision Making
b. Plan and manage activities to develop a solution or complete a project

5. Digital Citizenship
a. Advocate and practice safe, legal, and responsible

use of information and technology
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity
d. Exhibit leadership for digital citizenship

6. Technology Operations and Concepts
a. Understand and use technology systems
b. Select and use applications effectively and productively
c. Troubleshoot systems and applications
d. Transfer current knowledge to learning of new technologies

NASA MMS Key Marketing Messages:

1. MMS is the fourth mission of NASA's Solar Terrestrial Probes (STP) Program. The goal of the STP Program is to understand the fundamental physical processes of the space environment from the sun to Earth, to other planets, and to the extremes of the solar system boundary.