LIVE BROADCASTING OF ASTRONOMICAL EVENTS IN THE WEB

M. Serra-Ricart¹, M.A. Pio¹

¹Instituto de Astrofísica de Canarias(Spain)

mserra@iac.es , mpio@iac.es

Abstract

Since the very beginning of the information technology era, astronomers all over the world were fascinated by the idea that software could contribute to the spreading of science knowledge among the general public. Astronomical events (like solar eclipses or northern lights) and their explanations have always been well received by media and public alike.

As part of this initiative, live broadcasting of several astronomical events were included in the GLORIA project (GLObal Robotic telescopes Intelligent Array for e-Science), with two main goals, broadcast the event live on internet and promote related educational activities.

During 2012 year three webcastings were done: 1) June 6th a Venus Transit from Australia, 2) August Northern Lights from Greenland and 3) November 14th a Total Solar Eclipse from Australia. In the talk we will show main results (astronomical infrastructure & technical aspects) of broadcastings.

Keywords: Broadcast, educational, activities, robotic, telescopes.

1 WHAT IS GLORIA?.

GLORIA stands for "GLObal Robotic-telescopes Intelligent Array". GLORIA will be the first free and open access network of robotic telescopes of the world. It will be a Web 2.0 environment where users can do research in astronomy by observing with robotic telescopes, and/or analyzing data that other users have acquired with GLORIA, or from other free access databases, like the European Virtual Observatory.

The community is the most important part of GLORIA project. Access will be free to everybody who has an Internet connection and a web browser. Therefore it will be open not only to professional astronomers, but also to anyone with an interest in astronomy.

Many Internet communities have already formed to speed-up scientific research, to collaborate in documenting something, or as social projects. Research in astronomy can only benefit from attracting many eyes to the sky — to detect something in the sky requires looking in the right place at the right moment. Our robotic telescopes can search the sky, but the vast quantities of data they produce are far greater than astronomers have time to analyze. GLORIA will provide a way of putting thousands of eyes and minds on the problem. GLORIA is intended to be a Web 2.0 structure, with the possibility of doing real experiments. The community will not only generate content, as in most Web 2.0, but will control telescopes around the world, both directly and via scheduled observations. The community will take decisions for the network and that will give "intelligence" to GLORIA, while the drudge work (such as drawing up telescope schedules that satisfy various constraints) will be done by algorithms that will be developed for the purpose.

2 EVENTS.

One of the most important and relevant points of GLORIA project is to bring the astronomy to the citizen. For this reason, last year we have made some broadcasts of astronomical events of difficult observation, thus bringing these events to the rest of the population.

But in the spirit of serving and helping future generations, together with each of these events, we created an educational activity related to the astronomical event and a web tool, that would allow the students to do such activities in an easy way. Thus useful tools for educators to work with students necessary math concepts and fundamental physics, concepts that will help them in the future.
2.1 Transit of Venus.

2.1.1 Phenomenon

A transit of an astronomical object occurs when it appears to move across the disc of another object which has a larger apparent size. There are different types of transits, like the Galilean moons on Jupiter’s disc, and exoplanets moving across their mother star. But it is the transit of the inner planets, Mercury and Venus, across the Sun’s disc that capture the interest of the general public because the phenomenon can be observed without telescopes.

While there are around 13 or 14 Mercury transits every century (the last one was on 7th May 2003), the Venus transits are an extraordinarily unusual phenomena. On average only two occur in just over a century. These two transits are separated by 8 years and the interval between these pairs of transits alternate between 105.5 and 121.5 years. Sometimes, as happened in 1388, one transit of the pair does not take place because it does not coincide with the passage through a node of the orbit. Only six observations of the Venus transits have been reported: in 1639, 1761, 1769, 1874, 1882 and 2004. The last transit was on 5th-6th June 2012 and it was the last opportunity to observe this peculiar phenomenon, with the next one not taking place until 2117!

2.1.2 Expedition

The expedition was formed of three groups (see Fig. 1): Group1 (G1) Cairns (Australia); Group2 (G2) Sapporo (Japan) and Group3 (G3) Tromsø (Norway), and were coordinated and directed by Dr. Miquel Serra-Ricart, Astronomer of the Institute of Astrophysics of the Canary Islands and Site Manager of Teide Observatory.

2.1.3 Broadcast

The Venus transit lasted 6 hours and 40 minutes. The event broadcast was performed at two levels:

1) Live Connections. Three live connections lasting 70 minutes in total. They coincided with the most interesting points of the transit.

- **Conn. 1**- Venus entered the Solar disc: 5th June 22:04–22:34 UT (00:04–00:34 CET).
- **Conn. 2**- Halfway point of the transit: 6th June 01:25–01:35 UT (03:25–03:35 CET).
- **Conn. 3**- Venus exited the Solar disc: 6th June 04:26–04:56 UT (06:26–06:56 CET).

Figure 1. Observing points of the Venus transit. Locations were: 1) Cairns, Australia 2) Sapporo, Japan 3) Tromsø, Norway.
UT: Universal Time; CET European Central Time

2) Five-Minutes Time-Lapse. From 5th June 22:00 UT and every five minutes the Sun–Venus image was updated from the three points to keep the portal of the broadcast up-to-date.

The broadcasts was bilingual (Spanish and English).

2.2 Northern Lights.

2.2.1 Phenomenon

According to latest predictions, the Sun will start its 24th period of solar maxima in the middle of 2013 (see fig. 1). Solar activity is defined by the number of sunspots detected on the surface of the Sun. As we approach the maximum, the number of sunspots increases, as shown in Figure 2.

![Solar activity plot (sunspot number against time)](http://www.cde.com).

**Figure 2**: Solar activity plot (sunspot number against time). The first maximum corresponds to the last solar maximum (during the end of 2001); predictions indicate that the next maximum will occur in the middle of 2013.

One of the consequences of the solar maxima is that the Sun increases the emission of very energetic elementary particles (solar wind) in what is called solar storms. The main effects the solar maxima have on Earth are:

1) Interference problems in communications networks (terrestrial and satellites);
2) Possible problems with electricity supply due to the massive arrival of electrons at the terrestrial surface;
3) Possible effects on the terrestrial climate;
4) Increase in frequency and luminosity of polar auroras.

During the solar maxima the intensity of the solar wind increases, leading to an increase of flux of elementary particles arriving at Earth. These particles are directed towards the magnetic poles where they interact with the Earth’s atmosphere, causing the aurora borealis (Northern hemisphere) and the aurora australis (Southern hemisphere). The best zone to observe the aurora borealis is in a circle around the magnetic North Pole (between 60 and 70 degrees North). The magnetic pole does not coincide with the geographic North Pole and moves over time. It is currently located off the coast of the Canadian island of Ellef Ringnes, meaning that southern Greenland is well-placed to view the aurorae.
2.2.2 Expedition

The Shelios 2012 expedition was promoted by the scientific-cultural association Shelios and was coordinated by its president Dr. Miquel Serra-Ricart, Astronomer of the Institute of Astrophysics of the Canary Islands. The main objective of the expedition was the observation of the aurora borealis from the South of Greenland, coinciding with the increase of the solar activity.

2.2.3 Broadcast

There were a daily broadcast between 24 and 28 August 2012 from the surroundings of the Qaleraliq glacier (longitude=46.6791W; latitude=60.9896N) located in the south of Greenland (see Fig. 5 & 6). The broadcasts were between 00:30 to 1:30 UT (22:30 - 23:30 local time of the previous day in Greenland, 2:30-3:30 CET; where UT means Universal Time and CET Central European Time). The event broadcast was performed at three levels:

1) Live Connections (stream1). Five live connections lasting 50 minutes in total from 24 to 28 August. Every night 10 minutes- 01:00–01:10 UT (23:00 - 23:10 local time of the previous day in Greenland, 03:00–03:10 CET).

M. Serra-Ricart (spanish) & Vanessa Stroud (English) explained astronomical concepts related with auroras and solar activity and could be watched on the GLORIA live website live.gloria-project.eu and the main collaborator sky-live.tv.

2) One-Minute Time-Lapse. Every night during one hour and every minute an image of the starry night was updated to keep the portal of the broadcast up-to-date. Two color Canon 5D-MarkII with identical lenses were used (separated a minimum of 1km and a maximum of 50km). These images were accessible in order to do the proposed educational activity.

3) Live sky images (stream2). Every night during one hour a B&W night camera point to the sky and will produce a video streaming of aurora movements.
2.3 Total Solar Eclipse.

2.3.1 Phenomenon

After more than a year without any total solar eclipses (the last one took place on July 11th, 2010) the Moon's shadow revisited the Earth's surface on 13th November 2012. The journey of the shadow began in Australia, and then moves out to the Pacific Ocean. The maximum of the eclipse, with a duration of 4 minutes and 2 seconds, was in the middle of the Pacific Ocean at 22:11 UT, with the Sun at 68 degrees above the horizon.

2.3.2 Expedition

GLORIA chosed to observe the eclipse in the northeast of Australia (State of Queensland) around the city of Cairns (totality duration ~ 2 minutes). The three observation points were as shown in Fig. 4, one located on the coast (G3 near Oak Beach) while the other two were in the inner zone (G2 at 81 Rt road, G1 in Mareeba town). The Shelios Association (shelios.org) was responsible for the planning, logistics and execution of the expedition, which were coordinated and directed by Dr. Miquel Serra-Ricart (Astronomer from the Institute of Astrophysics of the Canary Islands and Manager of Teide Observatory). The “lie of the land” at each observing location can be seen in Figs. 5a, 5b and 5c.

![Figure 4: Observation points of the expedition. The red line indicates the centre of the band of totality. One observation point was located on the coast and two were inland (red dots G1, G2 and G3).](image)

2.3.3 Broadcast

The total duration of the eclipse was 1h 50m and the retransmission was performed in two ways:

1) Live: There was a live connection with a total duration of 15 minutes to encompass the second (C2) and third (C3) contacts and with streaming images of the Sun from the three locations G1, G2 and G3. From location G1, astronomers Miquel Serra-Ricart and Vanessa Stroud provided commentary in Spanish and English.

Connection: Contacts 2 and 3 – 13th November 20:30 to 20:45 UT (21:30 to 21:45 CET).

Note: The local time at the observing sites were 6:30 to 6:45 Australia EST (14th November).
2) Time-lapsed: From 19:45 UT on November 13th, and every five minutes thereafter, the image of the Sun (partially eclipsed by the Moon) was refreshed from the three observation points.

3  EDUCATIONAL ACTIVITIES.

As we said before, we made an educational activity for each event, even for the Transit of Venus we made two, and here we are going to explain them a little bit. You can find the educational activity in this address, [http://gloria-project.eu/venus-transit/didactic-activities/](http://gloria-project.eu/venus-transit/didactic-activities/)

3.1  Transit of Venus.

For this event, we made two different activities. In the first one, the main objective is use directly images of the Transit of Venus taken from two different sites in the world, and with them calculate the distance between Earth and Sun (parallax). In the second one, the objective is calculate the latitude of the observer that take images of the Transit, just measuring the height of the Sun above the horizon.

3.1.1  EDUCATIONAL ACTIVITY 1. Calculating the Earth-Sun distance from images of the transit of Venus.

Were taken pictures from Sapporo at the North of Japan and from the near Cairns, simultaneously. With this images we produce an manual with you can messuare the distance between Earth and Sun. (Ref [1])

Linked to this, we have also created a web tool to perform calculations more easily by the students, located in: [http://www.gloria-project.eu/webcalc/](http://www.gloria-project.eu/webcalc/).

3.1.2  EDUCATIONAL ACTIVITY 2. Calculating the Latitude of the observation site from images of the Midnight Sun.

From Tromsø, in the northern of Sweden, were taken pictures for the Transit coinciding with another phenomenon called *The Midnight Sun* and with this images, the students can calculate the latitude of the observer (so the latitude of Tromsø) just measuring the height of the Sun in the images. (Ref [2])

3.2  Northern Lights.

3.2.1  EDUCATIONAL ACTIVITY 3. Calculating the height of formation of the Northern Lights.

The height at which a polar aurora forms can be calculated from photographs taken by two observers spaced several kilometres. Each observer will see the same aurora projected on a background of stars slightly different. This angular separation can be measured, and knowing the distance between the two observers (by its location on a map or GPS), you can calculate the height where the aurora was produced. By this procedure, the Norwegian physicist Carl Störmer using 40,000 photographs obtained between 1909 and 1944 estimated the altitude limits of the aurora: 70 to 1,100 km, with an average around 100 km altitude (Ref [3]).

3.3  Total Solar Eclipse.

3.3.1  EDUCATIONAL ACTIVITY 4. Measuring local atmospheric changes during the solar eclipse (2012 Total Solar Eclipse)

An interesting effect that occurs during the course of an eclipse, more remarkable in a total eclipse, is the decrease of the environmental temperature due to the decrease of the solar radiation or ambient brightness (see Ref. 8 in the reference document). The interesting thing is that the phenomenon does not occur instantaneously when the sun is completely covered (maximum eclipse or second contact), but is an effect that occurs after a time ranging from 2 to 20 minutes.
This time delay depends on many factors, such as the time of day when the eclipse occurs, the presence of nearby bodies of water such as a lake or ocean, proximity to wooded areas, but it is easily measurable. The time at which the minimum intensity of light occurs, coincident with the maximum Eclipse (second contact) must be noted. Then, the time at which the temperature is a minimum is also recorded. The thermal response of the atmosphere or the atmospheric thermal inertia is the time interval between these two minima (Ref [4]).

Also, linked to this, we have also created a web tool to perform calculations more easily by the students, located in: http://gloria-project.eu/eclipse-meteo/

4 INFRASTRUCTURE.

4.1 Portal Web of the Broadcast.

For all the Live broadcast that the infrastructure deployed was based on a VMware vSphere 5 Cluster (http://www.canarcloud.es/vmware/) over an Intel Nehalem architecture, interconnected to a centralized iSCSI RAID storage, capable of supporting the load of thousands of requests against the portal along with a broadcast DNS balancer, which will link all web instances, both physical and virtual from all the collaborators, ensuring equitable load distribution of all the visits to the website between all instances.

![Figure 5: A diagram of how the infrastructure of the Web request was made.](image)

The operation of this architecture was as follows:

- Customers make a request to the website of the broadcast, which should be designed so that its size (in bytes) is the minimum possible.
- A Load Balancing system decides which of the servers in a cluster will serve each request that comes in terms of the policy implemented.
- The server selected by the load balancing serves the client
4.2 Web Partners.
We request the cooperation of public or private institutions, associations, foundations, etc. to help in the dissemination via Internet of the main portal of the broadcast (live.gloria-project.eu) in an attempt to prevent the collapse of massive confluence of requests.

4.3 Advanced Web Collaborators
Have collaborated with one or more heavy machines compatible with VMware vSphere 5, with 3 or more IPs and a bandwidth of 100 Mbps or more integrating these machines as remote nodes of the cluster.

4.3.1 Websites with embedded player
Besides the previous contributors, we also found websites that requested the addition of a player on their websites consuming our video signal but independently supporting web visits.

4.4 Video streaming.
The infrastructure deployed by CanarCloud (www.canarcloud.es) was based on a cluster of instances Wowza 3.1.2. on Amazon Elastic Compute Cloud (Amazon EC2) in a configuration of 100 repeaters along with DNS balancer, which interconnected all repeater instances to support up to 60,000 simultaneous visits, ensuring equitable load sharing to all visits among all instances.

![Broadcast Infrastructure – Live Video](image)

**Figure 6:** A diagram of how the infrastructure of the Video streaming during the different broadcast was made.

4.4.1 Video Collaborators
Wowza collaborators
Contributors with one or more machines compatible with VMware vSphere 5, as we explained before, but with a bandwidth of 1 Gbps have collaborated integrating these machines as remote nodes of the
cluster and enabling deployment 3.1.2 Wowza instances joining to the instances deployed by CanarCloud.

Televsions and Repeaters

Contributors with Live-Stream infrastructure have been redeployed our own signal through their web portals or television

5 STATISTICS.

5.1 Portal Web broadcast.

To obtain statistics of visits of the web portal of the broadcast, was enabled a statistics collection service of Google Analytics for global data of the portal and locally the Awstat collector to analyze the individual contribution of each collaborator. Here we presented only the the statistics obtained with the Google Analytics service, just to summarize and compare results.

5.1.1 Transit of Venus.

Under Google Analytics service we can see that in the analysed period were obtained 52.674 visits and 86.581 pages visits, with a maximum of 11.245 visits and 23.172 pages shows at the beginning of the first connection as we see in the chart below.

![Figure 7](image)

Figure 7 : Picture to see the moment of the maximum access.

5.1.2 Northern lights.

Under Google Analytics service we can see that in the analyzed period we obtained 21.163 visits and 32.769 pages visits, as we can see in the following graph.

![Figure 8](image)

Figure 8 : Picture to see the moment of the maximum access.

5.1.3 Total Solar Eclipse.

Under Google Analytics service we can see that in the analyzed period we obtained 186.298 visits and 249.994 pageviews, with a maximum of 33.946 visits and 54.554 pageviews at the time of the broadcast, as we can see in the chart below.
5.1.4 Asteroid transit 2012-DA14.

This phenomenon had a special treatment, because we did not make live broadcast but we were putting images of the asteroid in real time.

Under Google Analytics service we can see that in the analyzed period we obtained 153,756 visits and 397,553 pageviews, with a maximum of 35,877 visits and 108,387 pageviews, as we can see in the chart below.

REFERENCES