IAC-11-E1.5.2

ISSLIVE! – BRINGING THE SPACE STATION TO EVERY GENERATION

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Just 200 miles above us, the International Space Station (ISS) is orbiting. Each day, the astronauts on board perform a variety of activities from exercise, science experiments, and maintenance. Yet, many on the ground don't know about these daily activities. ISSLive! - an education project - is working to bridge this knowledge gap with traditional education channels such as schools, but also non-traditional channels with the non-technical everyday public. ISSLive! provides a website that seamlessly integrates planning and telemetry data, video feeds, 3D models, and iOS and android applications. Through the site, users are able to view astronauts' daily schedules, in plain English alongside the original data. As an example, when an astronaut is working with a science experiment, a user will be able to read about the activity and for more detailed activities follow provided links to view more information – all integrated into the same site. Live telemetry data from a predefined set can also be provided alongside the activities. For users to learn more, 3D models of the external and internal parts of the ISS are available, allowing users to explore the station and even select sensors, such as temperature, and view a real-time chart of the data. Even ground operations are modelled with a 3D mission control center, providing users information on the various flight control disciplines and showing live data that they would be monitoring. Some unique activities are also highlighted, and have dedicated spaces to explore in more detail. Education is the focus of ISSLive!, even from the beginning when university students participated in the development process as part of their master's projects. Focus groups at a Houston school showed interest in the project, and excitement towards including ISSLive! in their classroom. Through this inclusion, student's knowledge can be assessed with projects, oral presentations, and other assignments. For the public citizens outside of the traditional education system, ISSLive! provides a single, interactive, and engaging experience to learn about the ISS and its role in space exploration, international collaboration, and science. While traditional students are using ISSLive! in the classroom, their parents, grandparents, and friends are using it at home. ISSLive! truly brings the daily operations of the ISS into the daily lives of the public from every generation.

I. BACKGROUND AND PROJECT OVERVIEW

ISSLive! started in early 2010 at the NASA Johnson Space Center (JSC) as an innovation project with the intention of releasing current space station crew timeline data to the general public. This timeline data includes the daily schedules of the astronauts on board the ISS, science timeline data, and generic information about each daily activity. Through this release, ISSLive! will provide some new insights on how the space station operates and what occurs on board. During a field research opportunity at a local Houston middle school in May 2010, students were able to identify with this kind of information and showed an active interest in the project. Over the course of the year and half since the projects' conception, ISSLive! evolved into an ambitious proposal to include not only timeline data,

but also real-time streaming telemetry data, current video and audio streams from the ISS, and integrated educational lessons that use the data provided on ISSLive! as a means to further understanding. ISSLive! accomplishes all of this in an innovative way built with the idea of meeting the future needs of the ISS program just as well as it does today.

II. ISSLIVE! – DELIVERING THE ISS

ISSLive! is designed to capture the attention of today's increasingly technology focused society by targeting handheld smart devices as well as traditional computers. Today, many have smart phones or tablets; the words "Twitter" and "Facebook" have entered into our lexicon. With this in mind, it is critically important that ISSLive! delivers the dynamic and interactive rich internet experiences that are expected by today's users while focusing on providing an educational experience for students and life-long learners. In order to accomplish this, ISSLive! is comprised of an interactive website, iOS applications, Android application, and mobile-enhanced website. All of these modes of accessing ISSLive! share a common data source, but each will present the user that information in a slightly different way, optimized for each mode of communication. This section discusses the various components of ISSLive! and also presents conceptual designs for the ISSLive! website.

Bringing Everything Together

One of the biggest aspects of ISSLive! is the fact large datasets from various aspects of the ISS program are integrated into a single environment like never before. Instead of having to visit multiple websites to find out everything that is going on onboard the ISS and also to learn about its core systems, flight control positions, orbit location, and systems status a visitor can simply go to one website and retrieve all of this information. Much of this data integration work is accomplished via backend components of ISSLive!, most of which the everyday user will never see directly. Examples of this include a push-server to serve out approximately 300 of the most common and interesting telemetry parameters from the ISS and the translator application, which takes current planning, crew scheduling, and communication data from various NASA systems and puts it in a public friendly language and format.[1]

Timeline Displays

The main feature of ISSLive! is the ability to see in near-real-time the daily schedules of the astronauts onboard the ISS. During field research performed by a team of graduate students at Carnegie-Mellon University, it was shown that there is an interest in knowing what is going on onboard the ISS, and that during certain activities such as extra-vehicular activity (or a spacewalk) this interest increases greatly.[2] Due to this demonstrated interest in the daily lives of astronauts on board, ISSLive! includes several different timeline displays for the public. The first display, as shown in figure 1, provides an overview for all of the crew members onboard at the specific time of day that the user is looking at.

Figure 1. Concept View of the Overview Timeline Screen in ISSLive!

A second display (shown in figure 2), customized for each individual crewmember, provides more details for that specific crewmember and his planned daily activities. Integration with Twitter®, Facebook®, and other social media outlets are available, giving visitors quick and easy access to already existing ways to connect with the space program. It is also possible to dig-down into specific activities from this screen by viewing an explanation of the activity and links to visit in order to gain more information. This is especially true for the science timeline, which is the final timeline display in the project. The science timeline integrates various on-board science activities into a single timeline, and provides information about each science activity along with reference material to get greater details. In the past, this information was not easily accessible by the public – but ISSLive! will integrate this all into a single location and provide easy access to existing additional resources already provided by NASA and other space agencies and their partners.

Figure 2. Concept View of the Crew-Specific Timeline Screen in ISSLive!

Three-Dimensional Interactions

A key aspect in today's world is the ability to interact with what we experience in the digital world. Even video games have begun to change from simply sitting in your chair with a controller to you actually becoming part of the experience. With this in mind, ISSLive! utilizes a popular and widely used three dimensional software program to bring both the ISS and the Mission Control Center (MCC) in Houston to life for visitors to interact with. An example of how this is presented to the visitor is shown in figure 3. The particular program selected to develop the three dimensional experience also allows for the same or similar experiences to occur within the handheld, mobile environment which allows for a more unified and seamless experience with ISSLive! from a visitors computer at home to their mobile devices.

Figure 3. Concept View of the Three Dimensional Interactive Models within the ISSLive! environment. This concept shows the ISS MCC, which is located in Houston, Texas, United States.

The environment created by the model allows students to directly interact with either the MCC or ISS in a virtual environment. During the research by our Carnegie Mellon* team, they indicated that "… students expressed a lack of interest in telemetry as a whole because they didn't understand what every term meant and the types of data it encompassed, however, when asked if they would be interested in knowing about how humid it is on the ISS or how far the ISS is from where they are standing, they placed these topics in the category they would like to learn more about."[2] To address this issue, the virtual environment of the MCC allows students and visitors to directly "sit" at a flight control console and see in a format that they understand what the flight controller there would see. An example of this is shown in Figure 4. Instead of technical terms, the displays used in the model would relate directly to something that students understand, such as, in the example above, the humidity of the ISS, the temperature of the space station, and so on.

Gradually, students would be introduced to the technical terms and find out that this is *telemetry*, and hopefully spark their interests in finding other pieces of telemetry, now a familiar term, that are interesting to them. Reference materials provided, and to be discussed shortly, provide the ability to dig deeper into each aspect of the ISS and MCC, should the student or visitor choose to do so. The ISS version of the model would do much the same, but allow students to interact with the ISS. Read-outs from various sensors may be displayed in the model, at the location in which the sensor is found onboard. It is then possible to switch to the MCC display, and see that that same data is transmitted to the ground and viewed directly by the flight control teams on the displays that the students have previously interacted with.

* As part of their graduate studies in Human Computer Interaction, a team of students from Carnegie Mellon conducted research both at NASA/JSC and in the field. Their research was used in the creation of their own iPad application for ISSLive! and also incorporated into other aspects of ISSLive!

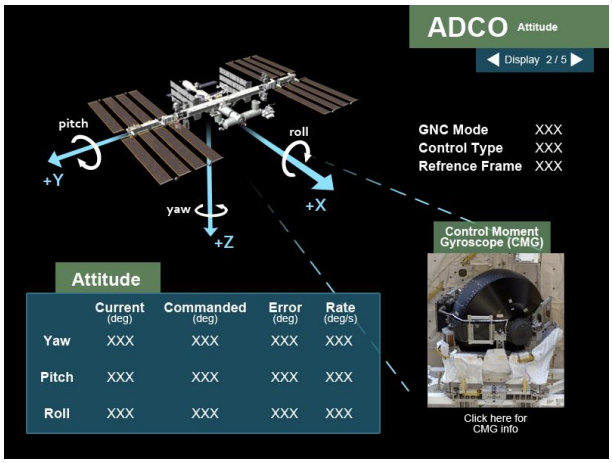

Figure 4. Concept View of one of the Flight Controller Displays. This display is for the ADCO position, and shows current ISS attitude information.

Of all of the different components of ISSLive!, the three dimensional models truly bring the most interactive and realistic virtual presence experience to the students and visitors, and when paired with the other reference aspects of ISSLive!, make it something that users will want to return to – as opposed a single static experience that never changes, every time a user visits the website or application, they will not be presented with the same data or same set of static activities.

Integrated Video and Audio Feeds

While the simulated environments provide a near-realistic interaction for the students, it was also needed to present them with the reality of the MCC and the space station as it exists in the real world. In order to achieve this end, already broadcasted and published NASA video and audio feeds will be provided where appropriate throughout the site. One noticeable example of this is in figure 1; live mission control video is displayed alongside the overview timelines. This drives home the connection that the data that they are looking at is actual data in near-real time and has a solid grounding in the world in which they live in each day. Without this integration, it would be easier for visitors to disconnect the site with the real-world, and think that it was something made to show them an example of what might happen day to day, instead of showing them what actually is happening day to day.

Integrated Reference Materials

ISSLive! provides detailed reference materials on various MCC console positions and related ISS systems. These reference materials, in an academic sense, provide greater detail and understanding then simple interaction with the other aspects of ISSLive! can supply. It is expected that students will use these materials while they are pursuing their coursework, especially that which has been and will be developed for use with ISSLive!

III. INTEGRATING STUDENTS DURING DEVELOPMENT

Student integration with ISSLive! has been a critical part of the project from the beginning. As was shown with previous projects like KidSat and the ocean-observing project, we knew that ISSLive! could be brought to the classroom. These projects provided students with direct access to data and in the case of KidSat, direct control of cameras onboard space vehicles.[3] Each of these projects was successfully integrated into the classroom environment. Wanting the same goal with ISSLive! it was critically important to involve students from the beginning. They would not only help with the development of ISSLive! but also become the end-users.

To achieve this goal, the project team has integrated students and teachers across all grade levels. In May 2010, the core project team visited a local Houston area middle school to conduct field research. Over the course of a day, students had the opportunity to learn about the ISS, NASA, JSC, and the astronauts' schedules. Students were asked at the end of the day to complete a "quiz" that included attempting to provide, in their own words, a name for the activities that astronaut's onboard the ISS could be working on. Students were provided only with original NASA data, and the knowledge that they had learned over the course of the day to complete this exercise. These responses helped shape the development of the translator application. In addition to the paper responses, verbal feedback was collected from the students on what they would like to learn about the ISS; feedback was collected from teachers on how they felt ISSLive! could be integrated into their own classrooms and lesson plans. The curriculum development team has also brought in secondary school teachers to assist with the creation of specific lesson plans for advanced placement (AP) students; this involvement helps to make sure that teachers will be able to successfully integrate it into their own classrooms.

Beyond secondary school involvement, the project team also brought in graduate level students to conduct their own research and also contribute to the development of an iOS application for ISSLive! The study conducted by the student team included interviews with students, teachers, and NASA flight controllers. Their final report provided vast insights in how to motivate students and teachers to integrate ISSLive! into the classroom, as

well as providing data on how to best design the software to spark interest with this audience. While the student team is designing their own iOS application, their recommendations have impacted all aspects of ISSLive! Examples of this include the interface development for the main website, classroom lesson plan development, and determining how to best present the vast amount of data to students in a way that is understandable, motivating, and exciting for them. The student team's independent iOS application also serves as a test case in application development that uses the data provided by ISSLive! but outside of the main ISSLive! environment.

As shown, student integration within ISSLive! has spanned not only all phases of the project, but also from elementary to graduate student levels. This involvement has not only resulted in a higher quality educational product, but also one that truly looked at the end-user before development began. By doing so, the end-user is presented with an experience that not only engages them as they want to be engaged but also provides the entire set of the data that the core project team identified in early 2010. Without this level of integration, it would have been unlikely that both a high quality product and all intended data for release would have been available. ISSLive! started fulfilling education goals even before release to the public.

IV. BRINGING ISSLIVE! TO THE CLASSROOM

Getting ISSLive! into the classroom is critical to achieving one of the stated goals of the project. Doing so is not an easy task, as As stated "for technology-based and data-enhanced educational experiences to become incorporated into the classrooms, the experiences must be meaningful, engaging, dovetail into standard [science, technology, engineering, and mathematics (STEM)] curricula and address educational standards"[4] All of these aspects have been looked at and incorporated by the ISSLive! team. The experiences that a student would gain by being able to "be a flight controller" in the simulated mission control environment are meaningful and engaging.

In order to facilitate integration into the classroom, these experiences play key roles in the lesson plan development aspect of ISSLive! Our lesson plan development team includes industry professionals, current and former teachers, and works directly with the ISSLive! development team. From the beginning, it was identified that any educational content would a) match NASA-identified STEM educational goals, b) match directly to United States national standards for STEM curriculum, and c) be developed with and by teachers that would have the opportunity to bring it to their classrooms. With the ISS recently being designated a United States National Laboratory, getting students involved and excited about the work that is going on onboard is critical to inspiring the next generation of engineers and scientists. ISSLive! provides a unique, hands-on model for education which is currently not available elsewhere.

For the initial phase of the project, eight lesson plans are to be developed, with the first to become available in October of 2011. Each of these eight lessons will focus on a system of the ISS, such as life support or thermal control. Students will be asked to understand the specific scientific concepts that relate to each system. One example of this could include such questions and concepts as these for the life support system: Life Support must be able to process carbon dioxide and produce oxygen, how can it accomplish this and at what rates does it need to do so in order to keep the environment safe? Throughout the associated lesson, students would learn how the system worked, come up with their own ideas and thoughts, and be tested on this information and predications. The integration of real-time life support system data and telemetry feeds not only enhances the entire lesson from beginning to end, but creates a real-life connection to their educational content – a key finding of the research performed by the ISSLive! graduate team.[2]

For the first lesson, the focus is on the oxygen generation system and the ETHOS console position. Specific areas to be explored include reactions, electro-chemistry, and stoichiometry. While the content in these lessons are specifically designed for AP students they are adaptable to multiple grade levels and curriculums. The ISSLive! educational team is currently working on identifying the remaining seven initial systems for lesson plan development, and over the course of the 2011-2012 United States academic year plans on developing and releasing these lessons. A challenge for lesson plan development is that they are built with ISSLive! integration in mind, which requires them to link to a set of approved telemetry values that ISSLive! displays. While ISSLive! currently displays around 300 telemetry values, there are over 100,000 available. For some lessons, enough values are not currently provided publically to produce high quality lessons. This issue is being worked by the entire ISSLive! team to bring more telemetry values to public display, thus increasing the options for educational lesson plan development.

When complete, the educational lessons will complete the goal of making ISSLive! accessible to students not only at home but directly in their classrooms. These lessons are directly tied to what they are learning across

all of the STEM disciplines and will help to inspire our next generation of engineers. When the students leave the classroom for day, we hope that they are excited enough to encourage their parents, grandparents, and relatives to explore what ISSLive! has to offer, allowing us to reach our other main audience: life-long learners.

V. BRINGING ISSLIVE! TO LIFELONG LEARNERS

At a recent workshop on lifelong learning hosted by the National Academy of Engineering identified that engineers should "expand their learning over a lifetime because their career trajectories will take on more directions, many new, due to the rapidly changing technologies"[5] ISSLive! helps facilitate lifelong learning by providing a framework to understand how the "greatest engineering achievement" functions in a day to day environment. Wanting to learn is not limited to those in their school years, and for many the only opportunity that they will have to learn about the space station is after they have graduated or moved on from school. Lifelong learners will find the integrated references the most useful in learning the details of the station. Combining these with the other resources that ISSLive! provides as has been mentioned previously create an experience that further enhances this learning.

One of the greatest aspects of ISSLive!'s appeal to lifelong learners, especially parents, is that they can follow along with their own children who are using the program in school instead of simply hearing about it but never seeing it. This truly bridges the education gap, extends the audience of ISSLive!, and brings the international space station to every generation.

VI. THE FUTURE VISION

ISSLive! is just beginning. While October 2011 will mark the first official release and the completion of the majority of the major development work of ISSLive!, it will not be the last release and update to the site.

Work is currently continuing on development of additional educational lessons, and they are expected to be rolled out over the year following the main release. Additional educational products are currently being assessed on how they can be integrated into the ISSLive! environments. Another major goal of the team is to continue to increase the amount of live telemetry data that is being pushed out to the public of the approximately 100,000 values that are sent down from ISS on a regular basis. Finally, ISSLive! was not meant to be the only user of the data that it provides. Work is currently ongoing to develop a fully functional application programming interface (API), which will allow anyone who wishes to develop their own application to get the same data that ISSLive! has. This data includes timeline, telemetry, and communications status. The future for ISSLive! is bright, and with it we hope to inspire not only the next generation but also all of those that have come before and those that will come after.

[1] Healy, Matthew D. et al. "ISSLive! Translator: From NASA Operations Nomenclature to Every Day Language" Biennial Research and Technology Report, Johnson Space Center (2011). Print.
[2] Dudiak, Eric et al. "Team Pyxis Research Report Spring 2011." (2011) : 1–128. Print.
[3] Way, J et al. "The KidSat Project." Geoscience and Remote Sensing, IEEE Transactions on 37.4 (1999) : 1753–1767. Web.
[4] Hotaling, L. "Using Observing System Data in STEM Education." Oceans 2007 (2007) : 1–3. Web.
[5] Dutta, Debasish. "Lifelong Learning Imperative in Engineering: Summary of a Workshop." (2010). 1-38. Print.