MISD CENTER FOR ASTRONOMICAL STUDIES PROPOSAL

THE FEASIBILITY AND IMPACT OF AN ASTRONOMY CAMPUS UTILIZING OBSERVATORIES FOR SOLAR, PLANETARY, AND DEEP SKY SCIENCE AND EDUCATION

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SUMMARY

Mansfield ISD schools have tools to facilitate modern ASTRONOMY education. However, it lacks access to these tools. What follows is a proposal for a way to give Astronomy students *at all levels* a way to access our astronomy tools (and its data) **daily**, transforming this traditionally classroom-based discipline into, quite literally, a universe-sized *laboratory*. If the details outlined in this document come to fruition, Mansfield ISD will become a trailblazer in the area of astronomy education, the reach of which will grow beyond its regional stance to have a major impact upon science education statewide, nationally, and perhaps, even globally.

A rare few ISDs and private schools have attempted to expand their Astronomy programs in order to give students learning opportunities **outside** of the classroom, presumably because it is "too difficult" or "too costly" to do. Those with such an ambition opt to do so by constructing large and costly *planetariums*. We have seen it locally at the high school level, at Mesquite ISD and St. Marks School of Dallas, for example. However, the educational benefits of such facilities become confined to existing "shows" or programs, the likes of which must be created or purchased, good for one, maybe or two days per year of educational value and student involvement at outrageous staffing and transportation costs. Planetariums yield a very limited overall impact, with an awful cost/benefit ratio.

To be fair, some astronomy educators have attempted to utilize existing opportunities via Internet, tapping into shared science and "Citizen Scientist" types of programs. This, of course, is a good start in the right direction. However, alignment with state objectives is an issue; and too much is required in terms of expertise of the individual teacher.

For the average Astronomy teacher (or primary level teacher) with very little means, there is too much lacking. Teachers are left alone to discover other ways to make astronomy education fun and interesting, perhaps with a couple of "viewing nights" during a calendar year; or through classroom activities like model-building or giant scale solar systems; or perhaps through observing logs, where a student remembers (hopefully) to look up at the moon during the course of a semester.

To make the course more applicable in this district, many MISD Astronomy teachers have been acquiring astronomical instrumentation for several years now.

But *collecting equipment* also comes with another set of problems. After all, *how do you make best use of this "night time" equipment during a "day time" school program*? Because of this, truth be known, these assets are underutilized, and in some cases, **never utilized** because of the logistical headaches that are involved - not to mention weather! Likewise, some MISD telescopes exceed 200 lbs. in weight. Therefore, in order to get the full educational and scientific potential from these existing (and future) assets, a permanent facility is required because they lack true portability.

Unlike the planetarium, today's technology makes the centralization of these astronomy tools within an actual **observatory** quite easy. In fact, such small, working observatories have become very much the domain of amateur observatories all over the world. And being located on the southern side of the Metroplex and already owning district properties much darker than typical urban and suburban skies, the feasibility of a local observatory or "Center of Astronomical Studies" makes much more sense for a district like Mansfield ISD.

Coupled with that is the need to develop programs, with supporting curriculum, for the utilization of a whole new level of access to these tools. Since astronomy education, through 21st century technologies, could then be directed toward all students and at all levels, then programming to make this happen becomes a necessity.

PURPOSE

In this document, we will describe a phase approach for the construction of an "Center of Astronomical Studies (CAS)," a facility that allows for connectivity to MISD astronomy assets on a daily basis and a data-collection medium for continuous (i.e. daytime) classroom study. Included will be a description of the required components/costs needed and a clarification of the cost/benefit ratio to the district.

We will also include aspects of the programs and curriculum pieces, describing ways that we can assure that the "MISD Center for Astronomical Studies" has maximum yield within the district's overall educational programs. We will talk about the ways our program and facilities can become self-sustaining. We will address issues of resources, staffing, obsolescence and scalability requirements in both the short and the long terms.

There is much to discuss!

For future reference in this document, the concept of the "MISD Center of Astronomical Studies" will be referred to collectively as MISD CAS, CAS, or simply the "Astronomy Center". These terms are specific to the entire facility on the whole. Specific structures and features of CAS will be referenced by individual names.

When people think of an observatory, they picture a huge telescope atop a mountain somewhere. But what we have seen is that observatories (and their telescopes) do not have to be as large as the Keck Observatories in Hawaii, nor do they have to be as well-known as the Hubble Space Telescope. Instead, think smaller. **Much smaller.** Today, the astronomy "hobbyist," equipped with off-the-shelf hardware and software, can now build an observatory (think "enclosure") with a "hobbyist" budget.

Because of this fact, the vast majority of traditional astronomy is NOW accomplished not by professionals, but rather by amateurs.

Obviously, this is made possible because of the technology (chiefly due to advances in camera technology) that is readily available today and the small amount of capital that can purchase this technology. In fact, with an Internet connection, a $500 telescope (or less) can actually be controlled from the opposite side of the world and most of these modest telescopes can be setup to run unattended. Astronomy observations can now be remotely controlled, even scripted to run via automation. ***The "Robotic Observatory" is born!***

The result is an amateur astronomer, with strategically chosen tools, controlling astronomy equipment from inside the home, even watching television and helping their kids with homework, **simultaneously** doing astronomy. Today, when an amateur astronomer goes to bed, the astronomy gear is waking up, already programmed with the work to be accomplished that evening.

This capability did not exist 15 years ago.

But today, it is fast becoming the rule, not the exception.

This shift in the direction of astronomy is important to science on the whole. Because the amateur is now capable of doing what the big observatories once did, the professionals can now focus on loftier inquiries. While McDonald Observatory is bringing its astronomy power to bear on the difficult cosmological puzzles, amateurs with a little bit of time, ingenuity, and extra cash can do things like all-sky surveys to find comets, novae, and supernovae; or take spectra of previously unmeasured stars; or chart the cycles of variable stars. Even more mind-boggling is that amateur gear can even detect planets in orbit around OTHER stars.

Can a Mansfield ISD student accomplish these things? Absolutely. And in a way, it's outlandish that they haven't already.

In reality, the power and amazement can be found within the simple things that we can do, such as capturing pictures of the cosmos (remotely via Internet); logging lunar, solar, and planetary data; using data of all types to supplement daily classroom activities; and providing participants with a sense of awe and an enjoyment of the learning process.

The foundation and technical "savvy" to transform Astronomy education currently resides within MISD personnel, most notably the authors of this document. And the costs, especially compared to the benefits, are insignificant to a school district this large.

Thus, the question is not, "Does MISD have the resources to best utilize this project?" but rather, "Why aren't we pushing forward to reap the substantial benefits of it?"

In early summer of 2002, Dr. Fred Koch of Quanah, Texas, began providing equipment for the Copper Breaks State Park's Astronomy Program. As a volunteer to their monthly "Star Walk," Jeff Barton and I began contemplating ways to expand the programs by providing non-traditional forms of public observing. Jeff had experienced limited success in using video cameras to display "live" images over a small video monitor of what the scope was "seeing."

But the first truly positive response from the public crowds occurred when Jeff and I used my automated Meade 10" LX200 telescope and SBIG STV integrating imaging camera to project deep sky objects and planets onto displays large enough for several people to see simultaneously. Crowds began to gather around the displays, becoming transfixed to what was happening, quite literally, in real-time. Seeing the public interest in this, and knowing that CCD cameras were the future of providing interesting, entertaining, and educational content for such groups, Dr. Koch began to help fund these efforts more fully. ***Thousands*** of visitors were impacted by those early efforts.

Those efforts turned into a for-education, non-profit 501(c)3 corporation, the Three Rivers Foundation (www.3rf.org). Today, "3RF" has a science division, which now exists primarily as a 700-acre astronomy campus near Crowell, Texas, featuring facilities to house up to 100 visitors overnight and hundreds of visitors per weekend. They host twice-monthly open-public events, in addition to private events hosted throughout the year. Serving as their first Director of Astronomy during its first 3 years of existence, author Jay Ballauer had the pleasure of organizing and running their earlier on-campus efforts and installing much of the current technology, including several of their observatories, one of which can be demonstrated as "proof of concept" for our MISD efforts.

Simply put, witnessing first-hand the public impact of available technology during those first StarWalks provided the impetus toward the ambitious pursuit of a greater reach **with** these technologies, enough so to form the para-educational institution known as 3RF.

What was learned from our 3RF experience?

Today, 3RF continues to impact those who visit, but it relies on associations with educational institutions (chiefly Regional ESCs, local schools, and scouting groups for new visitors). Unfortunately, although 3RF employs technologies to allow for off-site, remote usage, most of the general public have yet to understand how uniquely impactful this astronomy campus is in itself. Unless a person commits to the more than 3 or 4 hour drive west of Dallas-Fort Worth (or any large urban area), he or she will not be able to appreciate what is being missed.

This is the dilemma with astronomy. In order to appreciate stars, you typically have to drive away from the city lights for many hours to see them.

Astronomy education has suffered the same fate within our schools. Unless you have a way to bring darker skies closer to home, or extend such astronomy facilities "virtually," you are left with a study that becomes unapplied; or, in the least, is

Image of M45 – The Pleiades - Taken by Jay Ballauer via remote Internet connection in 2008, from Grapevine, Texas, to a small observatory at Comanche Springs Astronomy Campus (3RF) near Crowell, Texas.

extraordinarily difficult to apply. This leaves a course on Astronomy to be taught out of a textbook, despite the fact that the Texas Education Agency requires such a class to have at least **40% of high school instruction coming from lab or field studies; and up to 80% at the primary school level.**

This is where technology comes in. Today, we have the ability to extend the functionality of an observatory via the Internet, using camera technologies that make the need for a "dark-sky" site somewhat unnecessary. We can also do this in way that does not require a physical presence to do an observation. A relatively ***new way*** *of doing astronomy, perhaps a decade old, this connectivity has only very recently become quite reliable.*

There is nothing fancy about the technology either. Astronomy hardware (mounts, focusers, cameras, observatory encoders, etc.) now utilizes a protocol known as ASCOM, which is a standardized set of drivers for all industry components. The PC software that runs them (telescope-pointing and camera-control programs), make for easy connectivity to existing networks via remote-desktop connection (RDC) or through an Intranet. As long as live-streaming webcams (IP security cams) are monitoring the dome and telescope movements, and the telescope's slew limits are engaged, then all operations can be performed remotely, even automated completely using "scripting" software tools. Power-ups and shutdowns are performed with managed power distribution units (PDUs), either through direct commands given by the remote user or by automation. With its own built-in meteorological station, a small observatory now makes use of sensors to provide shut-down automation during surprise weather events.

Ultimately, observatories are completely controlled by any platform or device that permits the RDC connection. ***The authors often control their own personal telescope gear with their iPhones and iPads.***

The level of integration between hardware and software is quite simple, yet extraordinary.

Whereas a campus like 3RF's astronomy site lacks the ability to reach a whole lot of on-site visitors, it does make use of these remote technologies to allow remote connections to perform observations and advanced science studies.

Such a model for doing astronomy "science" is now prevalent among many private individuals and small educational entities world-wide. In fact, the authors of this paper have gone on to help others in the private sector to setup similar observatories. To count, we have done exactly this with seven such observatories over the past several years.

Even so, there exists no extensive astronomy efforts currently employed within traditional education circles (i.e., school districts). All that must be done for a district like Mansfield ISD to experience these same advantages is for *somebody who knows what is possible* to put in the large commitments of time and energy necessary.

Astronomy education can be **transformed** as a result. In fact, it is just a matter of time before we start seeing others within education shifting toward this applied learning model in Astronomy. It's just too easy to do from the standpoint of the technology.

In summary, the interactivity of the educational experience, as demonstrated by some organizations like the Three Rivers Foundation, is sorely missing from today's Astronomy education model. At this time, Mansfield ISD Astronomy is currently ***light-years away*** from the interactive experience that modern technological astronomy tools can provide.

PROBLEMS/NEED

In light of how this paradigm has shifted, it becomes rather sobering when you think about the current state of Astronomy education; specifically, how poorly EVERYBODY is doing it. This is perhaps the largest indictment of the current astronomy education model; it's not just about what we are missing, but rather how **astronomically far** we are from what is achievable.

As a simple example, an astronomy student, while sitting in a classroom, can actually use an iPad to schedule a nighttime observation using the school's equipment and come to school the next day to download the data. Or, since the observatory will be online at the same moment, the student can perform a day-light solar observation.

Of course, if it's that easy (it is), then the obvious question becomes, "Why haven't other school systems done this?"

Simply put, unless one of these expert astronomy "enthusiasts" is **also** an educator employed by a school district, such capabilities just remain ***well-kept secrets.*** In fact, in personal dealings with many people connected in education at the university level, such capabilities remain a secret to most of them too. The perception is that one must be like the University of Texas and build a McDonald Observatory in order to "compete."

Therefore, unless you are a well-researched and capable amateur, you likely would be unaware of what today's technology can do for the explorer/learner. Amateurs astronomers know that High School Astronomy no longer has to be the only science class without a lab.

In surveying district astronomy teachers within brainstorm sessions, and in polling amateur-astronomers across the world, the authors have been able to identify ten specific educational needs (there are more) that we feel can be corrected by accepting this proposal, as shown in the table that follows:

Identified Educational Needs – Top 10			
Need	**Currently Being Met?**	**Notes**	**Under this Proposal?**
1. Lab/Field Studies are required within K-12 Astronomy TEKS.	No	K-1st requires 80% field time 2nd – 3rd requires 60% 4th – 5th requires 50% 6th – 12th requires 40%	Students lab requirements are exceeded in all levels
2. Proper use of existing astronomy assets	No	MISD owns $20,000+ in astronomy tools that see very little field use because of size and logistics.	Astronomy tools are permanently housed in a centralized facility, ready for daily use via online access.
3. A merger of a core science with actively-applied technology	No	Technology use is passive only within science (using iPads for research, notes, etc.)	Students use technology to control other technology to perform actual science.
4. Adding excitement into what should be an amazing subject	No	Class is taught from a history perspective or passively with videos.	Putting eyeball to eyepiece, students will experience observations directly and routinely.
5. Students take ownership of the learning process	No	When there are observations, they are not made primarily by the individual. There are no processes in which a student may take ownership.	Students will be actively involved in collecting their own data and making their own observations (see *Bloom's taxonomy* affective and psycho-motor domains).
6. Vertical alignment of key programs and curriculum	No	There are no unifying themes, concepts, and programs throughout the entire K-12 experience. Connections are not made from year to year.	Students will study vertical threads of common themes and topics throughout their K-12 years (e.g. magnetism, the sun as important to life, understanding the moon, using astronomy tools). Key programs include sky preservation, energy conservation, astronomy clubs, and
7. Are we impacting a community?	No	Athletic programs are not the only way to impact a community. Astronomy has a way that impacts a town educationally, financially, and communally. This is not currently being experienced.	The stars are an audience for all people, young and old; thus it is, by nature, a communal happening. Our programs will provide such experiences to Mansfield, as well as education in energy conservation/savings and environmental concerns that affect us all.
8. Making connections globally?	No	Currently, there are no shared educational experiences beyond MISD borders. The opportunity to work in global teams to solve problems in not currently realized.	An emphasis is placed on collaborative education utilizing new and existing science initiatives around the world. Our students contribute to global science.
9. Transitioning students into responsible adults?	No	Adolescence is characterized by self-centric thinking. To grow, a student must expand their "world-view" and realize that the world does not revolve around the individual. We are missing a key opportunity here.	A thematic element to our programs will be social, environmental, and out-of-the-box thinking. We embrace the opportunity to have students think beyond themselves, as small (but special) parts to a much greater universe that surrounds us.
10. Be a destination district!	No	Mansfield ISD is not currently thought of as one specific thing. Families know they will have good schools (and programs) if they move here, but we are not associated with any one thing in particular district-wide.	MISD becomes a true destination district, known for its astronomy facilities and innovation in education. Under this proposal, we establish a new paradigm in both technology-integration and contributory science.

Based on this information alone, we feel that the opportunity in front of us is too great to pass up, and we feel almost a ***moral responsibility*** to let the district know what we are missing.

With this realization, the authors know how to fix these items of educational need. It is not so much about what we can promise, but rather about the natural evolution of these educational tools and processes that will go into place; there is no way we can possibly fail in this regard.

We know what will happen if given the chance to show it.

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"With much Power comes much Responsibility"

The authors of this proposal, in conjunction with many fellow astronomers in the North Texas area, have laid the groundwork for transforming astronomy education, just as our own private lives as amateurs, have been transformed by what our capabilities are.

Logically, the next step should involve expansion into the public education sector; the broadening of astronomy "accessibility" to students.

Mansfield ISD is ready **now** to experience the "new astronomy." Students are ready to perform actual science in a way that contributes to astronomy knowledge world-wide.

To begin with, we will clarify the powerful capabilities of such a program, including how MISD Astronomy can impact science AND education in the future. We will also outline the advantages that observatory center and matching programs can bring to the district.

THE IDEAL PROGRAM

But how is this done specifically? What kind of science could we expect our students to do? What does an educational model based on technological astronomy tools look like?

We feel that a K-12 astronomy program can have four main points of emphasis:

- Doing real science
- Incorporate active technology
- Uses an applied curriculum
- Has an entrepreneurial focus

Below, we take the time to summarize each of the above bulleted points. While there are philosophies that undergird how everything is implemented and there are TEKS objectives that much be satisfied, the following will demonstrate how rich and complete our investigations can be; how learning activities can be grow out of a tremendous diversity of connecting facets at all grade levels.

A Program that Does Science

Every image taken with our cameras has the potential to image something that has never before been identified. This is a strong point of emphasis; however, even the shortest of images collected with a camera represents "data" that serves some purpose. The purpose is defined by the nature of the inquiry; the hypothesis being tested. As such, our tools will provide us with the ability to perform "blink" comparisons of properly-calibrated images to find supernovae, novae, or other "chance" objects. Likewise, when coupled with our astrometric and photometric tools, we yield a wide variety in the types of astronomical science we can accomplish.

Whether our goal is to produce pretty images of the sky or to study variable star intensities, these are areas where the authors of this project already have plenty of experience. In fact, with knowledge and experience of the complexities of these technologies behind us, doing actual science becomes the "easy" part of the CAS initiative. As such, you can expect MISD students to begin exploration into these areas of scientific inquiry:

- **Near Earth Objects (NEO)** – MISD Robotic telescopes and CCD cameras will be used during less desirable imaging periods (full moon) for hazardous object searches. This would maximize the use of MISD equipment. Grants are offered in this area for purchase of equipment and for operational expenses. An example of such grants is the Shoemaker NEO Grant - honoring pioneering planetary geologist Gene Shoemaker. Besides detection, these searches also perform follow-up observations to refine the trajectories of known objects. NEOs include asteroids, comets, and minor planets.
- **Extrasolar Planet searches** – MISD Robotic telescopes and CCD cameras could be used to try to detect slight drops in starlight that occurs when a planet crosses in front of the star. This "transit method" and others have found over 3,400 planets outside our solar system, many by amateurs with similar instrumentation. Grants are offered in this area.
- **Quasar searches** – 'Quasi-stellar radio sources' are mysterious objects that are both radio sources and sometimes optical sources displaying high redshifts. These objects produce vast amounts of energy, thought to exceed the total energy output of a galaxy. MISD equipment could be combined to layer radio emission data and optical photometry data. Searches in the vicinity of galaxies may help determine if there is a parent/child relationship.
- **Novae and supernovae detection** – Stars are volatile bodies, with the potential to do some fascinating things. Finding such events in the sky is a simple process. MISD can introduce a program of surveying the sky for such happenings.
- **Variable star observations** – MISD can contribute to observations of known variable stars, supplying important data for science.
- **Solar science** – With the number of tools available, MISD students can create a meaningful, daily record of solar activity in a multitude of spectra.

A Program that Incorporates Innovative Technology

With our CCD cameras, telescope robotics, and district network technologies, Mansfield ISD stands on the cusp of extending our service area to, quite literally, the whole world. This is a key goal for this proposal. Not only will students in our district do remarkable science, our technologies will allow anybody with an Internet connection to utilize our telescopes via a simple browser interface. As such, we have the capabilities to not only do shared research with others around the world, but can make our platform available to others in both profit and non-profit ways.

For example, advanced educational institutions without such means (there are a lot of them) can use our scopes for their own research or for student projects. This is a quickly growing phenomenon right now, and will allow us to make associations with established astronomy programs. But equally important, it gives MISD students the power to perform its own meaningful science and group projects, all without needing to be at the telescope itself. This is the nature of robotic, automated technologies.

In other words, this is an ***active technology*** implementation, defined as an application of technology that enables a task to be accomplished, whereas it could not possible be accomplished any other way. This is not just buying iPad to use in a passively in a classroom. It is transformative and absolutely necessary to the learning process.

The excuses for not doing astronomy, for not using real astronomy tools, are no longer valid. ***Astronomy now is akin to programming your DVR player***…chose what show you want, record it went it comes on, and play it back later. Night time observations while at school during the day is no problem…just record it!

A Program with an Applied Curriculum

Doing astronomical science does not happen overnight. And science that actually contributes something to the world of Astronomy will be certainly take place at the higher levels of our programs. But this happening is something to which students of **all ages** can aspire; a curriculum process whereby we scaffold logical threads and activities that bring students to the level at which they can do contributory science, or in the least, learn from the process.

Typically, it would be impossible to stay on the cutting-edge of curriculum design in such a high-technology discipline; however, we would not attempt such a project if we did not have the background and experience to know exactly what such a program should look like. Therefore, staying true to the TEKS objectives at each level, we can rework our astronomy education model to provide new, innovative curriculum throughout Mansfield ISD. Not only does this increase the impact our tools can have on education directly, but it builds teacher confidence in our science programs and provides incentive and excitement for kids of all levels.

But make no mistake, one does not have to perform actual science in order to learn Astronomy by application. The tools of Astronomy science are relevant at all levels of education: our scopes show the kids a universe of information that a textbook cannot deliver; our data (in both raw and processed formats) allows our students to ***learn via discovery***; and even our kindergartens will have an opportunity to connect with the physical elements of the cosmos, learning what it means to be an observer of life...to be able to ask questions to take ownership of the learning process.

This can be done by designing a curriculum around specially identified threads that are concepts within all state educational objectives. "These concepts include progressively relevant "Big Ideas" such as:

Identified Curriculum Threads		
Magnetism	Energy Conversation	Space Discovery and Travel
Life cycles	Astronomy Tools/Optics	Archaeo-Astronomy
Coordinate systems	Solar Dependence	Scientific Method
Patterns (Daily, Diurnal, and Yearly)	The Effects of our Moon	History of Astronomical Science

Learning the Sky	Planetary Science	Universe Formation & Philosophies
Observing Life	Electromagnetic Radiation	The Role of Mathematics
Seasons	Size and Distance	Gravity
Heat and Color	Non-optical Astronomy	Rotation and Revolution
Perspectives from Earth	Perspectives from the Sun	Celestial motion
The Nature of Light	Weather Phenomena/Impact	

It becomes important that these Big Ideas represent a progression of sophistication, from basic understandings at the early levels to advanced concepts of astronomical and astrophysical mechanisms/models that define our reality, in a way that grows a learner very reliably into somebody with emerging capabilities in scientific reasoning.

A Program with Entrepreneurial Focus

One of the more unanticipated operational goals for our project will be to reach the point of creating educational and entertaining content for distribution, marketing, or classroom use. In fact, given the time, resources, and natural production within our programs, we can actually publish original materials.

Because of this, there is the potential for revenue. The tools and programs lend themselves to the creative talents of individuals. Our program can earn its own keep, in a way, and go a long way to becoming a self-sustaining entity. Examples would be:

- The sale of annual calendars, posters, professional wall prints, and other publications.
- Student-led imaging seminars and workshops on visual astronomy and astronomical imaging.
- A line of products tailored for children might be produced. Items would include night-lights with changeable transparency images; puzzles with images; placemats with informative images; books, posters, and t-shirts. These items could also be tailored for school classroom environments.
- The selling of telescope scope time on our robotic telescopes to amateurs and schools without having to be there in person.
- Renting out our AstroTruck mobile labs to businesses and other school districts.
- Admissions charges to the public access facilities, featuring interactive science displays, kiosks, and learning opportunities for the public.
- Partnerships with equipment manufacturers become a possibility, providing an ideal test bed for emerging technologies astronomy technology. This could lend itself to unique opportunities for our students.
- YouTube channel content published for educational use by other schools.

But no matter what is involved in our programs, or how many of these types of projects we decide to do, all this goes to show that we are only limited by our imagination.

We feel that it is important to remember how empowering our technological advancement will be to our successes. Moreover, we want our students at all levels to feel a real ownership of the learning process, and there is no better way to do that than to make sure their efforts produce real, tangible outcomes that benefit them personally.

In summary, we'd like to share something our industry friend, David Hutchison, voiced:

> "Those who know me have heard several times my story of Astronomy. As a middle school student, I questioned the teacher about how real that photo of Saturn was in the text book. My parents took this opportunity to help me grow. And after spending a winter chopping wood to earn some money, they helped me purchase an Orange Tube 8-in Celestron Telescope. Through that telescope, I learned that there really were rings around Saturn, and so much, much, more.
>
> Because of that telescope, I became interested in Astronomy, interested in science, and interested in math. And because of that telescope, I became motivated to learn about trig and calculus way before I was allowed to learn it in school. That interest allowed me to discover engineering (radio telescopes). So, in many ways, all I have achieved in my career, and all that I have achieved is because of that telescope. Astronomy is about discover and education is likewise about discovery. Give hope of discovery to a student and great things will happen.
>
> And, by the way, that old orange tube telescope is now close to 40 years old and is used regularly to capture spectra of star lights and to capture the imaginations of new students."
>
> \- Dave Hutchison
> Staff Engineer, DRS Technologies
> Long Time Amateur Astronomer
> Dallas, Texas

If there is a moral to be shared, it would be that the greatest ideal for our programs will be to educate in a way in which our students will be impacted for a lifetime!

GOALS/OBJECTIVES

Once we have identified the way we want our programs to look, we can begin to target with precise goals and objectives; specifically, what types of results we would like to see, both within our kids and within our district on the whole.

What follows is a comprehensive list of what MISD can do with the addition of the MISD Center for Astronomical Studies, it's programs, tools, and curriculum…

- ***Taking Hubble-Like Images of the Cosmos*** - Using proper gear, amazing images both inspire and provide activities centered on the digital data

collected. The author has been doing exactly this for almost 20 years now (see example of the "Crab Nebula" (at right), producing images and even seeing them published. Even an iPhone image captured though the eyepiece of a telescope yields dozens of learning opportunities for students. Students of all ages (not just in astronomy) would have access to use images within their own projects. For some, they would have the bragging rights (not to mention the educational value) when they create such images.

- ***Maximizing Telescope Time at Night*** – There is nothing more frustrating for an Astronomy teacher to **not** be able to practice Astronomy. Short of holding class at midnight, there is very little that can be done about that. That is, until now! Gear usage will be maximized with an observatory. And although weather can be a hindrance to astronomy access, an observatory solves the issue because entire observing nights no longer depend on the weather. Instead of **hoping** the skies are clear and then having to reschedule an observing event when they are not, every night is potentially "observing night."
- ***Observing During the Day*** – Most people do not realize that our Sun can be safely viewed with amateur gear, and some teachers have actually brought personal gear to the schools to demonstrate this. Not just white-light views either, but rather hydrogen-alpha views of solar prominences, flares, filaments, and smaller surface features. The moon is often visible during the day as well, a fact known to too few people. Even better, a permanently mounted telescope can lock onto planets like Jupiter, Saturn, and Mars during the day. They are visible if you can find them, and our telescopes can do that for us if properly aligned.
- ***Real-time Views and Accessibility*** – Cameras have the ability to stream real-time data via the Internet to anywhere in the world. At an observatory center, this can be true of both astronomy targets as well the entire sky. At any given time, we can look at the current condition of the sky, not to mention checking in on what the Sun looks like. And this isn't one person at a time, or one classroom at a time; this is any classroom and every classroom, simultaneously. For night time observing, students can visit a webpage to see live-views of what our telescopes are showing, all without needing to be there personally.
- ***Creating a Data Repository*** – Once Astronomy students collect data, this data will be catalogued and stored for future use. A daily Solar or Planet Log comes immediately to mind. Lunar Journals and Observing Logs can be supplemented each day. International Space Station passes, Iridium flares and satellites, and meteor shower data can each be logged. Data may also be collected and stored automatically, through scripted automation.
- ***Provides Visibility Beyond Visual Astronomy*** – No matter how dark the skies are; imagination is required when looking through the eyepiece. Because our astronomy gear is adorned with cameras, nothing is left to the imagination, turning "faint fuzzies" into galactic spirals; and smudges of brightness into globs of thousands of stars and wispy nebulae. Thus, the number of opportunities for doing astronomy increases exponentially as compared to traditional, visual astronomy. This means more "contact" time with students.
- ***Creates an Atmosphere for Dialogue*** – Ownership of the learning process not only promotes engagement but also dialogue. In our experience, **applied** astronomy promotes conversation, and this is very true when those applications are experienced first-hand. And it is not just a dialogue about the *view*, but also about the learning *process*. When a student looks through an eyepiece or takes an image, the follow up questions from students are inevitably, "What can I do to do this better?" or "How does all this work?"
- ***Contributing to Science*** – It is one thing to do science. It is quite another to contribute **to** science. Amateur astronomers often contribute data to scientific communities. This is a typical goal for many amateur astronomers who pattern their observations around specific objects and types of data collection. For an MISD high school student, it would not

necessarily be a goal in itself (certainly not in the lower programs), but contributory science often happens as a result of the inquiry. Many comets and nebulae were discovered this way.

- ***District-Wide Data Collecting*** - With training by district personnel, teachers and students can make contributions to district webpages with regard to astronomy, weather, or space weather. In other words, data has secondary use beyond their intended uses in the classroom. Similarly, students can be their own promoters. Imagine a student-led mentor program whereby advanced astronomy students notify mentees and/or district teachers of new observations relevant to their curricula by sending out a web link?
- ***Mobile, District-Wide Astronomy Labs*** – One of the key experiences that can enhance astronomy education is to provide an "a la carte" experience for district teachers. In the same way that a teacher can sign-up to use a computer lab, a teacher could also sign-up to have a district personnel bring astronomy gear and activities to them. We already have experience in this area, from leading young students in hand-on activities to showing students views of solar system objects (like sun, moon and planets) or even hosting "star-parties" at night.
- ***Sharing of Astronomy Assets*** – A unique aspect of Astronomy is that much of what scientists do is collaborative. Even among amateur astronomers, many team up from across the globe to share data sets and work jointly on projects. The authors of this paper have long-standing associations with other private observatory owners all over the globe. With our own observatory to "share," joint programs and sharing can be done with anybody around the world. How about MISD Astronomy students having access to the same technology (which is very standardized) to do real-time, night sky observations in Australia? Cloudy tonight? How about seeing if we can trade some time with a similar observatory in Wyoming?
- ***Content and Promotion*** – Aside from contributions to curriculum, images of the night sky make for good content in various PR materials. And if our students take these images, it would be groundbreaking in education circles. The images we have taken to this point trigger a sense of awe and they make people want to find out more about us.
- ***An Innovative, Powerful, Vertically-Aligned Astronomy Curriculum*** – The thing that holds back curriculum design and development in technology classes (be it industrial or career-tech), is the lack of experience within the astronomy industry. Without knowing what's possible, it becomes **im**possible to stay on the cutting-edge of curriculum design. Staying true to the TEKS objectives at each level, we can foresee an opportunity to rework our current astronomy education model to provide a cohesive astronomy program throughout Mansfield ISD. Not only does this increase the impact our tools can have on education directly, but it builds teacher confidence in our science programs and provides incentive and excitement for kids of all levels.
- ***Cross-curriculum Involvement*** – A set of astronomical data has to be processed. This data can take the form of an image, which relates to Photography. Remote control of telescopes and facilities falls solidly in the field of Robotics. A small observatory (and many of its custom-tooled components) is a perfect joint-project mechanical tech classes. The weather-sensors and logging software necessary for an observatory leads to perfect data within a Meteorology class. Observatories are about much more than **just** astronomy.
- ***Educating the Public*** – The message of education should be that we are all learners; and learning is a lifetime pursuit. As kids watch the world revolve around them, we can teach them that they are merely part of a much larger universe. *Nothing is better than Astronomy in this regard.* This same message can be conveyed to the public in general, since there is no reason why anybody within the district borders *cannot* reap the benefits of such a program.

Whether our goal is to teach our community how to learn or to preach the advantages of light-pollution/energy preservation, an entire community benefits.

- ***Shows off Mansfield ISD as "Forward-thinkers"*** – While there is a certain "coolness factor" to what can be done here, the real message to be conveyed is that Mansfield ISD thinks outside of the box when it comes to educating our kids. It is one thing to purchase iPads for kids in a school district, but quite another to provide a **universe** to look at WITH those iPads. Our Astronomy program would perpetuate excellence that is rare in education below the University level, yielding a broader reach. We would be known as a group that doesn't just talk science, but actually does it.

What is terrific about technology on the whole is that it opens up a vast potential of possibilities. In astronomy, it represents doing science more actively, efficiently, and powerfully, benefitting a larger number of people. However, the above CANNOT be accomplished by constructing an observatory alone. A full-scale implementation beyond a single classroom (with a trained teacher) would require a very concerted effort on a wider-scale. This is the way to impact an entire district.

Thus, none of the above can be accomplished without district staff to make it possible. Any full-scale implementation would be impossible.

In summary, a full-scale buy-in to the tools and facilities is not required. Those items are somewhat subject to scale or degree. However, with greater investment, these innovations can truly transform education, which is what we seek to do. If Mansfield ISD fully supports the initiative outlined here, the preceding items are just a few things that we promise to do.

OUR PROPOSAL OF "MISD CAS"

Having defined our educational need, the powerful nature of our tools, and a statement of what a technology-based Astronomy program can look like, we now would like to speak in terms of what we would like to see Mansfield ISD in terms of the actual project as proposed.

First, we will define what a "Center of Astronomical Studies" is, from our perspective. Then, we will highlight some of the features of some of the items in our proposal, as well as explain some of the technology we wish to implement. Following this, we will phase-out the project, detailing each aspect of what we feel is necessary. And, finally, we will project a time-line for each phase, with cost estimated at each stage.

What is a Center of Astronomical Studies?

Traditionally, when a school district wanted to expand their astronomy program, they would construct a planetarium, as rare as this is. As mentioned previously, the cost/benefit ratio of a planetarium is extremely poor because of the large expense, transportation costs, and price of the programming. It would be like building a movie theater and only offering one show each year.

Instead, there is significant benefit to building an observatory, where the show changes EVERY NIGHT (or day) and the students don't have to be there physically to reap a benefit…it's streamed right into the classroom!

Therefore, we define "CAS" as a facility (with grounds) that hosts telescopes (and other science tools) that will be USED by our students. Whether the student is physical on the astronomy campus does not matter in terms of ***use***; however, we would certainly want to provide students with the option of physically putting their eyeballs to the eyepieces. Both aspects, ***virtual and visual***, will be incorporated into our plan.

To accomplish this, our ***proposal is for a dedicated astronomy "campus," complete with observatories, observing fields, mobile labs (with garage), an outdoor learning pavilion, and a high-tech lecture hall and classrooms for advanced instruction.***

Highlights of the proposal include:

- ***Grounds/Campus (see more in Phase 1 details later) –*** We have discussed possible site locations with district leadership, targeting properties already owned by the district. While there are numerous possibilities, including building at an already developed location or current campus (such as Ben Barber), the only feasible locations are those that have yet to be developed, with preference given to sites that are "dark." While this is not mandatory, it should at least be at a location where existing structures do not have to be altered to meet our needs. For example, while it might seem logical to build at some place like our district's Agriculture facility near Rendon, the facilities sharing the property (including the neighboring schools) would need to address campus lighting in a way to protect the skies around it.

  We have targeted a 24-acre lot of district property located at W. Broad St. and Retta Rd. Located almost 2 miles west of downtown Mansfield, we view this location as a best compromise for the goals we hope to achieve. While it is not ideal in terms of astronomy (it's not on a dark mountain top), it is a centralized location in a less populated area of Mansfield. Because most of that area has yet to be developed, we can also begin from scratch with our lighting implementation and awareness/education efforts. Likewise, code enforcement (as it benefits us) and tapping into existing infrastructures is much easier (and cost effective) by building within the Mansfield city limits.

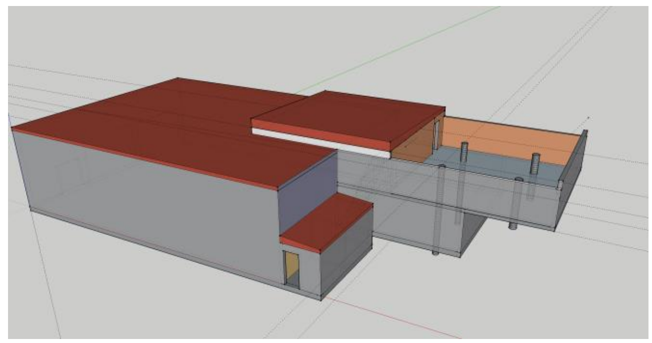
  Currently, this property is being targeted as a potential elementary school campus, but our understanding is that there are difficulties in bringing such a plan to fruition:

  - The existing site is an irregular lot, with several adjacent properties owned by others residents. This would require the district to acquire these properties prior to its use as a school. For our astronomy center, such a need is not required. We have no need for a contiguous, square lot.
  - There are severe drainage issues on the property, requiring complete exhaustive attention if the entire parcel is developed for a school facility. This would come at great cost, beyond what it typical for most developments. However, for our purposes, where there will be an emphasis on negative spaces (nature) as well as the

actual facilities, these items actually work to our advantage since we can simply incorporate the bad drainage areas into our outdoor observing areas (more on that later).

At a smaller scale, we could benefit from a site that is more remote, whereas the need for public access diminishes. At this point, we could keep our mobile labs at a separate, already owned district facility. But for our complete plan to succeed, a centralized land parcel of moderate size would see great utility for us, and in many ways, it is required to truly impact education the way we expect.

- ***Robotic Observatory Building (see Phase 2)*** – The first of our proposed facilities will offer fully-automated, remote, robotic astronomical science, using currently owned astronomy assets plus new tools for a robust set of applications. Built with a "roll-off roof" design, this observatory will be automated for 99% of its usage. It will be equipped with four instrument piers available for a variety of simultaneous scientific inquiries. Some of the instrument piers will (in part) utilize instruments already owned by the district:



  - Pier 1 (for Deep Sky Imaging/Video Observing): Instruments include Paramount ME2 mount, Celestron 11" RASA Astrograph, Skywatcher Esprit 102ED refractor, Nikon D810A DSLR and FLI ProLine astro cameras.
  - Pier 2 (for Solar System Imaging/Video Observing): Instruments include Paramount MX mount, Celestron C-9.25 SCT Telescope with Celestron Skyris camera; Celestron 3" refractor with white-light solar filter with Celestron Skyris camera; and Coronado Solar Max 90 Solar Telescope with Celestron Skyris camera.
  - Pier 3 (for Spectroscopy): Paramount ME2 mount, Celestron C-14 telescope, and SBIG spectrograph, and non-antiblooming FLI astrocamera.
  - Pier 4 (for advanced imaging and science): Paramount ME2 mount, Planewave 14" CDK telescope with FLI Proline astrocamera; Skywatcher Esprit 120ED telescope with FLI Proline astrocamera; and astrometry setup with non-antiblooming FLI astrocamera.

A small control room (including our data server) will provide direct visual access and control of all instrument piers. This allows on-site maintenance of control PC servers; equipment configuration & optimization; as well room for guided training of personnel, a limited number of students in the advanced program (special projects), and joint-venture research projects. Control PC servers and data storage servers will be priced into the project (see our price estimates later in this document).

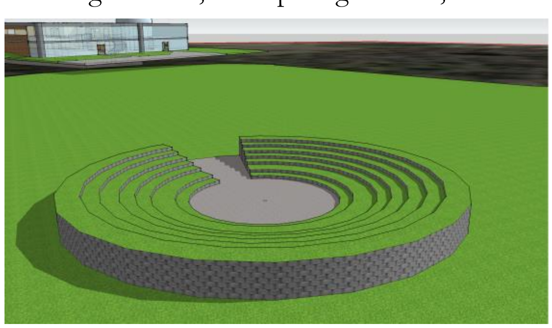
- ***Mobile Lab Garage/Workshop/Storage/Office/Restrooms (Phase 2)* –** We propose that a built-in component of the robotic observatory above is a storage facilities and indoor garage for our mobile labs. This allows us to change configurations for specific applications in our "AstroTrucks" when needed, as well as provide a home base for all district astronomy assets. Complementary to this is a basic workshop for metal/wood working for fabrication of custom adapters and solutions for our efforts. This helps to absorb costs related to expensive astronomy parts that must be outsourced. Basic restroom facilities and storm-shelter are to be included, as with any public code-compliant structure.

It must be emphasized that this is NOT a public-access site. It will be only for district-personnel and for those with the necessary permissions. Public access sites (those that facilitate student visitors and the community at large) come in subsequent phases. However, this first structure (including the robotic observatory and mobile labs) will provide a very large majority of what we hope to accomplish educationally.

- ***AstroTruck Mobile Astronomy Labs (starting in Phase 2) –*** To facilitate the hands-on astronomy education and presentations to all district students (especially at the earlier ages), we will be proposing three, fully-equipped mobile laboratories. We have done the ground-work on getting the first of these labs donated and built for the district, but as of this date we have not yet been awarded the grant(s) to make this possible. However, we are hopeful. Of course, this proposal is for three such vehicles.

  Directly supplementing classroom curriculum at all levels, these rolling laboratories will have both permanent and portable astronomy tools and telescopes, microscopes, and full presentations capabilities. Featuring a sliding, pull-out platform for the fixed instruments and monitors, it will be designed for quick deployment, ready setup, and isolated, self-sustained power (if necessary).

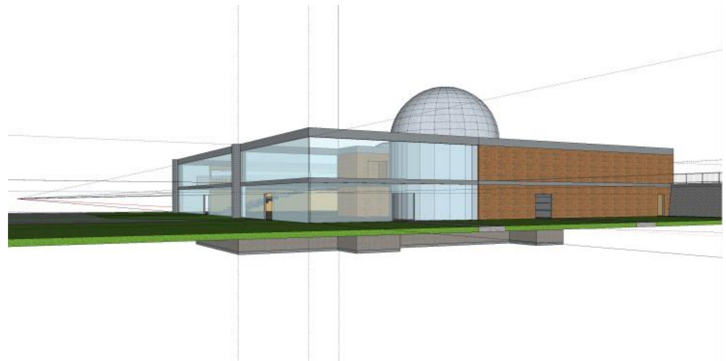
- ***Observing Fields/Outdoor Learning Pavilion (see Phase 4) –*** Taking advantage of the beautiful campus, we hope to offer grounds for visitors to setup their own instruments, promoting community observing events and student visits. This includes a covered, fully-powered outdoor learning pavilion (with restrooms and outdoor kitchen) and powered observing "pads." We also desire to offer large scale features on the grounds, such as a working sun-dial, "whispering" dishes, NASA displays, a solar-system scale model, and binocular stations. This also provides a natural ground for branching into radio astronomy, whereby we have a place to locate several small telescope dishes for future expansion.



  - ***Amphitheater (Phase 4) –*** A small, naturally constructed amphitheater for outdoor "planetarium" presentations (with green laser pointers) is strongly recommended for all public events. This allows a "theater in the round," where the stars are our **stars**!

- ***Public Astronomy Center (see Phase 5) –*** The main source of pride, impact, and cost comes from our proposed ~35,000 sq. ft. main building, housing two domed observatories for both visual and remote access, two control labs, a lecture hall, two high-tech classrooms, a gallery/interactive museum space, offices and restroom/storage/food service facilities. Many of the features are itemized as follows:

  - ***Domed Observatory One -*** Housing a world-class instrument cluster for a wide-variety of applications will be a 24 ft. aluminum dome. The main instrument will be a 24" Ritchey Chretien telescope for both public visual observation on-site, as well as robotic imaging capabilities. Piggybacking other instruments and consisting of an array of instruments on the "visual back," this will be the most capable instrumentation on the campus. The instrument pier itself will be visible from the lecture hall through a glass partition for maximum impact during presentations and on-campus visits. An attached lab/control room will provide local control over all processes. This will be the main "hands-on" experience on the campus, providing eyepiece views during select viewing times. When not being used publicly, it will provide an array of scientific capabilities, including advanced spectroscopy and photometry.



  - ***Domed Observatory Two -*** A second aluminum dome (20 ft.) will cover another instrument cluster, featuring a 17" Planewave CDK telescope and an array of solar system instruments, including an h-alpha solar telescope and planetary/lunar cameras. As with any of our instruments, these will provide live streams of current celestial events. While it may be equipped for occasional visual use, its chief purpose will be full automation of live-streaming views of solar system objects. When you go to our web-page to see what's going on, or as you walk through our Astronomy Center to look at our public display monitors or even through the window in our gallery area, this is the instrumentation that is delivering those views. A neighboring control lab will likewise power this observatory.
  - ***Lecture Hall*** - A two-story lecture hall (think NASA launch control) will house special presentations on campus, from both campus personnel as well as guest dignitaries. Seating capacity is 150 active and interested observers. With a window into Domed Observatory One, "launch control" will be an apt term, as instrument control will be duplicated to the Lecture Hall. Coupled with virtual reality technology, we plan to give a visitor's experience second to none.
  - ***High-Tech Classrooms*** – As our Astronomy Program grows to include advanced applications, we plan to have students on campus daily. Two classrooms (labs) will be equipped with PC application stations for proper

evaluation of scientific data, processing, and project management of our students. Teams of MISD students will perform actual science from these classrooms while meeting all of their educational objectives. Remote Desktop Control of all district-wide astronomy assets is feasible from the classrooms, and student-led production of on-line data, publications, content creation, program marketing, and commerce opportunities will happen from these well-equipped classrooms.

- ***Gallery/Interactive Displays*** – As the visitor walks into the facility on the building's top floor, they will immediately be greeted with kiosks, displays, and learning centers for interactive education. Modeled after the Perot Museum or Destination Imagination, visitors of all-ages, students and non-students alike, will enter the building with hands-on opportunities. A small lounge area will provide visuals of our monitor's showing our live-observatory feeds, weather, and space videos. Walls detailing the accomplishments of our students, interspersed between the celestial images they have taken will hang professionally within the gallery. One-part art museum and one-part NASA Space Center, it will be the most unique and powerful reminder to our visitors as to the power of technological science education. Pouring out to the exterior of this building, our public observing fields will continue this theme.

Our Technological Capabilities

In all astronomical observatories, each powered instrument pier is designed to be equipped with identical server hardware, software protocols, applications, and functional capabilities. The roll-off roof, robotic observatory in Phase 2/3 is rolled away at the beginning of an observing session, and then rolls back to its closed position at the end of the session. The domed observatories in Phase 5 are linked to the network via ASCOM to the same sky-control software that governs telescope pointing. The dome acts as a slave to the telescope, rotating its shutter to stay in synchronization with the scope's orientation.

For protection, all observatories are planned with a full suite of weather systems and security capabilities. Not only does this provide a way to prioritize observations by monitoring local weather conditions, but it provides a way to automate shutdown of the observatory in adverse conditions and it provides data for studying local weather trends.

Because the observatories utilize many powerful components yielding a plethora of capabilities, we elaborate on them as follows:

- A Davis weather system provides the weather data for all of CAS. This provides a way to monitor weather usages to best determine the types of observations that will be possible during an evening. In turn, each observatory will also be covered by a Boltwood Cloud sensor http://www.cyanogen.com/products/cloud_main.htm), which adds cloud detection and a line of defense against wind and rain. This allows us to set dome "triggers" (interrupts) for shutdown in the event of high-winds and/or rain. Therefore, there are both *reactive* and *proactive* aspects to changing weather situations.
- A small Doppler radar station will be installed for even more advanced study of local weather phenomenon, both for our own astronomy applications and for our district students studying meteorology.

- An external mast will be erected to include the weather sensors as well as an ip66-rated, PoE (PTZ) IP webcams, providing a 360-degree field of view. Likewise, the observatory interiors will utilize similar IP webcams to provide interior views of the observatories. For complete functionality, all security cameras will need to be accessed remotely, which is easy with the PoE (power over Ethernet) and IP protocol.
- Power can be cycled remotely (via Internet) to each instrument using managed power distribution units (PDU). This "remote power module" allows power ups/downs of individual instruments remotely. Thus, partnered with UPS systems (uninterruptible power supplies), we can be assured that the observatories can always be closed remotely in the likelihood of a shutdown event. Should we desire to digitize other feedback devices that are not covered by the standard systems (we cannot think of anything off-hand), we can do so using "Arduino" micro-controllers, with which we have experience.
- Speaking of UPS systems, backup power at the main facilities may also be supplemented by a back-up power generator.
- An "all-sky" camera will be implemented, which can be used campus-wide to check current conditions at the astronomy center. Such cameras are immune to the elements and provide a 360-degree field of view of the sky, at all times of the day and during all-weather conditions. The images they produce are constantly streaming over the Internet, providing visual feedback in real-time. They also double ***to record meteor data***, which provides another opportunity for astronomical studies. The image stream is independent of the observatories themselves, as such ***anybody*** in the world can go to our web page and see what our skies look like overhead.
- We also propose an atmospheric "seeing" monitor and a light pollution monitor to round out the feedback hardware. These items will allow for instance feedback of conditions necessary for scientific inquiry as well as the charting of data at the observatory site, accessed, of course, via the Internet. It also allows our scripting software to prioritize observations according to astronomical factors like atmospheric stability and transparency. These items, as well as the weather systems, should be installed on its own weather server. In this way, data from all system sensors can be logged and charted daily to assist in future forecast of weather trends.
- Initial scripting and remote connection can be made via software such as CCDWare's "CCDAutoPilot 5" and an RDC connection (remote desktop control). This will be for administrative functions and guided educational use.
- Once remote observing requests increase (our curriculum will utilize the observatories as tools), the scripting capabilities will become more robust. As such, a package such as DC3 Dream's Astronomers Control Panel provides many powerful capabilities, including Internet-browser based controls, priority observation scripting, automated notifications, and eCommerce usage. Priority observation scripting is made possible by a dispatch/queuing system, which is sophisticated enough to determine imaging priorities based on data-type and conditions. For-commerce usage is accomplished via eCommerce capabilities built-into its web interface. Of course, this would allow time to be purchased from external clients. So, if we decide to sell time to others to access our systems, then we will have an intelligent software method of running requests through the queue and retransmitting the data, as well as prioritizing our own student observation requests.
- Lightning is a difficult issue to address. District personnel would likely have an existing philosophy on how this should be handled, or perhaps have already standardized a lightning abatement system for MISD properties. We propose using fused-grounding for all instrument masts.

- Instrument server hardware should be built per our needs. An off-the-shelf PC does not work in these situations. They must be designed to include consideration for summer heat build-up in the observatories (which are largely non-insulated) and its use during the winter. Down-time is critical; reliability of utmost concern. Therefore, rugged, solid-state, fan-less PCs with small footprints should be employed. These are mounted to each of the instrument piers, and thus, shouldn't be intrusive and space consuming.
- The MISD Astronomy Center project, as proposed, would include monitoring of all Astronomy and Weather technology systems. The idea is that all observatory events, security views, and weather data are easily visible in the well-trafficked areas of the Public Astronomy Center, where monitor kiosk stations provide real-time views of all relevant information. If the entire astronomy campus is to be integrated technologically, then we will certainly want to provide this visibility. But campus all have such TV monitors displaying school news, district personnel will already be familiar to the overall cost and capabilities of these items.

We mention the feature-set of these observatories not only to introduce the capabilities of CAS, but also to demonstrate how technology-specific the plan is. It has taken ***many years of understanding and experience to get to this level of personal implementation***, an area of specialization that is not covered by contractors in typical construction and information technology (IT) fields. Therefore, we hope to demonstrate that the authors present the best way to make such a thing happen in this school district.

Likewise, it is our hope that this description of capabilities shows how cutting-edge MISD can be technologically. Once complete, the district (or any other) will not have anything that fully integrates technology with learning quite like this proposal sets out to do!

Construction and Program Implementation Phases

This section of the document will present the project timeline. We will focus on a phase approach detailing what we consider three key areas of the project: Facilities, Programs, and Curriculum. Development in these areas will run parallel to each other, since none of them can work without the others.

Going forward, here is the master outline (summary) for the phases (with timeline) of the project, as proposed. Afterward, I will explain more fully what is involved in each of the three key areas, phase by phase, and provide simpler tables with breakdown smaller aspects of each phase.

PHASE TIMELINE (Project Summary)			
Phase (with summary)	**Facilities**	**Programs**	**Curriculum**
Phase 1: Current Year (2016 to 2017) - Project Planning and Approval Process - Pooling current equipment resources - Forming collaborations	- Obtain additional equipment and ensure functionality to increase frequency and depth of observations offered by all 6 high school campuses under the MISD umbrella. - Current equipment includes Celestron RASA 11" scope with CGE-Pro mount, Nikon D810A astrocamera; Celestron Nexstar 4SE scope; Celestron AVX 9.25" SCT scope/mount	- limited observations with existing gear - piloting of TEKS-aligned activities from collaborative resources (i.e. 3RF, CBBHO) in H.S. Astronomy classes	- no enhancements or changes to existing curriculum - writing of vertical TEKS-aligned activities for high-school astronomy programming (for Phase 2 curriculum implementation)

Phase 2: Year 1 (2017 to 2018) - First Observatory added to the Center. - Additional equipment/software added. - Beginning of "a la carte" programs to high schools - Providing content and materials for public relations - Roll-out of dedicated MISD Astronomy webpage	- Construct Fully-Automated Roll-Off Observatory with/4 pier capability - Add additional equipment including: ▪ 60mm H-alpha solar scope ▪ 14" Planewave CDK telescope ▪ Dedicated Astro CCD large format mono-chrome camera ▪ Four Paramount ME2 mounts ▪ Two solid state control PCs with 8 to 16 GB memory, 2 TB storage and i5 or better processors - Add Software, including: ▪ PixInsight ▪ ACP Expert (Astronomer's Control Panel) ▪ CCDWare Software Suite ▪ TheSkyX Professional Suite ▪ MaxIm DL 6 Pro	- remote access from current Astronomy classrooms - automated & scheduled data collection (night/day) - Daily solar, lunar, and planetary observations - weather data archiving/study - image database and webpage gallery - produce materials for MISD public relations and miscellaneous programs - beginning of "a la carte" astronomy program to H.S. astronomy classes	- implementation of vertical, TEKS-aligned "a la carte" activities for supplementation to existing H.S. curriculum utilizing new observatory capabilities - writing of vertical TEKS-aligned activities for all-levels astronomy programming (for Phase 3 curriculum implementation)
Phase 3: Year 2 (2018 to 2019) - Secure and equip an Astronomy "mobile lab" - Roll-out of AstroTruck program - Beginning of "a la carte" all-levels program.	- Purchase/acquire vehicle/van for a mobile astronomy lab; "AstroTruck" - Secure equipment for lab, including: ▪ 60mm H-alpha solar scope ▪ Three 10" Dobsonian Telescopes ▪ 6 sets of binoculars ▪ 2 eyepiece sets.	- introduction of AstroTruck mobile astronomy lab program in all-levels curriculum supplementation - initial push of public observing and astronomy education programs into the Mansfield community - full online web presence for easy community and school astronomy news and opportunities - beginning of Astronomy project collaborations with other organizations and facilities -start of partial funding through online sales of content and images	- implementation of "a la carte," vertical, TEKS-aligned activities for all-levels curriculum supplementation using observatory and mobile-lab (AstroTruck) capabilities

Phase 4: Year 3 (2019 to 2020)
- addition of public areas at the observatory center, including observing fields and on-site, self-guided activities
- addition of restroom and storage facilities
- beginning of public observing programs
- open for school and public visits
- start of light-pollution and energy
	- Expand observing area for public visits:
	▪ Field Observatory/ Lawn
	▪ "Whispering Dishes"
	▪ Sundial
	▪ Small teaching circle (amphitheater)
	- Restrooms
	- Garage/Storage for mobile lab and equipment
	- Add to equipment for roll-off observatory, including:
	▪ Small refractors for piggy-back implementation (wide-field imaging, sky surveys, and white-light solar observations)
	▪ 60mm CaK solar telescope
	▪ additional astronomy DSLR camera(s) for
		- provide home-base for community programs
		  - public observing program
		  - public tours
		  - VIP tours
		- open for school field-trips
		- beginning of light-pollution and energy conservation programs.
		  - Initial public awareness
		  - Building associations with other such efforts
		  - Start push toward new-construction installation of energy-efficient
			- writing of new all-level Astronomy curriculum
			  - vertically aligned
			  - TEKS-aligned
			  - cross-curricular and full-scale technology implementation

conservation programs	additional data collection ▪ addition of basic spectrographic tools - Add to equipment for field observatory, including: ▪ 3 Obsession Dobsonian Telescopes (18, 20, and 25 inches) ▪ 3 eyepiece kits with high quality eyepieces	and sky friendly lighting	
Phase 5: Year 4 (2020 to 2021) - Construction of MISD Domed Observatory structure - Beginning of contributory science programs within high school curriculum - Implementation of new, rewritten Astronomy curriculum. - Push of assets into cross-curricular areas	- Construct MISD Domed Observatory structure including: ▪ Twin Dome w/independent control rooms (labs) ▪ Dual Paramount ME2 setups with 17" and 20" research telescopes and dedicated full-scale astro-CCD monochrome cameras with research filters ▪ Advanced Spectrographic research tools ▪ 2 classroom/conference rooms ▪ Entry/Welcome/Gallery area ▪ Break Area • Kitchenette • Vending • Snack Bar or tables ▪ Pavillion/Porch (attached) • Field stations for beginners • Binocular Stations • Solar Walk (scale model of solar system) ▪ Pavilion (detached) • Outdoor learning center • Multimedia-capable	- H.S. Astronomy classes doing actual science. - data processing education - cross-curriculum programs - Photography - Environmental Science and weather studies - Nature/biology programs - guest speakers - push of MISD tangible assets and programs inside education circles. - Full-scale push of light-pollution and energy conservation programs - Begin a program for replacing existing lighting at all campuses and facilities	- implementation of new all-level Astronomy curriculum - vertically aligned - TEKS-aligned - cross-curricular and full-scale technology implementation - writing of curriculum and research activities for advanced, special projects, "Astronomy II" elective
Year 5 and following (2021 and beyond) - advanced science and applications - new Advanced Astronomy II class - National and International associations and recognition of facilities and programs	- Construction phases complete - Full-scale implementation of all astronomy assets - Astronomy gear additions and replacements	- advanced research and dedicated science applications - summer camps - start of equipment obsolescence program - first "discoveries" through our astronomy programs within next three years - first budgetary savings via energy conservation program	- beginning of district-wide Astronomy II advanced elective class - development of MISD Astronomy "App" for mobile platforms for both student curriculum and public education. - push of MISD astronomy initiative/curriculum to external education and para-education organizations.

Description of Phases

We shall now list each of the major items as it might be shown on a Schedule of Work for each of the 5 project phases. We have divided each of the phases into same areas as on the above summary chart, namely by facilities, programs, and curriculum. Personnel could have been a separate item (as we had originally intended to do); however, we have come to realize that this must be integrated into the project phases for this project to succeed. In other words, nothing happens without the creation of unique positions to make everything work (discussed more fully later in the document). Therefore, proper staffing is assumed.

A phase-by-phase breakdown is as follows:

PHASE 1 (through 2016-17 school year)

Facilities

- ***Planning and approval processes*** – The planning for this project has been on-going for years. The inception of such an initiative began long ago as we better understood the educational needs within our current astronomy programs and as individual experience was gained within similar ventures (please see below in the section titled **"People of Interest"**). Formulation of our plan, "selling" of the plan, and approval up the "chain of command" has brought us to the current point.
- ***Fund Raising/Bond Proposal*** – The authors of this initiative have been raising funds and writing grants for many years now, supplementing our classrooms with astronomy tools to give our students more opportunities. We are currently going after a large enough grant to cover the first of our proposed astronomy mobile labs (at approximately $250,000). We are also looking to become a part of this year's educational bond, with the desire to at least get the first 3 phases of our project completely paid. We also are looking for creative ways to pay for three full-time positions so that the project can receive our total attention.
- ***Seeking business partners*** – A key aspect of any project is to seek out partners to help with facilities and tools to lighten the financial load locally. More importantly, it is to target key people within industry to help us pilot programs, give us first access to emerging technologies, and gain dealer costs on important, future purchases. Key players are already in place, including Celestron, Skywatcher USA, Pier-tech Inc., and Park Place Mercedes to provide us products at their costs. We are also pursuing partnerships to provide computers, networking gear, and virtual reality technologies for our programs. Seeking such alliances will be an emphasis throughout all aspects and all phases of the program.

Programs

- ***Space Center Initiative (SCi) Membership Program*** – Our first foray into the community, our first program, once the project initiative becomes official, is to offer local and on-line memberships to many of the services we will provide. Primarily for news and announcements as the programs gain steam, we will grow the initial program into subsequent public education and awareness programs as they are implemented.
- ***Forming collaborative partnerships*** – Also important from the standpoint of programs, we will be seeking early partnerships early on, from local astronomy clubs to long established national groups. Connecting with our local DFW amateur astronomy clubs will provide us a steady flow of critical volunteers to our efforts. Thankfully, as longtime members of many of these clubs, we already have a strong base of support there. Also, many of our future programs, such as our Dark Sky Initiative and Energy Conservation Program, have national alliances willing to assist in our efforts.

- ***Early astronomy efforts into the neighboring schools –*** We are working with the Principals at our neighboring Elementary Schools to help campus teachers supplement their teachings about the Sun and Moon with activities, including visits to the schools to provide their students views through telescopes we currently own. We want to start early with the excitement, letting those kids know about the opportunities they will have to learn about the cosmos as they grow up in our schools.
- ***Building upon current alliances –*** We have a long history in the astronomy industry, having built and/or consulted on several working observatories for individuals, groups, and others within education. Some of these alliances have astronomy assets that can be accessed and shared with MISD because we retain access rights. Therefore, we have laid the groundwork for an Astronomy "cooperative," whereas resources and tools can be shared to increase the impact we can have if we went at it alone.

Curriculum

- ***No changes to existing curriculum*** – There is no more critical aspect of education than curriculum. The first area of our discussion, the first groups of district personnel we approached was our people on the curriculum side. We are grateful that they have received our out-of-the-box ideas and have supported us as we have attempted our grand venture. That said, there are no curriculum changes to be made in the initial phase, merely supplementation to our existing curriculum. As we gain momentum and the project becomes official within the district, we will be working close with our leadership in both science and co-curricular areas to revamp our astronomy curriculum to best utilize our powerful tools.
- ***Needs assessment*** – Being associated with our district's Astronomy teachers at the high school level for several years now, we have been able to properly assess the strengths and weakness of our current classes, judged how our current tools are being used, and have targeted many areas where we can improve instruction. Many of these items were listed earlier in this document, but we feel firmly that will not only meet our needs, but truly transform astronomy education with regards to curriculum.
- ***Study of relevant curriculum models*** – Over last several years, we have been able to identify many of the "big ideas" within current TEKS objectives at all levels and have a good idea of how our curriculum can look going forward. We have experience in this area having written astronomy curricula previously in some of our past dealings with para-educational associations and have become familiar with what most schools/districts are doing to address similar needs. Unfortunately, most within K-12 education have yet to take up that mantle. We have an opportunity in front of us to be trailblazers in this area.

PHASE 2 (during the 2017-2018 school year)

Facilities

- ***Architectural design and approval –*** The proposal is passed onto district architects for facilities design. Because of the proprietary need, where form must follow function, we anticipate this process to take a little longer than a typical district project.
- ***Site approval and ground-breaking for the campus facilities, including clearing/development of grounds –*** Depending upon how much buy-in we receive from our fund-raising efforts (we hope initial construction to go through Phase 3), we will begin

preparing the property, per architectural plan. We anticipate that the non-public areas (Phase 3 areas) are developed first, with complete grounds development completed as capital is available.

- ***Building of turn-lane/traffic signaling for property entrances; laying out easements and fundamental infrastructures –*** Two entrances to the property is anticipate by completion of all 5 phases, both public and non-public accesses. Any public access would require attention to traffic/road lanes and signaling. Non-public access would not need as much effort in this area. Thus, there is some variability in projection, depending on if both accesses are completed at the same time. Otherwise, sewage, electrical, water, and telecommunications infrastructures will be laid-out at this time, again, the extent of which depends upon how much of the project we are approved to build.
- ***Begin construction of the robotic observatory/restroom/garage facility*** – The heartbeat of transforming astronomy education begins with this facility in Phase 2. The total space is initially planned to be 4,000 square feet of a split level design. The 30x20 foot robotic observatory (600 sq. ft.) includes an attached control room, with window to overlook the four instrument piers, providing four simultaneous observations. A portable roof will roll-away on rails to reveal all instruments. The remainder of the facility is of more typical metal-fab construction. Bright reflective colors and a minimum concrete outside the structure will help to assure temperature equilibrium during the hotter summer months.
- ***Purchase and develop first "AstroTruck" Mobile Astronomy Lab*** – There is the possibility that we will have the first of these mobile labs paid for within Phase 1; however, in the event that our fund-raising efforts are thwarted, we would build our initial AstroTruck in this phase.

Programs

- ***Beginning of the AstroTruck Program*** – Even if we receive grant funding for the first AstroTruck in Phase 1, its first implementation will not be until the later Phase 2 stages. However, we can see existing curriculum support at all-levels occurring at the final months of the 2017-2018 school year.
- ***Early Astronomer's Program*** – Much the way a high school football coach builds a spirit of "team" at the early grades, we will do the same for the Astronomy program. We want to let our young students know that we have opportunities for them during their MISD lives.
- ***Student Observer's Program*** – Piggybacking on the successes of the Early Astronomer's Program, we want to teach students of all ages to be aware of the world around them; to be observers. As students age in our district, they will have opportunity to earn credentials (e.g. merit awards) based upon observing lists and astronomy project rubrics designed to grow them into young student observers. These merit awards will place a key role in their acceptance into our advanced high school programs, where we expect there to be competition (see Advanced Astronomy Program in Phase 3).
- ***MISD Astronomy Clubs*** – We want to actively encourage campuses to form student-led astronomy clubs. These clubs would be key to making certain that district students understand the opportunities that MISD will provide during their school careers.

Curriculum

- ***Implementation of TEKS-aligned "ala carte" activities*** - At all levels, we will be developing activities for teachers to include with their existing curriculum, especially as it helps to prepare their students for a visit with our StarTruck mobile labs.

- ***Teacher Development*** – It will become imperative within Phase 2 to meet with district-wide teachers to introduce them to our programs, tools, and personnel. We view this is as our most important task, since teachers must feel confident and comfortable with what we are doing. Likewise, with an awareness of the total astronomy program, teachers become ambassadors to the students, encouraging them every step of the way.
- ***Planning stages of new high school curriculum*** **–** A major goal for our initiative has been to change the way we teach high school Astronomy (as a class). Once our Robotic Observatory comes on-line, we plan to be using it with our students, directly within the classroom. Currently, there are no curriculum supplements or provisions for connecting such technological tools within the classroom. We must create this. The envision a three-year transformation, from supplementation at first, to full integration at the end. This will allow us to have students using our tools immediately, growing the curriculum as we go.

PHASE 3 (2018-19 school year)

Facilities

- ***Complete robotic observatory/restroom/garage construction*** – The robotic observatory component of this structure, being somewhat modular, could certainly be finished within Phase 2, whereas the completion of the remainder of the structure would occur in Phase 3. This, just in time for our second mobile astronomy lab.
- ***Purchase and outfit second AstroTruck Mobile Astronomy Lab*** – At this point, we fully intend to be attempting to visit every district campus on a routine basis. Therefore, we prioritize our second mobile lab at this time.
- ***Bring robotic observatory piers #1 and #2 on-line*** – Our first on-line observations are made possible with followed by a brief period of beta testing. This means usage of the facilities educationally with our students at the beginning of Phase 4.

Programs

- ***Advanced Astronomy Program*** – As a survey of all things "astronomy," there are actually limits to what can be done if the ONLY opportunity for students at the high school level is "Astronomy I." The scope of that class is far too broad. Because our Robotic Observatory is so powerful, we would need other class opportunities to take full advantage of it. There are current TEKS for advanced classes in astronomy, including Space/Earth Science, Astronomy II, Scientific Method, and Practicums in Science (individual studies). In an "Advanced Astronomy Program," students would be able to take elective courses throughout their high school careers. Students would need to be accepted into the program prior to class enrollment (beyond Astronomy I). It would be like a "magnet school" in Astronomy.
- ***Post-Grad Astronomy Program*** – A vital connection to a successful, sustained program is that we provide graduates within our program opportunities to continue the use of our astronomy tools at the next level of their educations. Likewise, we see tremendous value in having our former students as trainers and technicians going forward. As our students transition from school student to a valuable member of our community, we want to assure that they are never far removed from our programs. Even if astronomy doesn't become a vocation for our students, we want it to always be an avocation.

Curriculum

- ***Implement H.S. Level curriculum changes*** – With the robotic observatory now on-line, we target the district-wide implementation of a new Astronomy I curriculum at the beginning of the 2018-2019 school year. Revisions to the curriculum occur yearly from that point forward, as new capabilities can be implemented.
- ***Planning of new K-8 curriculum*** – Seen before as an "a la carte" supplement to the existing K-8 curriculum, a fully-scale rewrite to the astronomy portions of the curriculum begin in Phase 3. While the AstroTruck mobile labs will continue to provide tools to the pre-high-school age student, we will also utilize the Robotic Observatory, observing fields (Phase 4), and Main Astronomy Center (Phase 5) within the all traditional curriculum areas.

PHASE 4 (2019-20 school year)
(assuming a full 5 phase implementation)

Facilities

- ***Begin construction on main observatory/public building –*** The most exciting aspect of the entire project, ground-breaking for the Public Astronomy Building begins.
- ***Bring robotic observatory piers #3 and #4 on-line*** – Following a similar amount of beta testing, we anticipate instrumentation on piers 3 and 4 to come on line at the end of Phase 4.
- ***Open new outdoor public areas*** - Expand and manicure grounds for public observing fields, including powered observing pads, small amphitheater, outdoor displays (sundial, solar system scale model, and "whisper dishes"), and water features.
- ***Begin construction outdoor learning pavilion*** – A facility deserving its own bullet-point, the pavilion provides outdoor shelter from the hot sun, mainly serving as an outdoor, high-tech classroom. Restroom facilities and a small outdoor kitchen included. Capable of hosting district events, as well as astronomy activities. Construction to be finished in Phase 5.

Programs

- ***Collaborative Research Program*** – The first truly contributory science within our programs will likely come from shared research projects, known as "citizen science" collaborations. As a part of our Advanced Astronomy Program, our students will have the opportunity to target various initiatives where they feel they can assist with research, data contribution, and observations.
- ***Merchandising Program*** – One of the amazing capabilities of our new tools and facilities is the ability to create content that can be monetized. We want our programs, in part, to have an entrepreneurial spirit. Coupled with on-line eCommerce opportunities, we want to teach interested students how they can create content for sale, either on their own, as a part of their business curricula, or to assist with some of our programs' small capital projects and operations expenses.
- ***Community Observer's Program*** – With the opening of our outdoor public access areas, we plan to implement an astronomy program for the community, where the campus opens at specific times to teach and lead local amateur observers and interested public participants in activities geared to show-off the wonders of the cosmos. The program will include both a

guided, public curriculum as well as self-paced observation activities for independent public use. Citizens can bring their own telescopes (which we will help with) or use one of our own telescopes. Binocular observing and guided outdoor "planetarium" shows (with green laser pointers) will teach the Mansfield community what it really "up there."

Curriculum

- ***Implement K-8 curriculum changes*** – With the creation of content, online data repository, streaming feeds, and simple robotic telescope access, we can bring technological astronomy into the K-8 classrooms. Coupled with the capabilities already shared with our mobile labs, our students at early levels will be empowered by all of our current astronomy tools (including the robotic observatory), beginning with the 2019-2020 school year.
- ***Incorporate new curriculum activities made possible by public campus grounds –*** With the opening of the new public access areas outdoors, we can supplement curriculum to reflect those new capabilities. Field trips and curriculum instruction at all levels can now take place at the CAS "campus."

PHASE 5 (2020-21 school year)

Facilities

- All construction phases complete.
- Grand opening of main observatory/public building and facilities
- Full scale implementation of all astronomy assets.

Programs

- ***Dark Sky Initiative*** – MISD Astronomy will be working with our neighbors locally, as well as groups across the country, to promote awareness of light pollution and simple solutions to it. This is fundamental to our responsibility to the environment around us, and our program aims to educate the public on the nature of light pollution and how detrimental it can be.
- ***Energy Conservation Program*** – We pride ourselves in Mansfield ISD when it comes to the responsible use of energy and the savings it can provide, both in terms of usage as well as money. We will be promoting the full, district-wide use of full-cutoff lighting fixtures in outdoor spaces and the switch-over to LED technologies which we believe will save the district more money that any single effort. Likewise, we want to educate a community how to do the same.
- ***MISD CAS Public Tours*** – While the facilities will be open at certain times, we also want the opportunity to really showcase CAS to MVPs and guests. Therefore, we will begin guided tours when we want to really demonstrate our full capabilities.
- ***Summer Programs*** – Education does not stop during the summer months for us. A buy-in at all 5 phases would lend itself to summer camps for astronomy students (and other sciences), community observing nights (star "parties"), regional teacher workshops, and guest lecture programs (not exclusive to summer months). If 3 phases of the project are accepted (the robotic observatory plus AstroTrucks), then there are fewer opportunities in

this regard; however, much like students do "summer reading" in their Language Arts classes, we plan to provide summer activities for district astronomy students as well.

Curriculum

- ***New class offerings in Astronomy (meeting at CAS campus) –*** This finishing of our Phase 5 facilities allows students to come from all district high-schools to participate in advanced programs. We will be rolling out new TEA supported programs at this time.
- ***Further technology integrations into curriculum*** – At this point, we begin the progress of refining our curriculum model to embed technologies with the curriculum, perhaps designing a new MISD iOS app to better facilitate curriculum instruction.

As presented, these phases represent the total of how we plan to implement facilities, programs, and curriculum if our total initiative of a complete "astronomy campus" is accepted. Alternatively, we understand that we might be funded for a part of the plan (i.e. Phases 1 to 3), with the "opportunity" for Phases 4 & 5 to be started "down the line."

If we are only given permission (and funding) to construct the Phase 3 facilities (non-public access sites) and mobile labs, with no future intent for the Phase 4 & 5 as presented here, then Phase 4 would be redefined to include program and curriculum implementations that do not require additional capital. In other words, there are a number of items (limited and down-scaled) in the later phases that can still be done with the "small package." Likewise, some elements in the current Phase 4 & 5 that were "slow-rolled" because of the larger scope of our proposal. These items can be redirected into earlier phases. Once such example is the purchase and completion of the full mobile lab program, where multiple "AstroTrucks" are built at once.

Thus, the phase approach will be altered at various levels of the district's "buy-in" for the proposal. In listing the phases as we do, we desire to show the amount of thought we have put into it, showing that having diverse programs and educational plans not only targets the areas of educational need (as shown in the *Needs Assessment* portion of this document), but also helps assure the maximum number of people reached by our initiative, yielding a quality of education that is unrivaled within a community…anywhere!

Estimated Cost Projections by Phase

We have a very good idea as to the total costs of astronomy-specific items, the observatory-structures (domes and other mechanicals) and the price for each mobile lab. We also have hard cost projections based on previous district structures on a per-building basis, as well as estimates in infrastructure, site development, and traffic provisioning. Soft costs, such as architects, permits, and fees are rolled-into the per sq. foot estimates, albeit we do not fully understand the breakdown there.

However, there is no true way to deliver accurate cost projections whereas these two aspects are merged. In other words, we can price out a 24 ft. diameter observatory dome and an educational facility, but we cannot truly anticipate additional costs in successfully merging one in terms of another, at least not at the scale defined here. Because of this, we will be conservative with our estimations, building in more cost than is probable.

Likewise, as we have gone through this lengthy progress, we are amazed that the largest hurdles and not facilities, programs, and curriculum, but rather in the operational items and staffing considerations that must come out of a yearly fiscal budget. Therefore, at the completion of our phase breakdown, we will take a look at some of those anticipated items that will require yearly, on-going funding.

COST ESTIMATE THROUGH PHASE 3

At a minimum, the project must be accepted and capitalized through Phase 3. As indicated, this represents the building of the non-public facilities, including the Robotic Observatory and Garage building, as well as the first 2 mobile labs. This could be considered a "base proposal" with the larger amount of value. Phases 4 and 5 add the public sites, including observing fields, outdoor learning center (pavilion/amphitheater), and the larger 35,000 square foot astronomy building (with lecture hall and classrooms). The later phases will be projected separately.

These costs assume use of land currently owned by the district. Cost breakdown for the Phases 1 to 3 is as follows:

Phase 1 to 3 ("Base Package"): Cost Estimate

Item	Phase	Cost Breakdown	Notes
Robotic Observatory Facility Features include: - 4,000 square feet total space - 4 pier roll-off roof observatory - Control room - Workshop - Garage/storage areas - Restrooms - Storm shelter	Start Phase 2 Finish Phase 3	- 5,000 sq. ft. finished metal fab structure @ $50/sq.ft. - Astronomy-specific modifications = $50,000 **TOTAL = $300,000**	- Per sq. ft. pricing at the high side of typical estimates for metal fab structures, plus 20%. Covers foundation, structure, labor and extras (i.e. HVAC, doors, roll-off roof implementation). - Astronomy-specific costs include sliding-roof mechanism and pier plinth considerations.
Robotic Observatory Equipment Features include: - 4 pier instrumentation - Roll-off roof with ELK automation - Control/server room - Rugged control PCs (4) - Workstations (4) - Data Server	Phase 2	- 4 pier instrumentation = $204,600 - Observatory automation, weather station, security cams = $10,000 - Servers/PCs = $31,000 -Software = $11,500 **TOTAL = $257,100**	- instrumentation varies pier to pier due to application, thus price cannot be averaged on a per pier basis. - The weather station and an all-sky camera (a security camera) are campus-wide and do not need to be projected in later phases.
Site Improvements/Development Includes: - Traffic provisioning for one non-public entry - Development of ~2 acres property - Infrastructures (water, electric, sewer, data) - Earthwork for observatory split-level, elevated design	Phase 2	- cost for 2 acre parcel = $250,000 - landscaping = $20,000 - Parking lot = $30,000	- We project cost to be $1.5 million for a full 24-acre campus, including both public and non-public access drives. We prorate the cost here based on 1/12 of that figure. Realistically, these costs are higher for a ground-breaking.

- Landscaping/improvements		TOTAL = $300,000	
"AstroTruck" Mobile Lab (2) Features include: - Mercedes Sprinter Van with custom conversion (sliding bed) - 2 fixed pier instrument clusters - Portable telescopes, binocular, microscopes, spectrograph, meteorites, and manipulatives - Display monitors for presentations	Start Phase 2 Finish Phase 3	- Mercedes platform = $58,000 - Custom conversion = $42,000 - Astronomy & support technology = $94,000 Per Unit Total = $194,000 **TOTAL = $388,000**	- 2 mobile labs as part of this proposal. - Conversion includes secondary power system, back-up power system, custom slide-out bed, mounting of monitors for indoor/outdoor use, storage areas, and custom AstroTruck graphic wrap. - ready to use within 20 minutes of arrival to a campus.
Workshop/Maintenance Features include: - Fabrication tools for custom tooling - Maintenance equipment	Start Phase 2 Finish Phase 3	- mill and lathe for metal tooling = $50,000 - woodworking tools = $12,000 - site maintenance equipment = $5500 **TOTAL = $67,500**	- custom CNC mill and lathe for production of parts and adapters required. - woodworking and maintenance tooling for customization of spaces, and astronomy-related projects. - site maintenance equipment including landscaping tools and lawn tractor.
Personnel and Staffing Considerations: - 3 full-time director level positions - "Per event" staffing - Travel budget for marketing events - Site maintenance	Phase 2	- $85,000 per director positions (3) = $255,000 - travel budget = $30,000 - per event staffing = $50,000 - Site Maintenance = $5,000 **TOTAL = $340,000**	- expenses are yearly and repeating.
TOTAL FIXED COST: $1,312,000 (approximate) **ONGOING COST (less utilities) = $340,000 per year**			
Note: For a traditional masonry structure with metal observatory roof, we could approximate total cost on a $250/sq. ft. projection (which is typical of district buildings). This would add ~$1,000,000 to the cost of the metal fab structure estimated above. Therefore, a metal fabrication (as presented) would cost ~$1,312,000. A masonry structure would cost ~$2,312,000.			

Total one-time cost of the first 3 project phases to Mansfield ISD is $1,312,000 as presented. This is an approximation.

It should be stated again that a Phase 1 to 3 constructions is **non-public** site. It makes possible the use of an observatory that can be utilized remotely and robotically. On-site presence is not required for astronomy observations. The storage area will be used to house district-wide astronomy assets and to serve as a staging area for our fleet of mobile astronomy labs, which will also be stored here. ***It should noted that due to the valuable content of the lab vehicles (which must be kept in ready-to-use state), we cannot recommend exterior storage.*** Similarly, because the vehicles will be reconfigured periodically, they should be kept near the astronomy storage area.

COST ESTIMATE with PHASES 4 and 5

The real uniqueness of our proposal – the aspect with the most public appeal and visibility – is the addition of the public access facilities described in Phases 4 and 5. This is the "Full Package," 24 acres (as projected) site complete with the 35,000 sq. ft. main Astronomy Center building, observing fields, interactive displays, and public parking areas. This puts students "on campus," where they do not have to wait for a mobile lab in order to do hands-on instruction, which is the true spirit of our proposal.

Because various categories have been identified in the previous Phase 1 to 3 table, we will augment the "scaled" projections for the larger acreage within the following table. New items will be identified and costs analyzed for items specific to Phases 4 and 5. We will provide new estimates for staffing and on-going costs due to the need for support staff within the new public facility. Please the cost projections for the entire project as follows:

All Phases ("Full Package"): Cost Estimate

Item	Phase	Cost Breakdown	Notes
Phase 1 to 3 Facilities (see previous table)	Phases 2 & 3	**Total fixed costs = $1,312,000**	- Taken from the total fixed cost estimate in the previous table.
Scaled Site Development Costs Considerations include: - Scaled infrastructure for additional 22-acre development - Full-scale earth-moving for creation of outdoor spaces - Public parking lots - Traffic provisions for a new public access drive.	Phases 4 & 5	- 22 acre development = $1,675,000 - Two parking lots at 75,000 sq. ft. total = $278,000 **TOTAL = $1,953,000**	- This represents the increase in site development costs in terms of infrastructure as differentiated from the Phase 1 to 3 construction. - Price does not include development of previously priced 2 acres. Thus, this projects the other 22 acres.
Main Astronomy Building Features include: - 35,000 square feet total space - 2 domed public observatories - Interactive displays - 2 control labs - 2 high-tech classrooms - Lecture Hall - Lounge areas/shelter	Start Phase 4 Finish Phase 5	- 35,000 sq. ft. finished masonry structure @ $250/sq.ft. - Astronomy-specific modifications = $50,000 - Cost of two domes = $500,000 **TOTAL= $11,050,000**	- Per sq. ft. pricing at the high side of typical estimates for masonry fab structures, plus 20%. Covers foundation, structure, labor and extras (i.e. HVAC, elevator). - Astronomy-specific costs include construction considerations for two massive piers/plinths.
Domed Observatory Equipment Features include: - 1 pier instrumentation per observatory - Large instruments for visual and robotic use - Attached control labs - Life video streams to public displays	Start Phase 4 Finish Phase 5	- Observatory instrumentation = $400,000 - Observatory automation and security cams = $5,000 -Servers/PCs = $31,000 -Software = $11,500 **TOTAL = $450,000**	- Featuring 24" and 17" main telescopes - Same technological capabilities and science applications, but configured for public visual use as well. - Telescopes used for teaching of astronomy systems, online data streaming, visual observations, presentations, and science.
Observing Fields/Outdoor Structures Includes: - Observing Field with powered pads	Phase 4	- Pavilion quote with slab foundation (restrooms/outdoor	- We hope that typical use of our campus grounds includes district-wide, non-astronomy use, nature studies, and open (and rented)

- Water features and interactive displays/models (sundial, solar system model, whisper dishes) - Learning Pavilion (50 x 150 ft.) - Amphitheater - Landscaping/site improvements		kitchen/technology) = $250,000 - Other outdoor spaces (fields and amphitheater) and displays = $300,000 - Pond improvements and landscaping = $200,000 **TOTAL = $750,000**	public use/events. - Manicured lawns, a large recirculating pond (to control campus drainage), and outdoor learning areas are key features. - Pavilion prefabricated by Porter Corp. (Poligon model DB3-50x150 quote)
Technologies/Instrumentation Features include: - Student workstations (PCs) in two classrooms (60 count) and PC Workstations in office areas (5 count) - Virtual Reality (VR) technologies for classroom use (30 count) - Portable astronomy instruments (i.e. binoculars, field telescopes, astronomy kits) - Display monitors for presentations	Phase 5	- PC Workstations = $111,800 - VR technology = $90,000 - Display monitors (10) = $10,000 - Presentation technology = $20,000 - Portable astronomy instruments = $68,200 **TOTAL = $300,000**	- High-tech facilities with innovating instructional toys - VR technology we are targeting is from Microsoft, which is currently in product beta-phase. Price as shown is for their SDKs. We hope to pilot this program and have contacted Microsoft in partnership. Cost (if any) is uncertain.
Personnel and Staffing Considerations: - Facilities, mobile labs, and technology management positions needed - Receptionists, bookkeeper, and other para-support staff - Security/maintenance personnel - Travel budget for marketing events - Teachers (for mobile labs) - "Per event" staffing	Phase 5	- 3 additional management positions = $200,000 - travel budget = $75,000 - per event staffing = $100,000 - Site Maintenance = $50,000 - Teachers (3) = $170,000 - Para-support including bookkeeper, receptionists, and janitorial = $180,000 **TOTAL = $775,000**	- staffing expenses are yearly and repeating - operational costs (and perhaps staffing) are offset by grants, merchandising, and commercial efforts.
TOTAL FIXED COST (for all phases): $15,815,000 (approximate) for metal fab (Phases 1/3) **$16,815,000 (approximate) masonry construction (Phases 1/3)** **ONGOING COST (less utilities) = $775,000 per year**			

Total cost of the "full package" is estimated at $15.8 million is the initial Robotic Observatory structure is of metal fab construction. For masonry construction at that phase, total project cost is approximately $16.8 million. This does not include staffing, which must be budgeted yearly, and operational costs (utilities and asset depreciation/obsolescence).

The key benefits of an all-phase construction (as presented), as differentiated from the "base package" where we only build the non-public facilities is:

- The importance of building a "public space," where students can attend classes "on campus," cannot be overstated. This allows for the inclusion of advanced astronomy classes at the high school level (district-wide class enrollments), visits to the campus by earlier age students, post-graduation programs/research collaborations, and community programs that could not be accomplished without a dedicated public facility.

- Giving a "face" to our efforts in the form of a "grand structure" leads to opportunities that would not otherwise be there, including summer programs, community education programs, and guest lecturers. Similarly, it's the most obvious way to impact a community from the standpoint of providing a model for energy efficiency and dark sky preservation.

- There is no doubt we will create a new paradigm in astronomy (and STEM) education with this project, even if we only do the base package; however, the recognition of this will be very subtle (based on student successes only). With dedicated public facilities, we become a true Destination district, where families move to our district because of our more obvious visibility (and cachet), and we retain in-district students that we are losing to neighboring charters/private schools that are perceived as being "more innovative."

- Astronomy is one of the very few educational subjects that can become an avocation for billions of people. Think about it…one doesn't have to be a hobbyist to have a fascination with the cosmos. Even so, a huge world-wise hobbyist market has been made possible by technological advances, making the cosmos more accessible than ever. Regardless of one's level of involvement, it prompts philosophical questions about creation and existence unlike anything else that the district teaches. Astronomy deserves more primacy than it is given, which can best be demonstrated by devoting a facility to its study and promotion.

We have defined the MISD C.A.S. project sequentially within 5 phases. Correspondingly, we have associated a timeframe where ***each phase matches a fiscal/educational school year.*** However, this is more due to the need for program and curriculum development, which requires the presented timeframe. Upon total funding of the project, construction itself can most certainly be done on a timeframe of its own; phased-out sequentially OR concurrently.

Ultimately, speedy development and construction in this regard would put MISD in a position to pay for staffing/operations of public facilities without the readiness of student programs for which it is designed. Similarly, because of the nature of technology, it is always best to make those purchases just prior to their implementation because of their rapidly depleting life-cycle. Therefore, such items should be planned out to match the readiness and development of the programs themselves. ***This is a crucial element in developing a time-frame for construction.***

Keeping these issues in mind, we provide a table that shows total costs for each phase and a recommended time-line for their completion:

PROJECT CONSTRUCTION TIMELINE		
Phase	**Total Cost**	**Timeline**
Phase 1: "Planning and Approval Phase"	n/a	2016-17 School Year
Phase 2 & 3: "Robotic Observatory facility"	~$1.3 million (metal fab) ~$2.3 million (masonry)	2017-18 to 2018-19 School Years
Phase 4: "Outdoor Public Areas"	n/a	2019-20 School Year
Phase 5: "Main Astronomy Facility"	~$15.8 to $16.8 million (depending on Phase 2/3	2020-21 School Year

	construction type)	

CURRENT STATUS OF THE MISD CAS PROJECT INITIATIVE

While not officially a district initiative as of November, 2016 (albeit with full district support), the authors of the proposal consider our project to be in "Phase 1 status," as we have privately accomplished much of the initial phase to bring existing astronomy tools to the classroom. Thus, ALL of Phase 1 is with zero expense to the district; and time given to accomplish Phase 1 is already given to the district freely, as volunteers, working "over-time" to make everything happen.

Our efforts began long ago, but since the 2015-16 school year, most of our time and effort has come from pitching the proposal to key figures in the district, researching the required costs/resources available to make the project a reality, and producing documentation and materials to best communicate this initiative. We are happy to report that the excitement of this project has gone largely ahead of us…which leaves us always trying to keep up.

We consider it a good problem to have!

However, because the proposal requires the experience, vision, and direction of the authors, especially as we define and implement the programs outlined in these pages, there is no way to proceed unless we begin focusing on the project fulltime.

The immense task of creating infrastructure, tools, programs, and curriculum, in addition to facilities planning, project management, and communications requires more time than we can possibly surrender while on contract as teachers during the school year (as we have done to this point). As such, if the proposal is to be accepted in part (through Phase 3) or in whole (through Phase 5), the need for three-full time positions is a non-negotiable aspect of this proposal.

Therefore, beyond Phase 1, the proposal as written requires the creation of district positions for the authors of this proposal (Mr. Ballauer and Mr. Christensen), as well as for Mr. Jason Young, who is a partner in these efforts. We will be seeking sources for provide the funds for these positions so the district does not have to absorb the financial load; however, that is not a promise we can make. In lieu of this, we can discuss alternatives ways we can plan the project, including more of a partnership agreement whereby Mr. Christensen and myself form our own business entity; however, this not an optimal arrangement.

To this point, we are grateful to district leadership willing to listen to our desires and our campus administrators like Dr. Vonda Nunley and Mr. Gary Gates for singing our praises well ahead of our efforts. Dr. Nunley believes that people are assets, and she's gone a long way to support us as much as she has our proposal. Her belief in us gives us impetus going forward; however, regardless of the amount of cost to the district, nothing can truly get done without the creation of time to make these things happen. Simply put, the amount of time and energy required of us would not be fair to us (or our families) if we continued to do everything "after hours" or off-contract.

COST/BENEFIT RATIO

The difficulty with projecting a cost/benefit ratio for this project's completion is that "benefits" for Mansfield ISD are open to a high degree of subjectivity. For example, at the "full phase, maximum expense" completion of this project, the significance of ***our district being known internationally*** for this project and the educational empowerment of our students is difficult to calculate.

Likewise, at earlier phases (minus the public access facilities), operational costs are minimal since paid personnel is not required at what is essentially a private, autonomous facility. Utilities (power and data) for the observatory's use are essentially the only operational costs.

For the authors, the biggest "bang for the buck" occurs somewhere at the completion of Phase 4, where a site is provided for private, automated (robotic) astronomy access with garage/storage facilities for mobile labs for maximum reach to all astronomy campuses, coupled with an extended site to also include public observing grounds with outdoor "classrooms" (pavilion and small amphitheater). These items (sans a main astronomy facility) coupled with full-scale, rewritten curriculum integration and programs will deliver tremendous educational impact and community involvement.

As such, we have not projected costs for such a ***hybrid approach,*** though such can easily be estimated by looking at our itemized cost projections above (perhaps $4 million in total). While not desirable from the standpoint of being able to offered advanced classes and public access for our community, whereas we do not make full-use of our "District of Innovation" and "destination district" labels, it is perhaps a worthwhile model from the standpoint of financing. In other words, should the bond committee (our chief funding source) not see fit (for whatever reason) to fund the "full package," then perhaps funding for a hybrid model that provide some public access is palatable.

In such a case, we would push forward with Phase 5 capitalization independently, seeking funding from our alternative sources. We do believe that once MISD (and people of industry) see the impact of our programs through our initial constructions, then financing for the final phase will become not only justifiable, but desirable.

MEASURING SUCCESS

We are a data-driven industry. Whereas we are often motivated by trends, educators will always judge the success of facilities, programs, and curriculum by hard, objective data.

Because we believe in the importance of this, especially from the standpoint of accountability, we have identified many areas by which we will hold ourselves accountable, data of which can be used to judge our efforts, as well as to help us project future directions for our programs.

Therefore, success of this project, both the impact of the tools and facilities, as well as the programs overall will be measured in six key areas:

1.) Increased Astronomy Enrollment

During the brief era of 4-by-4 education, where four years of science were required for all new Texas High School students, districts worked hard to make a 4th science class available for students. For the most part, Astronomy became the default choice for MISD, a logical 4th year science course for many districts across the state. However, in our opinion, the relatively fast implementation and standardization of this course made for a very lacking educational experience. Teachers with very little expertise in the discipline combined with a sub-optimal curriculum to make for a less than impactful course.

Although Astronomy is now mainly an elective course (once again), or an option chiefly for those achieving the new "multidisciplinary" diploma credential, the opportunity for the course to be something students **want** to take is there. Quite simply, if students know prior to enrollment that a class in Astronomy will offer them multiple opportunities to use powerful astronomy gear in a real-life observatory, especially remotely via Internet access, then enrollment numbers will increase, gradually at first, but substantially once the program is established and actual science is being practiced.

2.) Counting our Reach

Objective measures are all about numbers. Being "data-driven" is an imperative component to all school-related programs, and any programs based on astronomy education would be no different. But unlike a typical school program, we can identify a variety of customer "types," each of which can be counted independently.

We view three types of customers to our prospective programs:

- MISD Students – We have nearly 34,000 students in our district's schools. Each time a student is served by an aspect of our astronomy programs, it must be counted.
- Community members – Unique to our proposal is the impact that our astronomy education programs can have on the Mansfield community. Educational outreach to Mansfield proper, and surrounding areas, is a major component to the "buy-in" of this proposal; the benefits within district borders being substantial. We view our communities as our customers and they would most certainly be counted.
- District VIPs and Special Guests – One of the more amazing aspects of this proposal is the amount of curiosity and wonder it will spark. Keeping track of key players, VIPs, in education, commerce, and business circles speaks volumes to the effectiveness of our innovative facilities and programs. Not only would such people be counted, but their names remembered for future service. If government leaders, entertainers, and media figures decide to visit (and they will), it obviously weighs heavily into the quality of our educational reach.

Our way of desegregating data that represents our program reach is also three-fold:

- Curriculum participation
- Outreach numbers
- Equipment usage

3.) Classroom "Measurables"

Measurable items in the classroom setting will always be the primary way to evaluate this, and every, program. These items include:

- Improvements on summative assessments within the units of study where these capabilities are being used.
- A measured increase in time "under the stars" within classrooms across the district, monitored by data repository download increase and usage logs.
- End of year teacher surveys to monitor participant feedback.
- Use of special, TEKS-correlated lesson plans and "a la carte" designed to utilize the equipment available. assignments would be graded both objectively and subjectively to monitor improvements in learning.

4.) Success in Actual Science

Astronomy is unique in the sense that it is one of the only true sciences where amateurs can make a meaningful contribution. No longer are sky-surveys (to find supernovae, novae, comets, and near-earth objects), variable star research, and measuring star spectra the domain of the major observatories.

Over the last decade, the use of CCD camera technologies and electronic (robotic) telescopes has left these observations chiefly for those amateur astronomers willing to take up the mantle. And increasingly, individuals with even modest telescopes can image much of the known universe, with remarkable beauty and clarity. These are scientifically viable images, demonstrating object interactions, composition, movement, and change.

Therefore, Astronomy students now have the ability to do their own supernovae searches, track asteroids, mark satellite trajectories, and take their own images of the cosmos. A student who discovers a comet will become famous, as well as the school district that made it possible.

The impact on student involvement and excitement would start at earlier levels, where even students in primary grades could be inspired to choose an academic pathway to give them the most opportunities at the high school level. Likewise, the ability to do actual science gives the district an opportunity to offer advanced, "Astronomy II" or special-projects electives that go far beyond traditional high school science education.

The measurable aspect success in this regard obviously the number of scientifically viable observations performed, as recognized by governing bodies such as the International Astronomical Union (IAU), which recognizes, catalogs, and organizes all finding with relation to the science of Astronomy.

As a district doing actual astronomy, Mansfield ISD will be known as a contributor to science.

5.) Public Relations Successes

Our ability to do science naturally gives opportunities for Mansfield ISD to be seen as a **trailblazer** in science education.

While some districts, such as Mesquite ISD, have constructed Planetariums to enhance their Astronomy curricula, this provides no real opportunity to experience Astronomy in a laboratory setting. Likewise, because planetariums are prohibitively expensive due to construction, technology, and programming costs, they are not a practical means of enhancing an Astronomy curriculum. Even so, school districts (and private schools) that have built a working planetarium are still **known** for having done so.

The economic viability and simplicity of having an easily accessible observatory facility, whereby these astronomy tools can be used, assures that Mansfield ISD not only has provided the means to receive great astronomy education, but results that are **marketable**. Periodical publications such as Astronomy Magazine, Sky and Telescope, and The Reflector would certainly be interested in running with this as a storyline - we already know many of the editors of these publications - as well as local and state news outlets who would report on the uniqueness and effectiveness of our program.

Likewise, the images, documents, abstracts, and findings produced by MISD astronomy students and staff can be branded by Mansfield ISD's **"DSS" (Discovering Deep Space) Program.** This will provide not only content for MISD's own webpage and PR materials, in addition to any other gains made through this Astronomy program.

Simply put, the tools and programs outlined in this proposal will produce beautiful images of the cosmos, images in which no other district in Texas can boast. And the number of published works *within all forms of media* is a tangible, measureable metric to our success.

6.) National and International Affiliations

Astronomy, by its very nature, is a collaborative effort. It is this aspect of astronomy that allows for advancement of technologies (especially those highlighted in proposal) which eventually can be found in the hands of amateurs and students. Much of these advancements arise out of necessity, where individuals and third-parties invent ways to make the tools work for them. As such, we plan to utilize many such tools, including both hardware and software, to get even more out of our existing equipment.

More importantly, the shared aspect of doing astronomy arises from the necessity to make sure that processes are followed in a true scientific methodology and that discoveries are verified and reproduced by a multitude of independent sources.

With scientific inquiry (whereas these astronomy tools makes possible), there becomes a natural growth in affiliations and associations within both academic and scientific circles. One such organization, the Three Rivers Foundation (www.3rf.org) is an educational non-profit organization whose mission is (in part) to enrich astronomy education in the North Texas area, runs a 700-plus acre, "Comanche Springs Astronomy Campus (CSAC)" in the dark-skies of northwest Texas. One of our MISD teachers, who helped found this organization more than a decade ago, is largely responsible for building much of the infrastructure and observatories at that site. Because of his continued affiliation with 3RF, we have a ready-made resource and partner for our exploits in Astronomy. (Please see more about the Three Rivers Foundation within this document in the section entitled **Key Personnel/Associations**).

In much the same way, connections are naturally made as the program grows, arising out of mutual-research needs/partnerships and in remaining connected to "real-life" astronomy efforts and current technological tools/procedures. (A list of "Citizen Astronomer" efforts are also listed in the **Key Personnel/Associations** section).

Such organizations, like Three Rivers Foundation, are also state-recognized vendors for on-going Professional Development Credits, hosting workshops for science teachers during the summer months. As the program grows, monitoring our involvement (by staff and students) will provide a direct metric to continued and effective Astronomy education.

7.) Community Sky Conservation

The importance of dark skies to the astronomy "laboratory" is critically important. In dark skies, smaller telescopes are capable of doing amazing science, without the high-dollar cost of larger instruments (and enclosures to house those instruments). With the availability of darker skies already owned by the district, it seems natural to take advantage of the assets that these MISD-owned rural properties provide.

That said, with dark skies comes the necessity for "dark sky education." Light pollution - the unnecessary and wasteful use of light at night – not only harms the ability to do astronomy science, but it also is a waste of energy resources. Many cities and large organizations in the U.S. have discovered the savings brought about by using lower-wattage, full-cut-off lighting fixtures. Even more, current LED technologies are drastically reducing operating costs in many larger businesses and developments. Locally, Globe Life Park in Arlington, home of baseball's Texas Rangers, recently adopted LED lighting. If Mansfield ISD did the same, not only would we benefit from darker skies, but a dramatic increase in visibility, safety, and security which is necessary for all district facilities.

But more importantly, as a district concerned about saving energy and its related costs, we would monitor the success of our Astronomy program by a **Dark Sky Education Initiative**; perhaps ultimately being measured by how much money Mansfield ISD saves in following this new way of light implementation.

Therefore, our astronomy can be measured by the economic and social impact that this grant helps make possible.

KEY PERSONNEL

We believe that innovation has less to do about technologies and facilities, but rather comes at the achievement of **people.** This project requires a certain amount of trust in people…in this case, it's largely about what we say and what we promise to do. Jumping aboard requires faith.

We, the authors, are prepared to answer any questions asked, demonstrate any of the technologies presented, and show any degree of transparency necessary to get people to buy-in completely to what we "selling." We hope that they acceptance or denial of this project initiative occurs only after all research is done; no stone left unturned. Therefore, we sincerely hope that our proposal (and our efforts herein) finds merit within MISD. We fear that people will be too quick to say no to our project simply because they lack the time to do their research.

But because we are selling ourselves as much as programs and facilities, we wish to let you know more about our backgrounds. For those who are not yet initiated, who do not know much about who we are, what follows is a little bit more about ourselves, the key people behind this proposal, including our educational and industry credentials:

Jay Ballauer (Astronomy-Technology Lead/Teacher)
www.allaboutastro.com

A mathematics teacher at Lake Ridge High School, Jay has been working within education for over 20 years. With a passion for teaching others, sharing his favorite hobby, amateur astronomy, has come naturally. Jay has a long history of consulting with private individuals and non-profit organizations, something he can do, not only because of his education background, but because he has very specific technical skills within astronomy circles.

Jay became seriously involved with amateur astronomy when he caught his first views of Comet Hale-Bopp in 1997. Over the next few years, he learned how to view the sky through his first telescope, a 10″ Meade LX-50. He quickly became a very proficient and knowledgeable observer. Shortly after, Jay jumped neck-deep into astrophotography. It quickly became the favorite part of his hobby because of the challenges inherent when merging art with science; technology with astronomy.

His images have been published on NASA's APOD, in numerous books/textbooks and astronomy magazines/websites, and a plethora of literature and media. Awards for his deep-space images include Best Deep Sky Image at the 2004 Texas Star Party and 1st Place in Sky and Telescope's 2007 Beautiful Universe imaging competition. He speaks regularly in 3RF-sponsored imaging workshops and Astronomy club meetings throughout Texas, national conventions such as the Northeast Astronomy Forum (NEAF), as well as major star parties such as the Texas Star Party, Okie-Tex Star Party, and Rocky Mountain Star Stare.

One of Jay's earlier associations was to help establish the Three Rivers Foundation (3RF), a non-profit organization located in Crowell, Texas (see below). He is largely responsible for building the infrastructure and initial observatories at their Comanche Springs Astronomy Campus. Jay originally served as the organization's founding Astronomy Director. He still maintains a consulting/volunteer relationship with 3RF and has private access to their substantial assets, including a new roll-off roof observatory that utilizes almost identical robotic technologies to those proposed within this document to MISD.

Another of Jay's current builds is the Wyoming-based CCBHO (see below), a privately-owned observatory scheduled to be operational in the late-summer of 2016. A remotely-controlled, robotic domed observatory, Jay is the technological lead, operator, and trainer. Once online, access may be shared with MISD in both collaborative and supportive efforts.

Today, with the power of modern CCD imaging cameras and world-class, yet modestly priced telescope gear, Jay has a passion for deep-sky objects, made visible by these technologies, as well as the sciences concerning them. As a teacher in Mansfield ISD, Jay views it as his duty, almost a moral responsibility, to communicate the educational potential and proof of concept of these technologies to district leadership.

Scott Christensen (Teaching Lead/Astronomy-Tech Support)

Teaching Astronomy classes at the high school level for nearly a decade, Scott Christensen understands the difficulty of making Astronomy education fun and exciting for his students. His view that the current model is largely a "history course" is not far from the truth. With this conviction, Scott set out to devise a way to bring "real" astronomy to the classroom. For several years, Scott partnered with Jay Ballauer to do *one* nightly observing event per semester, as well as the occasional outdoor viewing during class-time to view the sun using some of Jay's high-tech solar equipment.

Beginning last year, Scott accompanied Jay on an observatory build, the CBBHO project (see below), where Scott saw firsthand the power available to today's amateur astronomer and the potential to transform astronomy education. Thus, Scott has been learning the capabilities of a remote, robotic observatory and the high performance to cost ratio that it provides. He has also become a capable astronomer from the technology side.

Having a lot to gain as a classroom teacher, Scott is the main organizer and the chief point of contact for this proposal, using his natural sales ability to bring teams together to see the vision of what this effort is all about.

Scott can make a connection between curriculum/instruction and modern astronomy capabilities, and to provide training to other teachers who desire to improve their own astronomy classes.

Jason Young (Astronomy Teacher/Support)

An important, behind the scenes players in these efforts is Mansfield Timberview teacher, Jason Young. As the campus Astronomy teacher, Jason has seen much frustration with the way that Astronomy must be taught. Despite this, he has worked diligently to add something "extra" to his classes, writing grants for specific, powerful astronomy tools and putting them to use where practical. It is the "practical" part that poses most of the issues. Jason is one of the first to voice just how difficult it is to use our existing astronomy tools, and how under-utilized they really are.

More importantly, Jason has helped to identify our collective set of educational needs, as presented within this proposal.

Aside from helping with some of our contacts made throughout the district, which has helped us pave the way for our initiative, Jason is perhaps the most excited about the use of these new (to him) technologies and is ready to learn and train others in its use. Therefore, Jason will become much more visible as this project climbs the "phase ladder."

CONCLUSION

The foundation for our concept for transforming the way astronomy is taught at the K-12 levels began more than 15 years ago now, which means that the technology available for such a proposed educational astronomy "center" existed long before the project was conceived, and the authors began collecting experience using these technologies for public outreach and contributory science long ago. The practical point to be made here is that "proof of concept" can be found extensively within the backyards of many amateur astronomers, where accessible technologies make implementation and costs relatively inexpensive.

Amateurs all over the world are doing science that contributes to the scientific community; including the authors of this proposal. We also have the experience of connecting the applied aspects of astronomy to vast numbers of people, young and old alike, introducing new students to an old universe; old students to a new technology.

To this point, school systems have largely missed out on many opportunities of being a leader in this area; however, because the technology is still young, and the demand is increasing rapidly each day, Mansfield ISD can still reap huge benefits of building an powerful astronomy program based around a facility intended for applied astronomy.

Again, we are available to discuss any and all parts of this proposal, as outlined above. We have a strong desire to create something everlasting, whether by teaching a new generation of students a technology-based science or by building facilities that allow the people of Mansfield, Texas, to experience the same.

APPENDIX 1: PROJECT FAQ
(FREQUENTLY ASKED QUESTIONS)

As word of this project has become increasingly public, we have fielded several questions regarding the would-be proposal. Therefore, it is necessary to address those questions more frequently asked. There is a level of excitement that has come from news of these efforts; a snowballing momentum that exists among those who desire to see this happen in some way. It is our hope that we might clarify certain points so that we many eliminate any ambiguity in the message of those who author this proposal, and to communicate what we truly feel are NEEDED versus what is DESIRABLE.

Are you guys really asking for a multi-million dollar astronomy facility?

What started as a desire for the construction of a small observatory has growing to something much larger.

At this smaller level of implementation, everything can be funded almost entirely by private donations and grants. However, it would require the use of a small area of existing district property and the extension of the district's infrastructure (power and technology) to service the observatory. This requires approval; hence, this proposal in the most basic of senses.

However, here is the problem…with knowledge of how to implement these tools, teachers cannot use the tools. At most, such a facility only benefits the ambitious, well-trained high school Astronomy teacher. There are very few of those, meaning a very small number of students impacted by those efforts.

Therefore, the project must be of large enough scale, managed by individuals who can both implement programs and train district personnel in its usage. This is a problem!

Thus, the logical "next-step" to what is being proposed is a more grand scale of what we want to accomplish, both in terms of facilities, but also in terms of programs and student impact, an advantage that has been clarified within this proposal. We understand very well that doing such would require substantial capital from the school district itself, but at the significant **gain** of a full, district-wide, all-levels curriculum implementation; powerful cross-curricular implementation; mobile learning labs; and world-wide recognition for an innovative, "game-changing" facility and programs. More importantly, the notion of "students doing contributory science" is fully-captured within the later phases of this plan, as well as the investment into our students; particularly students who will be highly regarded going into their post-high school lives. Additionally, it provides educational access to the Mansfield community at large in a way no other programs can.

Changing education requires an investment in both people and resources, something we have become more comfortable with as we have progressed through Phase 1 of our initiative.

Does this proposed observatory (or observatories) require staff present for operation?

MAYBE. The layman's understanding of a classical observatory is that it needs to be "attended to" each night, requiring staffing during operation. With the technology of today, this is incorrect. The choice of these technologies is to assure that the observatory(ies) would be able to function for long stretches of time completely **unattended.** Many such observatories are able to go months without needing a single intervention. Only routine maintenance done of a monthly, quarterly, or even a bi-yearly basis is required to keep them running. For this reason, periodic maintenance can be accomplished by us during extra hours. It is highly likely we would spend many evenings "under the stars" anyway.

Thus, because these observatories are robotic in every sense, most all issues that can arise are capable of being fixed through a networked connection off-site.

But since this proposal includes future *phases* for potential public access sites, such as a main center for on-site learning, full curriculum writing/implementation, and a mobile learning lab(s), then it most certainly would require some degree of staffing. There is not a facility in Mansfield ISD that does not require some amount of on-site presence, even if it just is somebody to cut the grass.

Can we skip steps in the project plan in order see benefits sooner rather than later?

PERHAPS. Nothing really prevents all phases from being accomplished simultaneously, or slightly out of order. However, there are prerequisite steps, as defined earlier, which are required before many of the steps can be finished. It should be said that following the steps, as highlighted here, represents the best opportunity for success; the fastest way of getting the tools into the teachers' (and students') hands. Importantly, having facilities ready far in advance of the programs isn't good stewardship of our resources. Keeping facilities construction in pace with our program and curriculum development is much more practice (and responsible).

Rather than skipping or escalating the timeline, it becomes very important that all those associated with the project know the scope and sequence of these events. Careful orchestration of the project plan assures that delays are minimized; that one person does not have to wait on another to finish their task(s). Besides, the number one way to accelerate this project is to have people working on it full-time. In a way, the biggest problem for the authors is being able create time "off the clock" in order to work on this proposal. While it is certainly labor of love for us in the planning phase, the full implementation of the project can be accelerated by allowing us to focus on it full-time.

What is the difference between a "virtual" astronomy center and a real one?

Much of what can be accomplished in astronomy now can be done without being on-site in an actual, "real" observatory. With the internet, it becomes quite easy to remotely-control an observation session from some place other than the observatory itself, such as a classroom. With several telescopes having such capabilities, then a "virtual" network exists to serve those with the appropriate "permissions."

The level of permissions, of course, would be given to those in the more advanced astronomy classes or by those who provide guided access through projects at the lower levels. For the younger classes, it is more likely that curriculum connections are made by utilizing either the real-time streaming video feeds made possible with the observatories "secondary" instruments or by tapping into data already taken and posted to a data server.

This "virtual" aspect is encapsulated within the first two phases in this document, where 99% of usage, as proposed, will be from an off-site, virtual connection. The scale of this project phase, again as proposed, is not meant to accommodate more than a handful of on-site astronomers.

But what separates the later phases of this proposal is the increased desire for those in the district to have a physical presence with our astronomy program; a traditional, hands-on experience. This is where mobile labs (phase 3), observing fields (phase 4), and main astronomy center (phase 5) come into play.

Why not just build one facility to handle both virtual and on-site astronomy requests?

This issue with a single observatory providing both services is two-fold:

1.) When a curriculum "activity" calls for a virtual connection to the observatory, it must receive priority so as to be timely to that activity. These requests are determined by a computerized prioritization "queue," much like with the way a network printer has a server ("spooler") full of print jobs. Thus, on-site visitors would not be allowed to experience an observatory in person because priority must be given to the virtual requests.

2.) In an observatory with multiple piers (as proposed in Phase 2), having on-site visitors trying to perform observations on one instrument pier setup while a neighboring pier setup is attempting to do a virtual request runs severe risk of contamination of that data. Thus, any observatory(ies) that permit on-site observations must be prioritized for such usage; hence, the need for multiple facilities should the district desire both virtual and on-site forms of usage.

The authors prioritize the daily, virtual use of the observatory. Anything less undermines most of the objectives we have in going forward with this project.

What are the authors' primary concerns for this project?

Our primary concerns are the assumption by others that this is just *another educational facility*. We believe it is so much more than that.

Firstly, it should be stated that astronomy is in a core subject discipline (science), with connections also to physics, chemistry, and all grade-level TEKS. Fundamentally, this will influence a majority of people in the district (not to mention the community-at-large). Coupled with cutting-edge, but easily available technology, this makes an astronomy center much more vital than something like our district's Agricultural Technology facility, as fine as it is.

Secondly, we cannot take a "cookie-cutter" approach to this project. There are very specific requirements from an astronomy standpoint. For example, it might be easiest to construct a building on flat land; however, there is a significant benefit from the astronomy-side to mount delicate instruments higher in the sky, above the surroundings. In fact, a 10-fold improvement in astronomy "seeing" (atmospheric stability) can be gained by raising a telescope 30 feet off of the surrounding ground. Likewise, cement or asphalt pavement is an enemy to astronomy, as they continue to radiate heat upward for hours even after the sun goes down. The effect this has on the telescopic views is dramatic. As such, great consideration must be placed to landscape design and parking lot locations.

Thus, **form** most definitely follows **function**. This is one of those, "do it right, or don't do it at all" kinds of projects.

Thirdly, *bigger* is not necessarily *better*. There is *some* latitude to be given here to make some of the facilities architecturally impressive (keeping with the MISD "look"), but it is not a necessity from a "doing astronomy" standpoint. The question of facility size (within this document) becomes more about accommodating people on site. If district leadership wants students to experience a "campus-type" of environment (as outlined in the later phases here) then space accommodations and technology must exist to do that.

Will these observatories be available for public observing for on-site visitors?

Only the domed observatories included in the Phase 5 construction of the main building will be available for routine, public use. Until Phase 4 (public outdoor spaces) and Phase 5 (public indoor spaces), there is no provision in this plan for on-site visitors.

What factors were involved in the design decisions for the observatories?

The following issues are considered as important for the project to succeed from the standpoint of design:

1.) Priority must be given to accessibility and speed of our internet technology. Full access to our data server must be granted at all times.

2.) Technology placed within the observatories themselves (where exposure to ambient climates exists), must be "industrial" or "rugged," in nature. For example, control PCs at the instruments must be of the fan-less type, with solid-state drives and ip-65 rated weather-proof enclosures (or better). Similarly, lightning abatement (grounding of weather sensor and instrument masts), must be addressed.

3.) Instrument piers must be on separate systems from the surrounding floor. This serves to dampen external vibrations to the sensitive instruments. As such, pier footings will need to be drilled deeper than the surround slabs, reaching below the area's freeze line of approximately 42".

4.) Although we are not on a mountain-top, elevation of the astronomy instruments away from ground level is still crucial. Negative local atmospheric effects vary inversely with pier height. Our personal experience, and those of others, shows that 90% of all adverse atmospheric effects happens within 30 feet of the ground. As such, locating an individual observatory atop a second floor structure and/or building on a raised pad (hill) is advantageous.

5.) Domed-observatories are intended to house a single instrument pier, albeit with supreme protection from wind. A roll-off roof structure (where the roof rolls away to reveal the entire observatory area) provides less wind protection, but a larger number of instrument piers (with separate instruments for differing types of observations). The roll-off roof design is far more practical and cost-effective, though a domed design is certainly more "classic" in appearance (more attractive) and more useful for sensitive scientific applications. A dome also provides more space for visual observations as compared to a roll-off roof observatory; it accommodates many more people from a space standpoint. The two-observatories proposed in Phase 5 are domed observatories. A 4-pier roll-off roof structure it proposal as our initial observatory within Phase 2.

Why don't you guys just go into business for yourselves to accomplish these same goals?

The authors of this proposal are educators, working for modest pay, supporting families. Whereas we do indeed "moonlight" during weekends, holidays, and summers – we offer private consulting in doing mechanical, technical, and astronomy training to individuals and smaller non-profits - it fundamentally comes down to being able to earn enough income to support our families. We simply cannot risk leaving our current positions to do this. Nor can we surrender the income that comes from those part-time endeavors.

Perhaps more importantly, we do not have the ability to raise capital funds (through donations and grants) independently, solely on our names alone; such would require a direct association to the groups by which we were to represent. Plus, taken a step further, being already within education adds legitimacy to everything we do. On our own, we would stand little chance of persuading schools to pilot our programs, for example. Working together, all types of outside partnerships and relationships are possible from a funding standpoint.

Most importantly, the authors do have to protect their time on this. With the responsibilities we do have to our other projects while "off the clock," we do not feel that we will give integrity to our current responsibilities as classroom teachers unless our focus is 100% on that job while "on the clock." As such, we would ask that consideration be given to immediate full-time positions to manage this project instead of compromising our effectiveness as classroom teachers in a part-time (or overtime) role.

Can MISD make money off of this endeavor, as least enough to cover operational costs?

YES! Other than how we believe our students will be impacted because of these efforts, this is the part of the project that is most exciting for the authors. We believe that the facilities, tools, curriculum and programs will be so innovative, that the uniqueness and impact of our efforts will be so successful, that other districts will eventually want to pilot these programs as well. It will be difficult for competitive districts in Texas (and abroad) to sit back and watch us change so many lives. Once the Mansfield ISD program comes on-line and the successes become evident, we believe the market will grow rapidly.

Simply put, we believe that this future market for our curriculum and services will be huge. At that point, operating funds will be drawn from the piloting and licensing of our programs, curriculum, and technologies to other educational institutions and districts.

Servicing such a growing market might prove to be quite a challenge, and the authors of this proposal do have some suggestions for how those things might best be addressed. However, that is a discussion that goes beyond the scope of this document.

APPENDIX 2: PARTNERSHIPS

Because of our backgrounds in the astronomy industry, partnerships to our efforts are currently in place. While many of these have already been mentioned throughout the document, we would like to give full descriptions of these entities and the types of benefits they offer.

Three Rivers Foundation (3RF)
www.3rf.org

A non-profit, 501(c)3 organization based in Crowell, Texas, the Three Rivers Foundation, known simply as 3RF, supports science education via activities at their 700-acres **Comanche Springs Astronomy Campus (CSAC)**; outreach at schools from Dallas to Lubbock, Amarillo to Abilene; and partnerships with other organizations.

3RF hosts free, twice-monthly public star parties, as well as several public educational programs. It also provides TEA-recognized Professional Development workshops for most of North Texas' Educational Service Centers, including Regions 9, 14, and 17. 3RF also runs a "StarTruck" Mobile Lab to schools all over the north Texas area, which is the perfect model for similar program discussed here.

Campus buildings include a large roll-off observatory housing a 30-inch reflecting telescope and a smaller robotic roll-off observatory for remote-controlled operations (to which the authors have online access). Their main, 30 foot domed-observatory houses a 15-inch refractor, the largest telescope of this type in Texas that is used on a regular basis for public events. The attached classroom serves as inside instructional space during school visits, as well as an alternate location for small programs in case of inclement weather.

Additional facilities include two outdoor classrooms, four bunkhouses capable of housing up to 65 overnight guests, 12 RV spaces, 3 outdoor pizza ovens and an adjoining pavilion and a large new shower/restroom facility.

3RF has written a TEKS-aligned "Astro-Physics in a Nutshell" curriculum, used for campus activities, workshops, and science education support among schools. In addition to unique capabilities in Astronomy, 3RF also has curricula to engage students in hands-on nature activities related to The Plains as an integrated ecosystem.

There is a mutual benefit for a close association between Three Rivers Foundation and Mansfield ISD. 3RF already has an innovative science curriculum for science education - which can be piloted in whole or in part here - and proof of concept for many of the MISD Astronomy efforts defined in this document, including the concept of an "astronomy center" overall. For 3RF, involvement and impact within a district as large MISD would help drive 3RF goals and efforts, particularly for their Astronomy Campus. Located only 3.5 hours from Mansfield in very dark skies, 3RF deserves more attention than they have received.

Because of the existing relationship that former 3RF Astronomy Director, Jay Ballauer, has with the current 3RF Astronomy Director, Jeff Barton, the groundwork for a mutually-benefiting association is already laid.

CBBHO in Wyoming
www.cbbho.com

In 2014, during the planning of his own private observatory, Dr. William Cruzen lost two of his sons in separate, tragic events. His new observatory project, the appropriately named "Cruzen Boys Black Hills Observatory" or CBBHO, is located near Newcastle, Wyoming, on the edge of the Black Hill National Forest. Jay Ballauer, the Lead for the MISD efforts, is also the Lead for CBBHO, subcontracting infrastructure and construction of the remote-controlled, robotic domed observatory which will house some of the best equipment available to astronomers. Other setups, including outdoor telescopes and an on-site control center are also being constructed.

Lead teacher for the MISD effort, Scott Christensen, has teamed with Jay on this project, which has served as technological training for both Mr. Christensen and Dr. Cruzen. Through this association, Dr. Cruzen has already donated approximately $7500 worth of astronomy gear currently being utilized at Lake Ridge High School, which will be relocated to either the proposed observatory center or the mobile lab(s).

Because of Dr. Cruzen's desire to impact students with his own observatory, there will be a benefit for Mansfield ISD astronomy programs when it comes to performing observations and collecting data. His robotic observatory will provide additional telescope time to students for specific projects and inquiries.

Texas Astronomical Society of Dallas & Fort Worth Astronomical Society

The Texas Astronomical Society (TAS) is a Dallas-based club for people who hold an interest in the field of astronomy. Annual membership offers many advantages, including informational meetings, public interest groups, and public access to their Atoka, Oklahoma, dark-sky site with club astronomy equipment.

Established in 1949, the Fort Worth Astronomical Society (FWAS) is one of the first adult amateur astronomy clubs formed in the country, and we are one of the largest, with an active membership of over 200. FWAS members have a wide range of experience from beginners to professional astronomers. Historically, FWAS has taken a positive and active role in sharing our expertise and time with the public. The Society conducts numerous star parties and astronomy-related presentations for local schools, clubs, and other organizations throughout the year as part of its public outreach programs.

Together, both clubs represent a great cross-section of the type of amateur astronomy being accomplished in the North Texas area. Their members, always knowledgeable and passionate, look for opportunities to share what they know. These members have the spirit and time of a volunteer.

A healthy group of volunteers is imperative to the success of any astronomy program, and MISD does not have to look very hard for people willing to fill in the gaps to help our students or to assist in routine maintenance of astronomy assets and facilities. Being a long-time amateur astronomer in this area, Mr. Ballauer has many connections to people and resources in both clubs.

APPENDIX 3: COLLABORATION NETWORKS

These are existing "citizen science" networks where people are collaborating on astronomical science projects. This is by no means a comprehensive list of collaborative networks working toward the same program goals, but it just goes to show how amateurs are able to contribute in the field of astronomy. Part of a revamped Astronomy curriculum would become involved with some key "citizen science" programs such as the following:

American Association of Variable Star Observers

Center for Backyard Astrophysics

Citizens in Space

Gamma-Ray Coordinates Network

Global Telescope Network

Hubble Exoplanet Collaboration

International Meteor Organization

International Occultation and Timing Association

Lunar Impact Monitoring

Minor Planet Center

Society for Astronomical Sciences

Soicety of Amateur Radio Astronomers

SOHO Comet Hunting

Target Asteroids!

APPENDIX 4: COST TABLES FOR VARIOUS ITEMS

Computing Requirements through Phase 5			
Station Type	**Cost Estimate (approx.)**	**Key Specs**	**Usage**
Student Workstations - Quantity: 65 - Two classrooms of 30 PCs each - Five offices with 1 PC each - Compare to Dell XPS 8900 SE	$1720/unit $111,800 total	- 6th Generation i7 Intel Processor - 28" 4K monitor (compare to Dell S2817Q) - 16 GB RAM - 2TB + 256 GB Solid State Drives - Windows 10 - NVIDIA GeForce GTX 745 4GB DDR3	- For classroom graphics data processing in student classrooms and for office PCs
Lab Workstations - Quantity: 8 - Four in roll-off roof observatory - Two each in domed observatories - Compare to Dell XPS 8900 SE	$3349/unit $26,792 total	- 6th Generation i7 Intel Processor - UltraSharp 32 4K monitor (compare to Dell UP3216Q) - 32 GB RAM - 2TB + 256 GB Solid State Drives - Windows 10 Pro	- For lab workstation data acquisition; graphics data processing.

		- NVIDIA GeForce GTX 960 2GB DDR5	
Industrial PCs for Instrumentation - Quantity: 6 - Neousys Rugged Intel Skylake Fanless Computer (Nuvo-5000)	\$3564/unit \$18,984 total	- 6th Generation i7 Intel Processor - 16 GB RAM - 1 TB solid state drive - Windows 10 Pro	- To interface with astronomy instruments at the pier. Configuration complete with USB hub and PoE devices to drive security cams and weather sensors.
Rack Server - Scalable for external client growth and eCommerce - Data server (primary) with application expandability - Compare to Dell Power Edge R630	\$6486/unit	- Win Server 2012 (60 user license) - Intel Xeon processor E5 2600 - 16 GB - Two 1.2 TB 10k RPM SAS drives for RAID 1 configuration.	- long-term file storage (RAID1) - short-term FTP hosting - remote access - PC backup - IP security camera hosting/streaming service - webpage hosting - 360 mb/hour per session storage requirements (up to 6 sessions simultaneously)
TOTAL = \$164,062 (approximation)			