Selecting a Planetarium Projection Instrument

by Kenneth D. Wilson

“A man gazing on the stars is proverbially at the mercy of puddles on the road.”
– Alexander Smith

In building a new planetarium (or upgrading an old one) no decision is more crucial than the selection of the main planetarium projection instrument. This is the heart of the planetarium facility. It projects the stars, Sun, Moon, planets, and often such things as the Milky Way, coordinate grids, cardinal points, twilight glows, constellation outlines, eclipses, and special effects. Some even project computer graphics.

Although organizations with suitable resources can and have custom built their own planetarium instruments[1], today almost all are made by one of about a half dozen manufacturers. It is a tribute to these companies that they continue to offer such a wide variety of high quality planetarium instruments and continue to improve their qualities and features for such a highly specialized market. Contact information for planetarium manufacturers may be found through the IPS website [http://www.ips-planetarium.org/]

In selecting a planetarium instrument there are many factors that need to be considered: cost; permanent vs. portable installation; dome size; dome configuration; star field realism; accuracy of Sun, Moon, and planet positions; sight lines; instrument profile and footprint; parts and service issues; projected lifetimes; and control systems.

Types of Projection Instruments

Broad categories of projection instruments are (a) optical/electrical/mechanical planetarium projector, (b) digital video projection instruments, and (c) laser projectors.

The very first projection planetarium was an optical/electrical/mechanical planetarium projector developed in 1928 by Walter Bauersfeld, of the Carl Zeiss Company in Germany. The device used metal plates with tiny holes drilled in them for the stars. These plates were mounted inside lens systems clustered around a single, bright incandescent light bulb. Light from the bulb would shine through the lenses and star plates and project on to the reflective interior surface of the planetarium dome. The whole apparatus could be rotated to simulate the effect of the Earth’s rotation. Added to this star sphere was a series of separate smaller projectors for the Sun, the Moon, and the naked eye planets mounted on a complex system of gears to accurately simulate the apparent motions of these objects. Later models added a second star sphere for the southern celestial

[1] A famous example is the Academy projector of the Morrison Planetarium at the California Academy of Sciences in San Francisco, California, USA.

hemisphere and adjustments for latitude and precession motions. This basic design of optical/electrical/mechanical planetarium projector survives today primarily in machines built by Zeiss, Minolta, and Goto.

In the 1950's Armand Spitz decided that the wonderful Zeiss planetariums available at the time were too large and expensive for small communities, schools, and colleges. He designed an alternative planetarium projector for smaller domes and budgets. His scheme used a dodecahedrun of sheet metal star plates. Rather than an expensive system of lenses, Spitz used a small, point filament light source to project through the bare pinholes in the star plates. In time Spitz added small lens systems for the brightest stars; motorized diurnal motion; Milky Way, latitude, and coordinate grid projectors. The Spitz Company continues to design, build, and maintain planetarium instruments in a range of sizes and features.

The concept of a simple, inexpensive, lens less planetarium continues today in the form of portable planetariums with inflatable domes, produced by companies such as Learning Technologies, Inc., Goto Optical Mfg. Co., and R.S. Automation Industrie. The Starlab™ planetarium uses a pinpoint light source and interchangeable plastic cylinders with small clear spots for the stars.

The most recent improvement to the original electro-opto-mechanical design is the Zeiss planetarium that uses fiber optics to project star fields so bright that they can be easily seen under normal room lighting conditions.

Perhaps the most revolutionary new designs in planetarium instruments since the original Zeiss planetarium are the digital video projection instruments. The first one produced was the Digistar computer graphics planetarium from the Evans & Sutherland Company of Salt Lake City, Utah, USA. This system uses a powerful, real time, computer graphics system to draw the stars as dots onto an ultra-bright cathode ray tube (CRT) coupled to a single, large wide-angle lens system. Not only can this system display accurate star and planet positions, but also transport the audience to viewpoints anywhere within the solar system or within the stellar database out to 200 light years. In addition planetary algorithms and stellar proper motion data allow time changes of plus or minus one million years to be displayed. More recent developments in digital video projection include Minolta's MEDIAGLOBE and a variety of all-sky video projection systems using multiple video projectors.

Another innovative new planetarium design is the Omniscan™ from Audio Visual Imagineering of Orlando, Florida, USA. This system uses a computer controlled scanner & laser to project a full color star field and other computer graphics.

Have Planetarium, Will Travel: Portable Projectors

Perhaps the first decision that must be made is whether your planetarium will be fixed in location or be a portable facility. This decision may be based on economic factors, especially since portable planetarium systems are most often the least expensive planetariums to establish. More often the decision is driven by the initial mission that's been determined for the planetarium. Portable planetaria tend to be dedicated primarily to educational uses, especially as traveling outreach to schools. Although fixed location planetaria are often dedicated to educational uses, some are also multi-purpose theaters and classrooms that function as parts of a school or museum. Fixed location planetariums often require more staff and support resources than their portable cousins. Although not required and not universal, most fixed location planetaria present programs with pre-recorded sound tracks. Most programs presented in portable planetaria are presented live. Thus it's very important for the portable planetarium operator to be highly skilled at giving live planetarium programs to the target audiences of the facility.

At the time this is written there is not much variety to choose from in the area of portable planetaria. If this is the sort of planetarium you are pursuing then your choices may be limited. Nonetheless, you may have some choice in the size and type (inflatable vs. prefab) of dome and the quality of the star field provided. At least one manufacturer offers interchangeable star cylinders which offer (among other things) city vs. country skies; constellation outlines; and even continental outlines.

There are some considerations unique to the selection of a portable planetarium. First of all, you'll want to know how easy it is to transport, set up, and take down the planetarium. This will depend in part on how much the system's major pieces weigh and how much space they take up. Will it fit in the vehicle(s) available to transport it? Will the operator(s) be able to easily unload and set it up in all of the intended operation locations? Will it operate on the electrical service available at these locations? How long does it take to set up and take down?

In addition to the above considerations, developers of portable planetariums should carefully read the following discussion about planetarium projectors in general. You'll find that much of it also applies to the selection of a portable instrument.

Matching the Projector to Dome Dimensions - One Size Does Not Fit All

Most planetarium instruments are designed for a certain dome diameter range. The brightness of the projections, the focus of lenses, and parallax of various projection elements – to say nothing of the physical size of the instrument – need to be coordinated to the dome size. This is particularly important to keep in mind when considering a used projector or replacing an existing planetarium instrument.

Often the upper limit of dome size is limited by the budget of the project. The lower limit is usually determined by the total number of people that you want or need to fit under the dome at one time for a planetarium program. There is no simple formula correlating dome size to seating capacity. It depends on the size of the seats; the area devoted to centrally located projectors; whether or not the seating is directional; how much the dome is tilted, if at all; and the size of any stage area.

The table below will give you a very rough idea of typical seating capacities of various dome sizes.

Dome Diameter Range	**Approximate Seating Capacity**
Less than 7 meters	10 – 50*
7 to 11 meters	20 – 130
11 to 13 meters	40 – 200
13 to 16 meters	140 – 250
16 to 19 meters	200 – 270
19 meters and greater	250 - 680

* Audiences larger than 50 have been accommodated under special circumstances in which the audience is an unusually far distance from the dome with extreme dome tilt or height.

Not all planetarium projectors will work properly in a tilted dome situation

The Star Field

"Look how the floor of heaven
Is thick inlaid with patines of bright gold."
– Shakespeare: The Merchant of Venice V.i.

Perhaps the most important feature of a planetarium projector is the quality of its star field. After all, the realistic simulation of the starry night sky is at the core of the planetarium's unique character. Nothing indoors comes close to the realism and impact of the night sky projected by an excellent planetarium projector. Visitors will remember such an experience long after the topic of the show they've seen fades from memory. Beyond the aesthetics, the more realistic the star field is, the more effective the planetarium will be as a tool for teaching observational astronomy.

Star field realism is ultimately a subjective, individual judgment. Key factors that can greatly influence that judgment are: the accuracy and range of brightness; accuracy of star color; star dot size; star shape; contrast; positional accuracy, number of stars/limiting magnitude, and twinkling.

There is a great range in the brightness of the visible stars. From Sirius, the brightest star in the night sky, at magnitude –1.5 down to the hundreds of 6th magnitude stars visible to the dark adapted, naked eye in a dark sky lies a ratio of almost a thousand to one in brightness. The closer a planetarium's stars recreates this range of brightness, the more realistic the sky will seem. What's more, the individual stars must fall accurately within that range. Although a typical visitor to your planetarium may not be able to judge star brightness to within a tenth of a magnitude (as many variable star observers can); they will notice if, for example, the stars of Pegasus are brighter than those of Orion. Assuming accurate star brightness, you can gauge how faint the dimmest stars of a given projector will be by the total number stars that it projects. Less robust planetarium instruments may only project the 500 brightest stars (the equivalent of a light polluted urban sky) while others reach the naked eye, dark sky limit of 6^{th} magnitude by having some 5,000 stars. A few exceptional planetariums project objects fainter than 6^{th} magnitude so that patrons can even use binoculars in the planetarium to see objects that the eye alone can not see. There is also an argument that including stars fainter than 6^{th} magnitude makes for a star field with more "depth"—that the stars near the limits of one's vision adds a subtle but unmistakable quality to the sky.

Equally important to accurate star brightness is accuracy in the positions of stars in a planetarium sky. All planetariums, sooner or later, are used to teach people how to identify constellations and asterisms. It is almost impossible to do this without connecting the stars with real or imaginary lines to suggest key geometric patterns that help to identify and remember these star groups. If the planetarium star positions are not accurate, then the planetarium is considerably less effective for this use. Make certain that at least one person involved in the selection of your star projector is very familiar with the constellations of the real night sky. If you have no one on your current staff or board who knows the night sky, recruit an experienced local amateur astronomer or two to examine the stars of any planetarium projector you are seriously considering projected on an actual dome of the proper size.

Yet another important quality of a planetarium star field is star color. The color of real stars is subtle, but can be detected by anyone who looks for it, especially in reddish stars like Betelgeuse and Aldebaran. Some planetarium projectors show all stars as the same color while others exaggerate the colors. Ideally the planetarium should present star colors as close to the real ones as possible.

The size, shape, and quality of the individual star images also affect the audience perception of a planetarium sky. Some planetarium projectors display stars as evenly illuminated disks of varying sizes, larger disks for brighter stars and smaller disks for fainter stars. Other projectors use intense arc lamps to show stars with peak intensities at the center of the star disks and softer edges where the intensity of light rapidly falls off. Still other star projectors produce tiny blobs of light for the stars. No planetarium projector yet made produces star images that are perfect facsimiles of the real stars when examined closely. Which type of star simulation is best? This is a subjective issue with a variety of opinions among planetarium professionals. A good approach is to recruit a team of people that you trust and have them spend some time looking at the real night sky, especially near the time of a New Moon and from a dark, rural location. Then have them look at the various planetarium projectors that you are considering. Use this experience base to develop a consensus as to which projector produces the most realistic star field.

Some planetarium star projectors can make their stars twinkle at the touch of a button. This adds an extra dash of realism to Earth-based stargazing in the planetarium.

The Sun & the Moon

"I know that it is the sun that shines so bright." – Shakespeare: The Taming of the Shrew IV.v

Another area where accuracy is important is the appearance of the Sun and Moon. It is, of course, impossible to display a projected Sun image that is as bright as then real object. Nonetheless, a good planetarium Sun should be bright enough that it will stand out when blue dome lights and cloud projectors are used to simulate a day time sky. Audience members should not confuse the planetarium Sun with the Moon. They should see the projected Sun and say to themselves, without prompting, "That's the Sun."

Crafting a realistic Moon projector is an even greater challenge. Unlike the Sun, the Moon has light and dark features that can be seen by the naked eye. These features should be plainly visible, especially when the Moon is at full phase. The greatest challenge for the Moon projector is being able to demonstrate the phases of the Moon. To do so the projector must show the Moon from a very thin fingernail-like crescent, through quarter phase with a straight line dividing the day and night halves of the Moon; to the full disk of the Full Moon. Some of the lower cost planetariums accomplish this by having a series of small transparencies of the Moon in its various phases mounted on a disk that rotates through a small projector. The operator can manually rotate the disk to set the Moon projector to show the current Moon's phase. More advance projectors use an image of the Full Moon and a motorized occulting device that alternately uncovers and covers the Moon image to simulate the phases. This method allows you to, in effect, speed up time and show the Moon going through its entire cycle of phases in just a few seconds.

Moon projector realism can be judged by examining two aspects. First is the quality of the projected Full Moon image. It should, of course, look like the real Full Moon. If you haven't looked at the real Full Moon recently, spend a little time doing so. Then it will be much easier to judge the realism of the Moon projectors of prospective planetarium instruments. The second aspect to examine closely is how the realistic the phases of the projected Moon appear. Here you should examine the boundary between the light and dark parts of the Moon. This boundary is called the terminator. When the Moon is in its crescent phase the terminator should be curved. The closer to New Moon, the greater should be the curve of the terminator. As the Moon is advanced through its phases towards the

First Quarter Moon phase, the curve of the terminator should become flatter until, at First Quarter, it should be straight. After First Quarter the terminator should start curving in the opposite direction until it becomes a semi-circle at Full Moon. After the Full Moon, the process should reverse itself as the terminator returns on the opposite side of the Moon and progresses from semi-circle to straight at Last Quarter to steep curve at the crescent just before New Moon. If you ever visit San Francisco, California in the United States be sure to visit the Morrison Planetarium in Golden Gate Park. Its homemade planetarium projector has one of the best Moon projectors ever built.

When the first planetariums were constructed their Sun and Moon projectors were designed to provide disks that were true to the half degree diameters of these objects in the real sky. For some reason, these images appeared to be too small to the human eye-brain combination. By making the Sun and Moon projections twice (or more) the size of the real objects most of today's planetariums choose apparent accuracy over technical accuracy in this case.

The Planets

Most planetariums (hence the name) can project at least some of the naked eye planets. The list usually includes Mercury, Venus, Mars, Jupiter, and Saturn. The planet Uranus is marginally visible to the naked eye, although most people need binoculars or a telescope to spot it. Neptune and Pluto definitely require optical aide to be seen. Most mechanical planetarium projectors stick to the obvious naked eye planets and omit Uranus, Neptune, and Pluto. Some of the new computer based planetarium instruments include these outer three planets. Planets are usually shown as bright dots of light, although some planetariums show these objects as they might appear in a small telescope. Some project planets using zoom lens systems that allow the operator, at the push of a button, to zoom from the dot-like, naked eye image to a telescopic view.

Planets vary in brightness, both one to another, and over time. In addition there are subtle color differences between the planets. Mars should have a subtle reddish hue and Jupiter and Saturn should be pale yellow. The closer these projected planetary images are to the real ones, the better. Here again, having someone knowledgeable and experienced in observational astronomy to help with the evaluation is most helpful.

Positional Accuracy

In addition to visual accuracy the Sun, Moon, and planet projectors need to be very accurate in positioning. Except for the most inexpensive planetarium projectors, most planetarium instruments aim their Sun, Moon, and planet images using either computer graphics, computer positioned mirrors, computer aimed projectors, or projectors attached to complex gear systems. No matter the method, these objects must be accurately positioned to demonstrate such things as seasonal changes, conjunctions, and groupings of the Moon, planets, and stars.

To assess the positional accuracy of the Sun and Moon projectors of a prospective planetarium instrument, it's best to recruit someone knowledgeable and experienced in visual astronomy. He or she should carefully compare samples of the planetarium's Sun, Moon and planet positions and brightness as referenced to the projected stars and to projected coordinate reference lines, to tables and maps that are found in reputable almanacs, astronomical journals, and astronomy software. Checks should be made not only on the current date, but also several decades into the future and into the past.

Down in Front!

In selecting a planetarium instrument, consideration should also be given to how much of an obstruction the projector will be to the audience. Not only the physical size of the instrument needs to be considered but also how close it will be placed to the nearest seats and the configuration of those seats.

The new digital planetarium projectors gain the top marks in this realm, since they are smaller than their electro-mechanical cousins. Furthermore they can be designed to work either from the circumference of the dome (e.g., all dome, multi-projector video systems) or, as in the case of the Digistar, from below the center point of the dome.

If you are considering an electro-mechanical planetarium instrument compare the physical dimensions of the projector. All other things being equal, the smaller the projector is, the less of an obstruction it will be for other projectors (especially panoramas and all-skies) and for your patrons.

Many modern planetaria have their star projectors mounted on quiet elevators that can lower the machines below the floor of the planetarium chamber so that the space can be used for other events that don't require the star projector. Often these elevators are designed with an intermediate position which allows the instrument to still fill the dome with a projected (although not accurate) star field for background effect while minimizing, or eliminating, the obstruction of the star projector. Except for digital and portable planetariums, such elevators are highly recommended.

Turn, Turn, Turn…

Planetarium motions should all be smooth, quiet, and have a continuously variable range of speeds in both directions. In addition to the movements of the Sun, Moon and planets already described, the following movements are also replicated in a good planetarium:

Diurnal Motion: the apparent daily movement of the stars caused by the rotation of the Earth.

Latitude Movement. Latitude motion of a star projector allows the operator to show the sky as viewed from the perspective of different latitudes on the Earth's surface. Some projectors may have limits to the range of latitudes from which they can project. Also, some of the smaller, less sophisticated machines may not be capable of showing the stars nearest one of the celestial poles (usually the South Celestial Pole is the one that's lacking, if at all.) You'll certainly want to make sure that you can fully display the sky visible at the home latitude of the planetarium. So it's best to ask the manufacturer, or check the written specifications, about the range of latitudes and the extent to which the polar regions are covered. Ideally latitude function has a "home" setting to return it to a standard orientation.

Azimuth Movement. It's often very useful to be able to rotate the planetarium sky around the plane of the horizon so that audiences can face different compass directions. This is done with the azimuth motion of the planetarium projector. This motion should also have a "home" setting to return it to a standard orientation.

Precession. Precession motion of a planetarium allows you to simulate the slow 26,000 year wobble of the Earth on its axis. This motion is essential if you want to show how the sky has changed (or will change) over time spans greater than a few hundred years.

Electrical and Environmental Requirements

All planetarium instruments require electrical power to operate. You should make sure that any planetarium equipment that you are considering will operate (or be easily adapted to operate) on the electrical power that will be available for use. In addition to the obvious concerns of voltage, amperage, and current frequency you should carefully study the manufacturers requirements for the purity of the electrical current and the allowed tolerances for variations. These can be particularly important for planetarium instruments that depend on computerized components.

In addition to electrical requirements the manufacturer may also have certain limits of temperature, humidity, or dust for their equipment. Exceeding these limits may not only hamper the performance of the equipment, it might also void your warranty.

Auxiliary projectors

In addition to the basic Sun, Moon, planet, and star projections, many planetarium systems are available with auxiliary projectors. Some of these are so useful as to be considered almost essential, others may be used only on rare occasions. If these projectors are optional items it's best to carefully consider them before placing the order for the planetarium instrument.

Milky Way projectors display the hazy band of light that is easily seen with the naked eye from a dark location. Quite often the same system that projects the Milky Way also projects the Magellanic Clouds. These hazy, extragalactic patches of light are key elements of the southern hemisphere sky. Ideally these projectors have their own on/off switch and brightness control.

Most planetarium instruments have systems to project lines for various coordinate systems. Essential items in this category are right ascension, declination, ecliptic, meridian, and precession circle. Right ascension should have major markings at every hour of right ascension and minor markings for every 10 minutes of right ascension (ideally every 5 minutes). The ecliptic should clearly show each month of the year and have minor marks for each day of the Sun's position and major marks every five or ten days. Declination and the meridian should have major marks at least every ten degrees and minor marks for each degree. The precession circle should have major marks at least for every 5,000 years with minor marks for each interval of a thousand years. Other, less important, coordinate projectors are ones that project galactic longitude and local altitude. As with the meridian projector these lines should have labeled markings every ten degrees and minor marks every five degrees, at a minimum. These projected coordinate lines should have separate on/off controls as well as variable intensity.

A few mechanical planetariums have devices which simulate eclipses (both partial and total) of the Sun and Moon. Although these events can be simulated with separate special effect projectors or video and computer graphic projections, nothing quite equals the realism of a good eclipse projector mounted on the main planetarium instrument.

Most planetariums feature systems that project outlines of some, or all of the constellations. The more constellation outlines that the planetarium can individually project, the better. Ideally, you should be able to change these outlines by changing a transparency or, in the case of a computer graphics planetarium, edit the graphics files.

Often planetariums segue into the night sky by simulating a time-lapse sunset. To facilitate this, some planetarium instruments have special projectors that project twilight glows along the horizon. If well designed and constructed these projectors can be very effective and useful.

The projection orrery is a device that projects a round disk for the Sun and either bright points of light or small disk images of the planets as seen from a distance above or below the plane of the solar system. By switching on the orrery's motor the projected planet images appear to orbit the Sun with speeds determined by their distance from the Sun. The best of these devices have planets whose speeds increase as they get closer to the Sun and slow as the move away from it. One particular third party orrery will change on the fly from a Sun centered solar system to an Earth centered planetary system for historical demonstrations. Although orrerys can be simulated using computer software and a video projection system, having a dedicated projector can be useful, especially for educational uses.

Cardinal points projectors indicate where the points of the compass are along the horizon. These are very helpful when showing the audience where to look for stars, constellations, and planets. Ideally these projections follow the planetarium instrument as it is rotated in azimuth and, when the latitude is changed to either north or south pole, change to all south or all north, respectively. These should controlled by a single on/off switch and, ideally, have variable intensity.

Some planetarium instruments have devices that project small dots of light at the zenith of the dome and at the home position of the north (or south) celestial pole. These indicators are useful in teaching basic sky anatomy and orienting the sky after changing the latitude setting. If the planetarium instrument does not come with these projectors, substitutes can be devised using grain of wheat lamps or Light Emitting Diodes attached to the dome in the proper positions.

Astronomical phenomena such as comets, meteors, aurorae, and zodiacal light are sometimes available as auxiliary projectors attached to a planetarium instrument. Although these phenomena can be simulated using video, computer graphics, or third party special effects projectors, it often makes economic sense to acquire them as part of the main planetarium instrument if you can and save cove space for other projectors.

If you plan to use your planetarium to teach geography or celestial navigation you'll find the geocentric earth and astronomical triangle projectors helpful.

If any of the auxiliary projectors described above are important to anyone who'll be using your planetarium, make sure that look for them in any potential planetarium instrument. If they are optional and there's any chance that you might want to use them in the future, try to get them as part of the original planetarium instrument purchase. It's almost always harder to find the money later to add these and, if you wait to long, they may no longer be available.

Control Systems and Consoles

All planetarium instruments need some sort of centralized control point. In some cases this may be just a computer with a keyboard for input and control. Traditionally planetariums have used a control console where each projector and motion had a switch and/or knob. Such a manual control system is important whenever the planetarium is used for live, unscripted presentations.

Exercise care in the design of the planetarium to assure that the console is in the optimal location and that adequate power, ventilation, and control conduits are available. The console should allow the operator to see the audience and most, if not all of the dome while not blocking the view of the audience. Always build with more conduits that you think you need. It's a rare planetarium that does eventually want to add new equipment that requires more electrical and control circuits. Often the control cables need to be run through separate conduits than the electrical power to avoid interference. If possible have a source of cold water and drainage available near the console. This can be important if you ever need to install a water-cooled laser system.

Consider also how accessible the controls will be to unauthorized audience members. If your console may be unattended with an audience in the planetarium, it may be an attractive nuisance, especially to young children. Consider passive ways to minimize this risk. A locking half door, or a simple crowd rope, for example, may be all that you need.

Manual controls should be durable, reliable, and arranged in a logical fashion. Control labels should be easy to read in low light conditions and have a variable illumination system so that they can be read in conditions ranging from full room lighting to pitch darkness. This illumination should be shielded as much as possible so that it doesn't glare into the audience or up onto the dome.

In addition to the controls for the planetarium instrument itself, the console usually includes additional control panels for house lighting, the sound system, special effect projectors, video projection systems, and automation systems. These other controls may come from a variety of sources and may evolve over time. Thus, it's useful to have modular systems that use standard size rack mounts. For both aesthetic reasons and to minimize spare part inventories, it's a laudable goal to match the colors, lighting, knob style and materials, etc. of the various console systems as much as possible.

The control console should have adequate ventilation for any devices that require it. If these devices require fan cooling the console should have suitable passive noise reduction. The consoles should also have quick and easy access for the technician(s) who maintain them. There should also be several unassigned electrical outlets readily available in the console to allow temporary equipment to be powered and for the technical staff to power tools and instruments.

The console that contains the manual controls should also have a desk area for convenient placement of notes, scripts, etc. and this area should have suitable variable intensity lighting. There should also be space to store things such as microphones, projection or laser pointers, emergency flashlights, etc.

The console should have enough room for at least two people to sit or stand inside to allow for training or dual presentations. The console should have at least one dedicated swivel chair that is durable, comfortable, and quiet.

There should be, at a minimum, an intercom in the console that connects to a station outside of the planetarium that is always staffed during planetarium programs so the console operator can summon assistance if needed. The intercom can be supplemented or replaced with a conventional telephone; so long as the phone has a silent ‘ringer’ (a suitably dim and shielded light that flashes when the line is called is a good substitute). Handheld radios can be used for communication to the outside world but are less desirable because they are subject to theft, misplacement, and dead batteries. Some planetariums have a console mounted ‘panic button’ that rings an alarm throughout all planetarium support areas to summon help when needed.

A fire extinguisher rated for electrical fires and a first aid kit are important items to have handy to the planetarium console. Both a manual fire alarm and a smoke detector tied into the building’s systems should be installed, even if code does not require them.

Automation

Unless your planetarium will only be used for live, unscripted shows or simple pre-recorded programs, you should consider the prospect of automating the planetarium instrument. Some planetarium instruments come fully automated; others have automation as a factory option. In many cases, third parties can add automation to an unautomated planetarium. Important automation considerations are:

? Which functions are automated?
? How reliable is the system?
? What’s the precision of the automation?
? What sort of computer is used for the automation?
? Does it use hardware proprietary to the manufacturer or does it use commonly available computer components?
? How expandable or upgradeable is the automation system?
? How easy is it to program the automation system?
? Can it be programmed off-line (i.e., while the projector is being used for shows)?
? Does the system interface well with other automation systems such as those you may wish to use for other special effects, house lighting, or sound systems?

Upgradeability

Ask the manufacturer if the planetarium instrument is designed to allow for upgrades for additional features or improved hardware or software. Find out how much these upgrades are likely to cost. In the case of a computer based planetarium, also find out how often manufacturer software upgrades are typically issued and how much they cost. If the computers also use software from a third party (e.g., Microsoft DOS or Windows) determine how often this software may need to be upgraded and the cost. If you forego the software upgrades, how incompatible will your planetarium be with others like it?

Maintenance and Warranty Issues

Don't just rely on the manufacturer for information. Seek out experienced personnel from several planetariums with the same instrument you're considering. Ask them how much money, staff time, and down time they spend annually to maintain their planetarium instrument. With any prospective planetarium instrument look for:

- What items are covered in the written warranty and for how long? Study the written warranty carefully.
    - Does the manufacturer offer technical support? If so, is it available?
    - Free?
    - 24 hours a day, 7 days a week?
    - By phone, fax, and/or e-mail?
    - In what languages?
- Does the manufacturer offer a service agreement for the projector? If so, what does it cost for your location? Are others who have the same planetarium instrument satisfied with its performance and the warranty and service performance of the manufacturer?
- If you purchase spare parts from the manufacturer, how long are those parts warranted for and does the warranty start when you receive the part, or when it goes into service?
- What's the lifetime of the motors, bearings, lamps, and CRTs used in the planetarium instrument? Are these parts readily available and at what costs? How much do other replacement parts from the manufacturer cost?
- How long will the manufacturer maintain an inventory of parts for your machine?
- How long will it take for the manufacturer to respond to a service call at your location?
- How much routine maintenance does the planetarium instrument requires? This will depend to some extent how much the instrument is used and how (e.g., light shows or just planetarium shows).
- What skills are needed to perform routine maintenance on the instrument? Does the manufacturer offer training for your technical staff? If so, how much does it cost, where, and how often is it offered? Is the training required before you can work on your instrument without voiding the warranty?
- Is service available from third parties?

Contracts

“A verbal contract is not worth the paper it’s written on!” – Samuel Goldwin

A planetarium instrument can often be one of the most expensive pieces of equipment that an institution can buy. It is therefore in the best interests of both the vendor and the purchaser to have an explicit, unambiguous contract that spells out what is expected of all parties. You should have a lawyer, carefully review the purchase contract and explain any term or language that‘s not clear to you. Every piece of equipment and specification promised by the vendor should be spelled out in the contract along with a timetable for delivery and installation. If it is crucial financially that your planetarium open by a certain date, consider negotiating penalty clauses for late delivery or installation. Make sure that any verbal promises have been also made in writing and signed. It’s often wise to negotiate a stepped payment plan where a down payment is due when the contract is signed, followed by a substantial payment upon delivery and installation, and ending with a final payment due when the equipment has met all customer acceptance tests.

Buying a Used Projector

A well made and well cared for planetarium instrument often is re-sold to organizations desiring a planetarium but short of funds for a new projector. Used planetarium instruments may be sold by the original owners, by a manufacturer who has taken one as a ‘trade-in’, or by a third party who may have refurbished it. These used planetariums can be good values, especially if they’ve been competently refurbished and come with a warranty and a source for parts and service. If you’re seriously considering a used planetarium, follow most, if not all, of the above advice on acquiring a new machine. Make sure that you can still get needed parts, especially motors and lamps. In addition you’ll need to carefully check all of the instrument’s functions to make sure that they all work reliably. In particular, for mechanical instruments, have the slip rings checked. These rings allow power and control to reach the various motors and lamps on the moving instrument. Many machines have spare slip rings for use when key ones wear out. If all of the spare slip rings are in use in a used planetarium you won’t have any backup should any more rings fail in the future. Refurbishment or replacement of slip rings can be a very expensive undertaking. In any event, you’d do well to hire an independent consultant, well versed in planetarium hardware, to evaluate the machine you’re interested in.

Planetarium Projector Lifetimes

Nothing lasts forever. All planetarium projectors will eventually reach the end of their useful life spans. Since few developers start a planetarium with the intention that it should last only a year or two, the length of that life span is an important factor. For example, a $100,000 planetarium machine that lasts for only 5 years is not really a better value than a $150,000 machine that lasts for 20 years. Some well designed, well built, and well maintained planetarium instruments have lasted 40 years or more while others have barely lasted 10 years. In addition to the wear and tear on mechanical systems, planetarium instrument life spans are also determined by the availability of spare parts. In the case of computerized components this can sometimes be disturbingly short. In addition to requesting a written commitment from the manufacturer as to how long they intend to provide spare parts for a particular machine, you can check with other planetariums that have older projectors from the manufacturer you are considering. Ask them how old their instrument is and what the track record of parts availability is from that manufacturer.

The Last Word

There is a great variety of planetarium instruments to choose from, spanning a broad spectrum of quality, price, and capability. Make a careful assessment of your needs and determine whether your planetarium will be fixed or portable and how many people it will need to accommodate. Then visit as many planetariums like the one you want to build. Compare the qualities of their instruments and talk to the owner/operators about quality, reliability, and service experience. If you don’t know the sky well, bring along someone you trust who does. Then start comparing features, prices, and warranties of available planetariums that meet your needs. And always remember that, in addition to your concerns of price and durability, the quality your audience will most likely remember is the realism of the sky your planetarium projects.

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