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6 Key Factors in Selecting a Pan/Tilt System

A Guide for Making a Smart Pan/Tilt Decision

Pan/Tilt Guide

Executive Summary

The use of pan/tilt devices in camera systems, antennas, and other remote sensing applications has increased substantially over the past several years. And so have the types and vendors of pan/tilts. But not all pan/tilts are created equal.

As a system integrator or camera system manufacturer, your pan/tilt choice can have a big impact on your system cost, reliability and performance. It is an important part of what your customers see and experience, and influences their opinion of your company. The right pan/tilt and the right pan/tilt vendor can ultimately determine the success or failure of your application.

This guide is designed to inform you about pan/tilt systems and key things to consider in making your purchase.

FLIR MCS (formerly Directed Perception) has been a pioneer and leading manufacturer of pan/tilt systems for over 18 years. We have served customers with hundreds of different mission-critical applications in a wide range of markets. You can rest assured that this booklet will provide the key information to help you make the right pan/tilt choice for your product or project.

If you have any questions about this guide, or would like to speak with a pan/tilt applications expert, please contact us at: 650-692-3900 or visit www.FLIR.com/MCS.

Pan/Tilt Device Overview

Varying Classes

As use of sensors has grown, so has the use of pointing devices, or pan/tilt systems. Pan/tilt devices allow aiming of directional sensors and other instruments, often under computer control. There are a wide range of pan/tilt devices that are used in various applications. These classes of devices vary widely in their cost, performance and capabilities.

In the past, tracking pan/tilts, or "tracking mounts," were only found in extremely large, expensive systems used for niche applications in missile tracking. Today, advances in microelectronics, precision machining and motors, optical encoders and controls have created tracking pan/tilts that are extremely compact and low-cost, and yet provide much of the same capabilities as the traditional large tracking mounts.

Each application has different requirements and so may require a different class of pan/tilt device. However, it should be noted that capabilities such as continuous duty cycle and real-time control are integral to the design of the system and cannot be "added on."

Pan/tilt type	remote panning and tilting	computer controlled	industrial/ all-weather	accurate positioning	accurate dynamics	continuous duty	real-time computer controls	gyro-stablization
Analog CCTV pan/tilt	x							
Digital CCTV pan/tilt	x	x						
Precision pan/tilt	x	x	x	x				
Tracking pan/tilt	x	x	x	x	x	x	x	x

Figure 1

System Components

Some people think of pan/tilt devices as simple "motors." But modern computer-controlled pan/tilts are complex, highly integrated electro-mechanical systems that must meet a wide range of operating and performance requirements. Pan/tilt devices consist of the following elements:

Drivetrain System – The drivetrain consists of the motors, gear or belt system, bearings, and the core motion delivery mechanics. Common drivetrain architectures in pan/tilts include: belt drive, chain drive, worm-gear, direct-drive motors, and other gear reduction systems. Each drive system offers different advantages and disadvantages in terms of size, cost and performance.

Control Electronics – The control electronics provide the interface between your application and the motion control of the pan/tilt. Control electronics include:

- Motor drive amplifiers and electronics
- Feedback mechanism processing (potentiometers, resolvers or encoders)
- Communications – to the control application
- User interface
- Payload I/O and control
- Manage programmable parameters (min/max speeds, range of motion, etc.)
- Communications with your application to accept commands, provide user interface, and provide auxiliary I/O (e.g., multiplexed serial ports; digital I/O for payloads; temperature and health sensing of the device; and storage of user defined parameters (such as range of motion, min/max speeds)).

Feedback Device – A pan/tilt needs to know the current position of each axis in order to provide position control features, programmable range of motion, etc. Feedback devices include: potentiometers, resolvers, and digital encoders. Each of these types of devices has different capabilities in terms of position accuracy and repeatability, and stability over time and temperature.

Core Structure and Housing – This is the internal frame and/or external structure that make up the body of the pan/tilt device. Various materials are used for the core structures and housings, including plastic, steel and machined or cast aluminum.

Payload Mounting Brackets – These are built in locations where you mount your payload device.

Payload Wiring System – Some pan/tilt devices allow for routing payload wiring through the pan/tilt, usually through a slip-ring. The payload wiring system encompasses both the internal wiring that is part of the pan/tilt design as well as the connectors and wiring required to interface payloads with the pan/tilt device. Wiring voltage, current and frequency varies with according to signal types (i.e., video vs. power).

Each of these components weighs into your selection of the right pan/tilt device for your product or application.

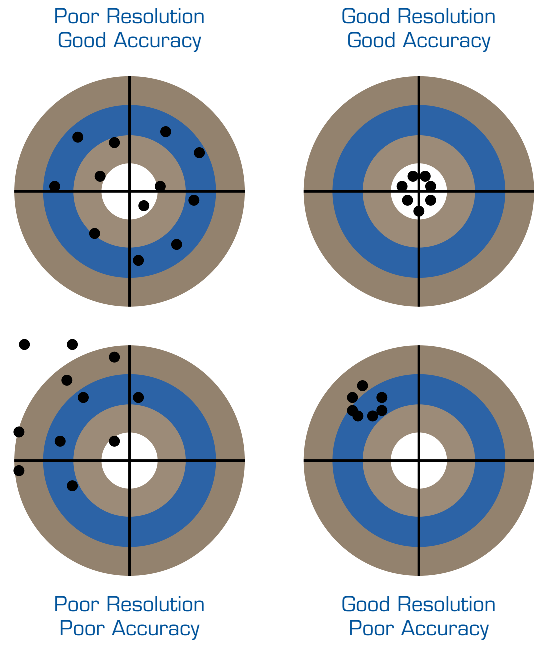

Figure 2: Resolution refers to how small an angle the pan/tilt can be commanded to, or how small an angle the position can be reported. Accuracy refers to how close the commanded position is to the desired position.

6 Key Factors

1. Accuracy

A pan/tilt is designed to provide pointing capability to your system/sensor. Different applications may have different accuracy requirements. Pan/tilts should consider both positional accuracy (goes where you tell it) and speed accuracy (goes at the speed you tell it).

Many traditional CCTV pan/tilt systems provide simple analog potentiometers for feedback, and provide only a "preset" functionality for commanding position. This means you move the pan/tilt to a location, and then say, "Save this position as position 1." Then your application can command the unit to return to position 1. If the pan/tilt uses analog potentiometers, this position may not be repeatable over time or over temperature since you are not really commanding the unit to an absolute position, but rather to a certain reading of the potentiometer feedback.

High-performance pan/tilts are designed to provide high repeatability of position where the position is specified in relation to the base of the pan/tilt. This is an absolute position which can be referenced to geographic or other external coordinates to provide true geometric pointing.

The positional accuracy achievable by a pan/tilt depends on several factors, including the type of feedback sensor used, the drive train system design, and the mechanical design of the device. It can also depend on payload mounting brackets. After all, what you really care about is that your sensor (or other payload) is pointing in the direction commanded, not simply the "axis" of the pan/tilt. Stiffness and rigidity of the overall mechanical design from the gear train through to the payload bracket all affect the accuracy and repeatability of the system.

- High-resolution digital encoders work by providing discrete "pulses" or counts of position. They are designed to provide stable readings over time and temperature. Potentiometers work by providing a variable resistance depending on the rotational position of the device. This resistance must be read by a microprocessor and digitized. There will be error due to resistance not being stable over time and temperature and to the digitization process.
- While relatively expensive, resolvers are sometimes used for positional feedback in pan/tilts. A resolver uses a rotating element inside a fixed one to provide an output of two sine waves that are 90 degrees out of phase. By measuring these relative sine wave values one can determine rotational position. Since resolvers provide analog outputs, these must typically be digitized and processed to be used in a computer-controlled pan/tilt. This digitization can limit the accuracy of the resolver position measurement. High-resolution optical encoders are typically preferred as feedback devices for high-performance pan/tilts due to their small size, low cost, weight and stability over time and temperature.
- Potentiometers are sometimes seen in low-performance pan/tilt devices. When only relative position or presets are required, these can provide acceptable performance. However, potentiometers are generally not used in high-performance pan/tilt devices.

Figure 3: This long-range automated gas detection system scans large areas to detect gas leaks. In order to provide the required capability to geo-locate the gas leak, it is critical that the system be able to scan accurately in a "raster" pattern. Any error in pointing angle of that scan will result in erroneous geo-coordinates of the gas leak.

2. Mechanical design – precision and flexibility

Geometry

The mechanical design of a pan/tilt is a key driver of the performance in terms of accuracy, durability, reliability, speed, size, weight and cost.

The geometry of a pan/tilt refers to the overall design of the system. "U" designs allow the payload to be hung between two supports. The U design allows for good balancing of a payload to reduce the amount of torque required. However, U designs are not amenable to multi-part payloads and limit the size of the payload that can fit within the U brackets. U-shaped systems also tend to be larger and heavier pan/tilt units, and often more expensive. U-shaped designs can also be less stiff with more torsion that can affect overall pointing accuracy.

Pedestal designs are more compact and allow payloads to be mounted on either side, the top or front of the device. For single-part payloads, balancing the payload center of gravity on both axes can be tricky with pedestal designs.

Type of Drivetrain

The drivetrain is responsible for transferring power from the electric motors to the output motion axes. Common drive systems used in pan/tilt systems include:

- Direct Drive –Direct drive motors have the advantage of eliminating the gear system, but provide less torque than can be delivered with a gear reduction. Direct drive motors also tend to be significantly larger, consume more power, and they are more expensive than gear-driven systems.
- Belt or Chain Drive – With belt or chain systems gear reduction is provided by a belt or chain connecting a smaller and larger gear set. They are a low-cost, lightweight solution, but they can have reduced performance in terms of backlash and overall system stiffness.
- Worm Gear Drive – This system directly links the motor through a worm and wheel gear drive. Worm drive systems are strong and compact and provide a rigid linkage between the motor and output shaft. Worm drives also provide holding torque even when no power is applied, so that the payload "stays put" when you power it off (does not "droop down").

Typical motor types used in pan/tilts include stepper motors and servo motors. Stepper motors offer the advantages of high acceleration and holding torque (holds position when not moving) without the use of a "brake" or other mechanism. Stepper motors can also be controlled with "micro-stepping" to provide very fine and smooth motion.

In geared pan/tilt systems, the gear system is critical to the performance and long-term wear of the system. Not all gear material is equal. Gear material will directly affect long-term reliability and performance.

Call to Duty Cycle

One way to assess the overall quality of the drive train system is to ask the vendor about duty cycle. Duty cycle refers to how much the system will be moving. This is often expressed as a percentage. For example, a 20% duty cycle means that the unit may move up to 20% of the time. Some pan/tilt systems are designed to only support periodic movement, or lower duty cycles. Other pan/tilt systems are designed to support up to 100% duty cycles – constant movement. Pan/tilts that are designed for 100% duty cycles are based on designs that have superior drive train systems. The reality is you do not always know the duty cycle you require. And you don't want to find yourself in a situation where you have to tell your customer, "Hey, stop using the system for today, because you are at your duty cycle limit."

Bearings

Bearings support the pan and tilt shafts and provide low-friction rotation and alignment of the shafts. Not all bearings are the same. Wear and imprecision in bearings will translate directly to inaccuracy in pan/tilt positioning. So it is critical that your pan/tilt use high-quality bearings to provide the best performance.

High-performance pan/tilts typically use high-quality ABEC3 bearings with precision alignment as part of the design and assembly process.

Sealing System

If you will use your pan/tilt system outdoors, sealing is critical to ensure reliability of the system in all weather conditions. The inside of the pan/tilt houses electronics, wiring, bearing systems, and gears – all of which will be damaged if there is water or dust intrusion. Pan/tilts are often rated with a weatherization specification called "IP Code" or "ingress protection rating" (IEC 60529). The IP rating is a two-digit code, expressed, for example, as "IP65."

The first digit refers to imperviousness to solids, and the second digit refers to imperviousness to liquids. For solids, "6" is the highest rating and refers to "dust tight" – no ingress of dust. This is very important for outdoor pan/tilt applications to avoid having dust enter the gearing or bearing system. The second digit ranges from 0 to 8. Many pan/tilt systems are specified as IP64 or IP65. "5" on the liquid scale refers to being protected against water jets for three minutes. "6" refers to powerful water jets, and "7" refers to immersion up to one meter deep for 30 minutes. Outdoor pan/tilt applications should require an IP66 or better to avoid damage from rainstorms.

Temperature Rating

If your pan/tilt is required to operate outdoors, the temperature ratings of the system are critical to reliable operation. Some pan/tilt systems utilize heaters or coolers in order to operate at the outer-rated ranges. Better pan/tilt designs are able to offer wide temperature ranges without the user of heaters or coolers. Heaters or coolers contribute to power consumption and are an additional complex subsystem that adds to size, cost and can be an additional point of failure.

Figure 4: Traditional tracking mount for range applications

3. Electrical system – flexibility and robustness

The electrical design of a pan/tilt system includes the internal connections of the control electronics to the motors and feedback system, as well as the routing of wiring from the base connectors, through slip-rings, and to the payload(s). The electrical design also includes specific features and capabilities. Here are some things to look for in a high-quality pan/tilt system:

Payload Cable Flex

In pan/tilt systems with internal wiring, the payload must connect to the pan/tilt to route signals down through the unit and out the base. Slip-ring is used to provide continuous rotation of the pan axis. But the tilt axis also moves. In some pan/tilt systems the cabling exits the body of the pan/tilt, and thus the cable that connects to the payload must "flex" in response to the tilt motion. This means that the cable you use to attach your payload must be capable of taking a potentially high number of flexes ¬– a hassle for your design and a possible point of failure. Other pan/tilt systems provide a payload wiring connection point that moves with the tilt motion. This means that your payload cable will not need to flex, reducing your cost and improving your reliability.

Input Power Flexibility and Protection Circuitry

You do not always know where your pan/tilt will be installed or where the power will be sourced. Power sources can vary dramatically in terms of quality and noise, (i.e., voltage surges, spikes, etc.). There is also always the possibility of plugging in the power backwards. High-quality pan/tilt systems provide integrated power protection circuitry to ensure robust operation in any type of power environment. A good power protection circuit should protect the pan/tilt from power voltage, current surges and spikes, and reverse polarity. It should also include fusing to protect the system from short-circuit situations.

Most high-performance pan/tilt systems operate on DC voltage inputs. However, better systems provide a wide range input (for example 12-30VDC). This provides you the greatest flexibility in installations and in matching pan/tilt power requirements with payload power voltage levels.

Figure 5: Advanced intrusion detection system

4. Control and programmability

Many early pan/tilt systems provided a simple analog control to turn the motors "on" or "off." It was left to your application to do any control of position, speed, etc. Modern pan/tilts provide digital interfaces and high-level commands to make control simple and provide advanced features for speed and position control. This is an important area, because if the pan/tilt you choose does not have a simple and powerful control interface, then you may spend significantly more time developing your application to achieve the desired result. Here are some key things to look for when selecting your pan/tilt:

Multiple Control Interfaces

Pan/tilts are typically integrated with other applications and systems. You want to have the greatest flexibility in integrating your pan/tilt into these systems. Typical control interfaces include serial interfaces such as RS-232, RS-422, and RS-485. Ethernet is also now readily available. Some pan/tilts provide only an "analog" interface, and thus require you to implement or add a controller that will accept commands and translate to analog voltages. High-quality pan/tilts will provide multiple control interfaces to give you the greatest flexibility in integrating your pan/tilt into other systems.

Besides the physical control interfaces, there is also the format of the commands that are accepted over those interfaces. This is sometimes called the "command protocol" or "protocol" and varies according to industry. Look for pan/tilt systems that support the protocol you need, or ideally, multiple protocols.

Web and IP Control

Increasingly, surveillance and other engineered systems are using web and IP as the interface of choice for pan/tilt control and video transport. A built-in interface providing Ethernet—which allows commands to be sent over IP—is ideal. This provides the greatest flexibility in integrating your system with others. A web interface can also be provided, allowing graphical configuration and control of the system without installing other software on your PC. A simple web browser is used to access and control the pan/tilt.

Programmability

Some pan/tilts are built to do what they do and nothing more. For these systems to be useful, you have to rely on the pan/tilt designer to anticipate all your future needs. Better pan/tilt systems however, allow you to program the key capabilities of the system. Programmable features include things like minimum and maximum speeds, range-of-motion limits, control modes, power levels, acceleration profiles, and more. Programmability is essential to ensuring that the pan/tilt can produce the motion you need in your application. Without programmability you may be stuck with a one-size-fits-all solution that is not your size!

Software API

Your software application that will control the pan/tilt system must issue commands and process responses from the pan/tilt. If your pan/tilt already has an available software API that can be compiled into your application, then you can skip this step. Using an existing and proven API also means lower risk for your project, since you are using a known software component to control the system.

Figure 6: Pedestal designs offer flexibility to mount antennas, multiple cameras or other sensors

Real-Time Control

When you command your pan/tilt to move, do you want it to move now, or in a few seconds? The delay from when you issue a command and when the pan/tilt actually executes the command is called command latency. This can be a critical factor for pan/tilts used in dynamic applications such as radar slew-to-cue or video tracking or human joystick control. If a person is trying to follow something through a video monitor with a joystick, any delay in the responsiveness of the pan/tilt will make it a frustrating task.

Watch Your "Jitter"

The "jitter"—or how the latency changes over time—is another property of real-time control. So, for example, if the latency or time to process a command is one second, is it always one second? Or does it range from 1 to 2 seconds? Be sure to look carefully at the latency and jitter characteristics of your pan/tilt. If you're doing video tracking at 30 Hz, then a pan/tilt that can only execute one command/second will not give you the performance you need.

5. Durability & reliability

Your pan/tilt is a key element of your system. A failure in the pan/tilt is a failure of your system.

Durability refers to the ability of the pan/tilt to continue. Durability can be impacted by the operating environment (i.e., weather, shock and vibration, and other external factors). A high-quality pan/tilt must be designed to operate in all the intended environments. If your pan/tilt needs to operate on an off road vehicle, was it designed to do so? Has it been used successfully for this in the past?

Reliability refers to how well the pan/tilt operates as specified without interruption. Reliability comes from the core design of the system as well as the manufacturing quality used in building it. From the core design, many of the factors we already discussed here such as mechanical design and electrical design affect the reliability of the system. Look for simplicity of design, quality of the manufacturing, and experience base of the product in similar application environments.

6. The manufacturer

At the end of the day, a pan/tilt can only be as good as the manufacturer of the system. The manufacturer determines the innovation and quality of the design, the quality of the manufacturing, and the service and support. There are several key things you should look for in selecting a pan/tilt vendor:

Experience Counts

With the growth of pan/tilt markets, new manufacturers are consistently looking to capitalize. But true innovation comes from really understanding your customer's needs and requirements over time. Experience feeds this innovation. And high–quality, reliable designs come from years of field experience. Choose a pan/tilt vendor that has experience in your application, and you will greatly increase your odds of success.

Complete Line of Tracking Pan/Tilts

FLIR MCS offers a complete line of true tracking pan/tilts for virtually any payload or application. FLIR MCS has distilled decades of experience into pan/tilt designs that carefully trade cost and size against the best performance possible. All FLIR MCS tracking pan/tilts offer:

- High precision
- High duty cycles
- Real-time computer control with tracking features
- Rugged, all-weather designs
- Compact size, light weight
- Modular mounting systems
- High durability and reliability – proven in 100's of applications
- Advanced features like gyro inertial stabilization and geo-pointing

Your project today calls for a specific pan/tilt configuration. But what about tomorrow? Or the next project? You are making an investment in a relationship with your pan/tilt vendor in their products and capabilities. You should select a vendor that offers a complete line of devices to meet all your pan/tilt needs.

Focused and Stable

You should choose a pan/tilt vendor that is a focused expert to be there for you over the long run.

FLIR MCS (formerly Directed Perception) has been a pioneer and leading manufacturer of pan/tilt systems for over 18 years. We have served customers with hundreds of different mission-critical applications in a wide range of markets. FLIR MCS is part of FLIR Systems, the world leader in the design and manufacture and marketing of thermal imaging camera systems.

FLIR MCS offers a complete line of high-performance pan/tilts that offer reliable performance in harsh conditions. FLIR MCS pan/tilts are precise, durable, and offer real-time control and advanced features such as Ethernet, inertial stabilization, and geo-pointing.

What is YOUR pan/tilt application?

What kind of pan/tilt is best for YOUR product or project?

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