U.S. Geological Survey,
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## From the Bench

# Cost Comparison of Wading Point Velocity Discharge Equipment

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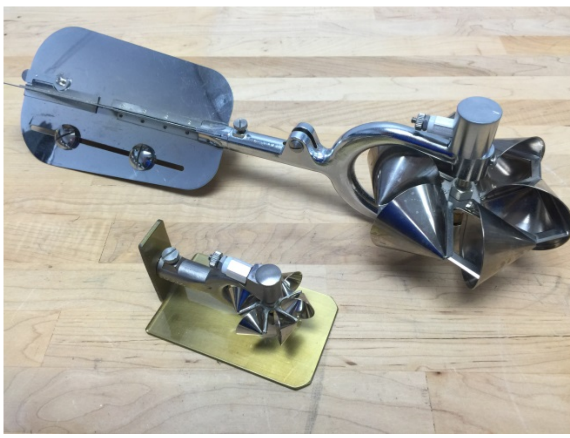
Instrumentation is vitally important to the streamflow data collection of the US Geological Survey (USGS). Advances in the ability to measure stage and velocity with newer instrumentation help to increase our efficiency as an agency. Ideally these efficiencies should result in cost savings allowing the USGS to do more with less budget while maintaining or improving the quality and amount of data collected. Taking the time to step back and analyze the cost of ownership in instrumentation is one way managers can make informed decisions about where their program dollars are spent.

Most discharge measurements made by USGS Hydrographers are performed by wading across a stream with a point velocity meter using the mid-section method. A tagline is suspended perpendicular to the flow and the Hydrographer subdivides the stream into sections. The depth is read at each section and a water velocity reading is made at one or more points depending on several factors. This is a standardized method that has been in use by the USGS for over one hundred years. The purpose of this article is to look at the equipment used in this process and do a cost of ownership analysis. This report will look at each commonly used and available class of instrumentation and try to assess the pros and cons. Analyses like this can help USGS managers make long term financial decisions about the appropriate equipment used in their program.

There are at least three categories of instrumentation used in the traditional wading mid-section method discharge measurement; mechanical, electromagnetic, and acoustic. Each class utilizes a different technology to obtain an accurate water velocity. Mechanical meters measure the force of water against a blade, vane or cup to obtain a velocity. Electromagnetic meters measure an electrical signal generated in response to relative motion between the velocity meter and water to provide a velocity. Acoustic meters measure the Doppler shift of particles moving with the water to obtain a velocity. All three methods use similar equipment such as wading rods and taglines so they will not be entered as part of this analysis. The USGS has made the decision to do all record keeping electronically so each method comparison will include the sensor and discharge calculator. Paper note related equipment will not be considered. A table at the end will show the up-front costs and the calculated cost to own over forty years.

# Mechanical Meters

There are several different styles and types of mechanical velocity meters that have been used to measure discharge around the world but the USGS over the last several decades has only used two, the Price Type AA meter and the Price Pygmy meter. These meters use a horizontal axis six cup wheel. Each revolution of the wheel is counted by and electronic counter over a specified time, usually forty seconds, providing a velocity calculated from a standardized rating. There are several options for counters but the USGS uses primarily two types, the Aquacalc Pro and Pro +, and the Current Meter Counter Signal Processor (CMCSP) paired with a Personal Digital Assistant (PDA) running the SWAMI software or a Tablet PC running the SVMobile software, both developed by the USGS.



The Price Type AA meter is used as the standard for comparison of all velocity measuring devices. Since 1970 the Price Type AA meter has been manufactured to a standard drawing package and a standard velocity rating maintained. Previously all mechanical velocity meters were individually rated and had to be rerated when components were changed. With the standardized components meter parts can now be changed or swapped while maintaining accuracy within the specified limits. In 1980 the Price Pygmy meter went through the same process and now has standardized components and rating. From 2006 both meters were updated to use magnetic switches improving the counting of the rotations with electronic counters. For the Price Type AA meter an ABS plastic wheel was developed to help reduce cost and produce a more dimensionally consistent wheel further helping to maintain a standardized rating.

Both mechanical meters have a 40+ year service life with regular maintenance and replacement of worn parts. Mechanical components wear out slowly over many years but are inexpensive to replace. It is not uncommon to find mechanical meters in USGS offices that predate World War II. Data capture by electronic methods is relatively new but the service life of these devices has normally been about ten years. At the end of the ten years replacement is normally the only option as the internal components are outdated and no longer supported. Repair could cost as much or more than buying a new updated device.

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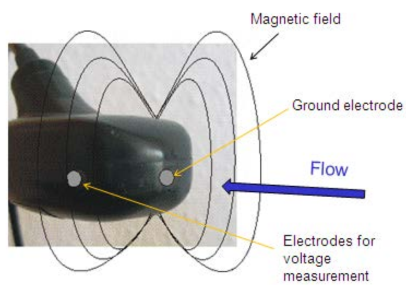
# Electromagnetic Meters

The USGS has periodically used electromagnetic velocity meters for making discharge measurements. Marsh McBirney has made a velocity meter designed for performing discharge measurements for over 40 years. With the recent combining of companies Marsh McBirney, Hach and OTT the electromagnetic meter has been given a new life as the OTT MF-Pro. The OTT MF-Pro utilizes the electromagnetic sensor and combines it with a detachable discharge calculator handset. The handset is a ruggedized computer with a color screen and the capability of taking point velocity measurements and calculating discharge in open channels.




The service life of the OTT MF-Pro should be about ten years. It is an all-electronic device with no moving parts. The sensor is separate from the handset and is also calibrated separately from the handset. This means if the sensor or handset fail, the user could just order the needed component without having to replace the entire setup. This is a relatively new instrument so repair costs are really just estimates at this point.

# Acoustic Meters

There are two acoustic meters on the market specifically designed for making point velocity mid-section discharge measurements, the Sontek FlowTracker and the OTT ADC. The FlowTracker has been in service with the USGS for just over ten years now while the OTT ADC is a relative newcomer and is still being evaluated for use by the USGS. Both meters use the Doppler shift of particles moving in the water to obtain velocity but do it in different ways.

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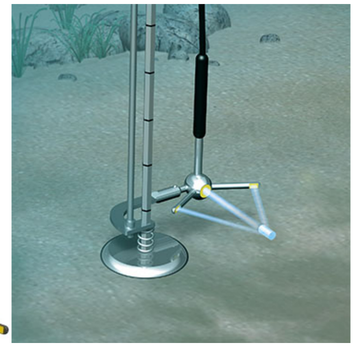


The FlowTracker is based off of Sontek's ADV design with a side looking sensor. It measures a very small space of water four inches away from the center transducer. This offset requires the use of an offset bracket on the wading rod to try to get the sampling volume closer to the position of the rod in the measured vertical. The FlowTracker is kept perpendicular with the tagline and the device measures any angles and corrects for them automatically in the software.

The OTT ADC uses two acoustic beams oriented into the flow and measures the speed of oncoming particles in the water. The sample volume is larger than that of the FlowTracker and is more comparable to the Price Type AA. The OTT ADC is capable of measuring the flow in the measured section without the need for offset brackets. The OTT ADC is held perpendicular to the tagline and is capable of measuring the horizontal angles during a measurement.

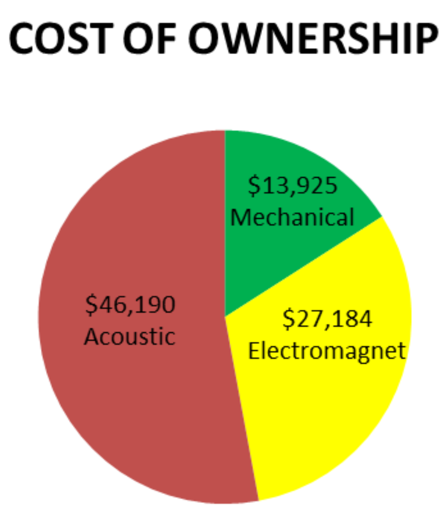
Each of the acoustic wading devices has a dedicated discharge computing calculator with internal electronics that should see a service life of about ten years before replacement parts are no longer available. For all the electronic devices listed above ten years may be overly generous considering the rapid turnover of consumer electronics and expansion of computing technology.

| Technology | Instrument | Purchase Price (Including Accessories) | Service Life | # owned in career | Estimated Repair Cost | 40 Year total cost |
|---|---|---|---|---|---|---|
| | | | | | | |
| Mechanical | Price Type AA | $796.00 | 40 | 1 | $400.00 | $1,196.00 |
| | Price Pygmy | $545.00 | 40 | 1 | $300.00 | $845.00 |
| | Aquacalc Pro + | $2,896.00 | 10 | 4 | $75.00 | $11,884.00 |
| | | | | | | |
| | | | | | | |
| Electromagnetic | OTT MF-Pro | $5,796.00 | 10 | 4 | $1,000.00 | $27,184.00 |
| | | | | | | |
| | | | | | | |
| Acoustic | Sontek FlowTracker | $9,290.00 | 10 | 4 | $2,500.00 | $47,160.00 |
| | OTT ADC | $8,805.00 | 10 | 4 | $2,500.00 | $45,220.00 |

## Cost of Ownership

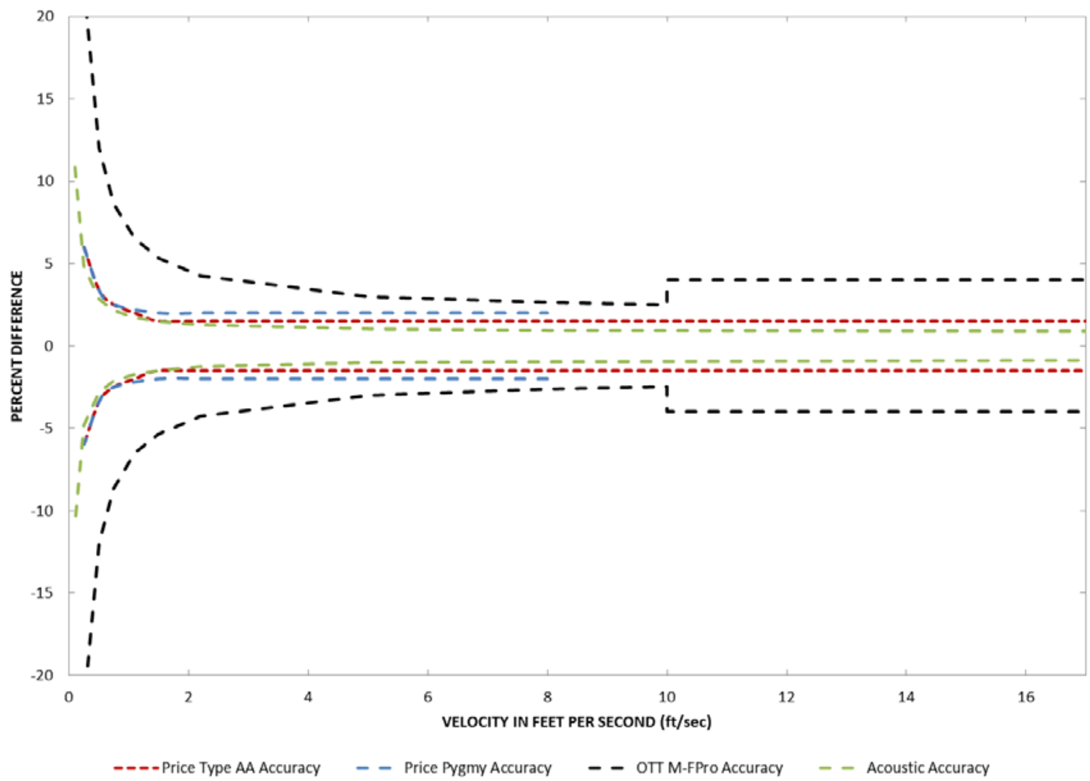
The table below shows the costs associated with these meters over the course of a hydrographer's forty year career assuming they purchased the equipment new at the beginning of their career. In fact, the hydrographer normally receives a set of hand-me-down equipment from the previous user and in the case of mechanical meters, possibly even the user before. Inflation is not considered in this table and an average cost of repair is assumed based on the costs observed with current equipment.

To looks at the differences graphically the total 40 year cost for the mechanical, electromagnetic, and the average cost of the acoustic devices are shown in the following pie chart.




## Performance Differences

Given the significant cost of ownership difference you would expect a corresponding difference or improvement in performance as you progressed from the less expensive to more expensive technologies, right? Well maybe not. Let's take a look at the stated manufacturer's specifications for accuracy for each of the velocity meters in this report. The chart below shows what the manufacturer's stated accuracy statement looks like when plotted against the standard ratings for both the Price Type AA meter and the Price Pygmy meter.




As you can see, there is little difference between the mechanical meters and the acoustic meters. The accuracy statement for the electromagnetic meter is the main outlier of the group. Below one foot per second the acoustic and mechanical meters are virtually identical in stated performance. Remember that this is a comparison of the manufacturer's stated accuracy; actual verified accuracy against a standard reference like the USGS Tow Tank Facility may prove to be different. The electromagnetic meters evaluated by HIF tended to do better than the manufacturer's stated accuracy and were closer to the performance of the Price Type AA meter.

## Summary

This analysis shows that the mechanical velocity meter has the lowest cost of ownership coupled with very good accuracy. It has a proven track record of data collection over many decades. Mechanical meters may not be the best choice for making a discharge measurement in every location. It is up to the hydrographer to have the experience and training to determine which technology will give the best result given the conditions at the time. Each of the technologies in this report has their place when measuring discharge and each do their job well in the right conditions. Let the conditions dictate the technology and don't assume that because the technology is newer it is somehow more appropriate to use in all conditions.