Adjustable Surface-Clamping Articulated Phone (ASCAP) Mount

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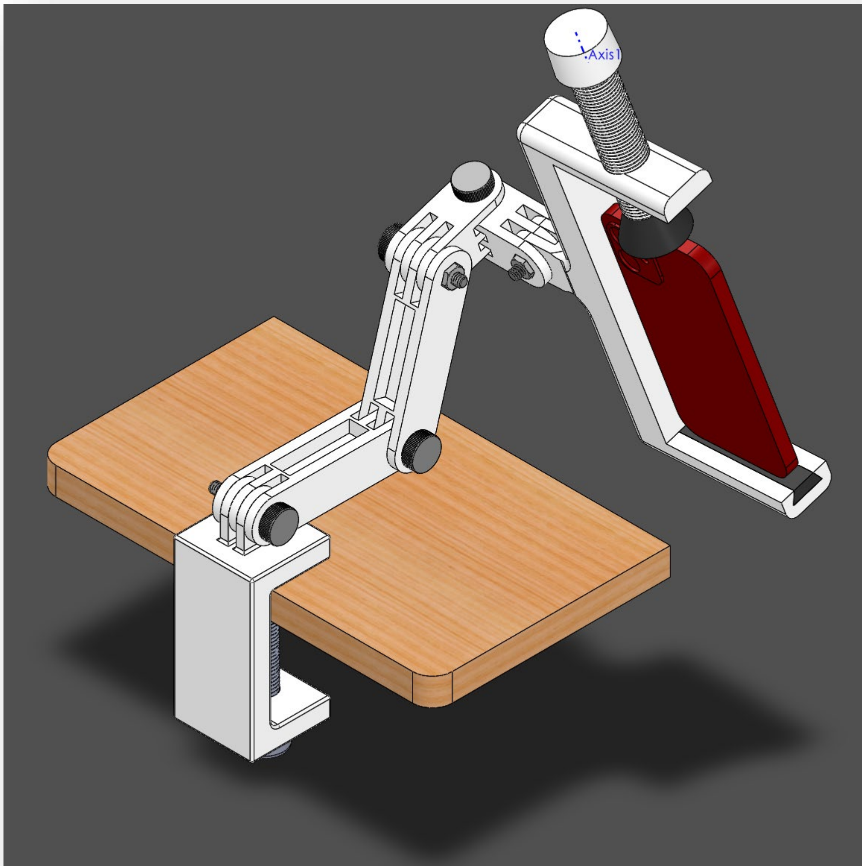

Executive Summary

The Adjustable Surface-Clamping Articulated Phone (ASCAP) Mount solves the issue of being able to orient a phone securely and safely for viewing near a working surface. Whether it is in a workshop, a kitchen, or any other possible working environment, the ASCAP Mount features an adjustable clamp made to accommodate mounting to any flat surface. Attached to the clamp is an arm constructed from a series of adjustable joints. At the end of the arm assembly exists an adjustable clamping mount that can hold phones of varying sizes. Numerous points of adjustability result in several degrees of freedom that allow the user to articulate and accommodate desired viewing heights and angles, while keeping the phone out of harm's way.

The team analyzed alternative product designs on the market to determine what modifications were required to create a more optimal design. By completing QFD and PDS documents, specific design objectives and constraints were defined and resulted in product requirements. Solidworks, a computer aided design (CAD) software, was used to begin developing the virtual prototype and incorporating the various product requirements into the design. Each group member separately worked on one of the three main sub-assemblies: the surface clamp, the adjustable arm, and the phone clamp. Once completed, the sub-assemblies were combined into one assembly file. After ensuring the functional requirements of the assembly were met and the individual parts were appropriate candidates for Polymer Additive Manufacturing (AM), the files were then prepared for manufacturing. Manufacturing processes were conducted on a team member's personal desktop 3D printer, utilizing PLA and TPU polymer materials. The final product can be seen below in Figure 1.

Figure 1) The final 3D printed ASCAP mount

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Design Problems and Objectives

It is a frequent challenge to prop one's phone up in a stable position for hand-free use. Whether it be at a desk, kitchen counter, workbench, or elsewhere, the device often slides down or falls over. Even if the phone can successfully be supported without falling, it almost never meets the desired viewing height or angle. The device is also at risk of getting dirty, damaged, or scratched from contact with ordinary surfaces.

The group aimed to design an adjustable articulated phone mount that would be adaptable and capable of clamping to various fixed surfaces. The design goal of the mount is to prevent the phone from falling over, be adjustable to any desired viewing height and angle, and keep the phone away from the working surface and out of harm's way.

Alternative designs and products on the market typically do not fit *all* the design criteria, as they are often wall-mounted or require screws to permanently hold it in place. Reviews of currently offered mounts suggest they cannot support the weight of a device and progressively sag down from the set viewing height. The few designs that *do* successfully meet all the design criteria can cost upwards of a few hundred dollars. The ASCAP Mount will solve all these issues by having a universal clamping design for mounting anywhere, employ screw tightening segments to meet desired angles, and will cost significantly less to produce.

Detailed Design Documentation

During the initial stages of the design process, the design team was required to assume that polymer additive manufacturing was the required manufacturing modality for the physical prototype. Furthermore, it was decided to use a team member's 3D printer which constrained the design to two polymer materials. The design consists of PLA and TPU components manufactured on a desktop 3D printer. It was also assumed that devices sizes and weights existed between certain envelope dimensions, specifically smaller than iPhone 12. All assumptions and decisions meet the customer requirements, given that material selection and manufacturing modality did not compromise tool point deflection, affordability, degrees of freedom, adaptability to various devices, and anywhere mounting. Dimensional accuracy, material stiffness, number of joints and system weight were functional requirements that were incorporated into the design to meet the market needs.

The PDS that was developed by the design team further exemplifies the performance of the final product. See Table 1 for the full Product Design Specifications.

Value Item	Description	Measure of Effectiveness
Performance	Device will be universally mountable, lightweight. compact, sturdy, and able to be put together by the end user without tools	<10 lbs. Deflection less than 1”
Environment	Typical indoor environments such as kitchens, workbenches, bedrooms, etc.	50-80F
Service Life	The device will be able to operate for multiple hours in one use case	3 hours of static use before re-adjustment
Maintenance and Logistics	Manuals provided with product, easily source able spares	Ensure parts can be found at typical hardware store or online easily
Target product cost	Cost should not exceed $30	Hitting target price within plus or minus 20%
Competition	AceTaken, Lamicall, TARION	N/A
Shipping	Item will ship disassembled in a small-medium sized package; will not require special shipping	Shipping does not exceed any shipping carrier's basic shipping category
Packing	Device will be packed in a cardboard box	Use properly sized, cost-effective cardboard boxes
Quantity	Initial Form, Fit, Function (FFF) Prototype for performance analysis	1, future production units if successful

Manufacturing Facility	Use FDM 3D printer(s) available to members	QIDI I Dual Extrusion Printer (owned by Spencer Cohen)
Aesthetics	The product will be a bright color (orange) and have a smooth plastic finish on the surface	Orange color and smooth to the touch
Materials	Built with substances that fit budget	Use easy-to-afford and safe-to-use plastics like PLA and TPU
Product Life Span	The device will remain marketable if the technology for mobile devices stays roughly as it is now	5-10 years
Standards and Specifications	Dependent on unit system of 3D printer(s) used	SI (MMGS)
Ergonomics	Each joint will be hand tightened via a screw that has a hand knob and threads into a nut on the other side	Assembly and adjustments of arms will require no more than hand tightness of screws. No tools should be needed at any point in relation to the device
Quality and Reliability	Highest risk is ensuring mount does not sag under load of device	< 1" overall deflection
Shelf Life in Storage	No shelf-life constraints.	N/A
Company Constraints	None	N/A
Market Constraints	None	N/A
Testing and Inspection	First Article Testing (FAT) to observe structural rigidity, tool-point max z deflection for various phone weights, and possible creep of joints	< 10 lbs. load < 1" overall deflection Parts easily, but snugly fit together
Safety	Shall not drop mobile device into harm's way or onto user	Zero instances of device being dropped during testing
Patents	None	N/A
Social and Political Factors	None	N/A

The ability to meet engineering specifications was validated by initial product assembly and First Article Testing (FAT). The team member that manufactured the polymer components was able to assemble the final product with the purchased hardware and his personal phone. This initial assembly validated the dimensional design of the CAD model, and the tolerances that were incorporated into the joints for friction fit. Furthermore, the implementation of his personal phone exercised the requirement of maximum z-deflection at the tool point. This test was successful, as the structure did not deflect, creep, or deform outside of the allowable criteria. Arm design incorporated cross-sectional geometry that reduced weight while maximizing stiffness, due to the increased moment of inertia derived from I-beam design.

Cost analysis was conducted prior to manufacturing to ensure that the CAD model and hardware resulted in a price less than the goal of $30. Given the volume of the individual CAD components, price of the PLA and TPU filament, and hardware quotes from online sources, the group was able to estimate the price prior to manufacture. Minimal post processing and operator labor is required for desktop 3D printing, which further reduces costs. No machining or post processing of the parts is required, eliminating the costly operations by printing thru holes and designing in friction fit tolerances.

Manufacturing process was performed using a QIDI TECH I 3D Printer, which is a Fused Deposition Modeling (FDM) Additive Manufacturing (AM) machine. This system has dual aluminum extruders, high precision deposition, an aviation aluminum heated build plate for print stability and smoothness, and compatibility with PLA, ABS, and other materials. The diameter of the stock PLA and NinjaFlex TPU filament used during this prototyping effort was 1.75mm in diameter and printed using a 60°C build plate temperature. To make the extrusion more fluid and prevent wear, the printer uses upgraded Micro-Swiss Plated Brass Wear Resistant Nozzles. Simplify3D was the software used to slice, cost estimate, and export print files.

Design for Excellence (DFX) results informed our team that the product has met the technical design requirements and therefore will satisfy the needs of the customer. All the QFH matrix criteria were taken into consideration in the design and successfully implemented into the final product. In addition to customer needs, the final design exercises techniques for Design for Additive Manufacturing (DFAM) allowing it to be easily printable and Design for Assembly (DFA) to make it easily assembled by the end user. Lastly, the design for testability (DFT) criteria was met by using a FAT approach to confirm the tool point deflection.

Human factors were considered by incorporating design and assembly techniques that were easily executable and interactable by the customer. Ergonomic tightening mechanisms, elimination of small components, ease of assembly, and ergonomic viewing height and angle have been incorporated into the design to improve the user experience. A common human error is overtightening of joints and screws. The design team not only used PLA, but incorporated NinjaFlex TPU: a flexible polymer with rubber-like properties. This design mitigates device damage from overtightening of the assembly by absorbing some of the applied load into flexible bodies.

Bill of Materials

The complete bill of materials for the ASCAP mount can be seen in the figure below.

BILL OF MATERIALS

Item to be created: ASCAP Mount
Qty to create: 1

COMPONENT	DESCRIPTION	BASE QTY	COST PER UNIT	SUBTOTAL
Screws	McMaster-Carr Plastic-Head Thumb Screws, Knurled, 1/4"-20 Thread Size, 1-1/2" Long (10 Pack)	5	$1.26	$6.32
Nuts	McMaster-Carr Medium-Strength Steel Hex Nut Grade 5, Black-Oxide, 1/4"-20 Thread Size (50 Pack)	5	$0.18	$0.90
Surface Clamp	CAD designed; PLA 3D printed clamp (30% rectilinear infill) for base of product to universally clamp to surfaces	1	$1.00	$1.00
Surface Screw	CAD designed; PLA 3D printed screw (30% rectilinear infill) that fastens to the stabilizing surface	1	$0.20	$0.20
Arm Style 1 (Short)	CAD designed; PLA 3D printed arm (20% rectilinear infill) - smaller of the two arm styles	2	$0.35	$0.70
Arm Style 2 (Long)	CAD designed; PLA 3D printed arm (20% rectilinear infill) - longer of the two arm styles	2	$0.59	$1.18
Phone Clamp	CAD designed, PLA (10% rectilinear infill) and NinjaFlex TPU (20% rectilinear infill) 3D printed phone clamp to universally hold a variety of mobile devices	1	$1.58	$1.58
Phone Screw	CAD designed; PLA 3D printed screw (30% rectilinear infill) to fasten devices to the phone clamp	1	$0.59	$0.59
Soft Screw Endpiece	CAD designed, NinjaFlex TPU (10% Full Honeycomb infill, printed on a PLA raft) 3D printed screw endpiece to dampen the hold on a device	1	$0.33	$0.33

TOTAL COST: $12.80

Safety

As for any product that is designed and engineered for public use, the safety of end users and personal property was the top priority while designing the ASCAP mount. Ensuring the device does not harm the user was a major consideration while developing the design. Minimal risk is associated with this event, given that user injury would only result from impact from the phone if it fell from the ASCAP mount. Another safety consideration prototyping was the safety of the device being secured. If the device was dismounted from the holder, damage could ensue from the fall or the surrounding environment. Lastly, ergonomics and human interoperability were taken into consideration while designing the arm mechanism and the joint hardware. The mechanism shall allow for viewing positions and angles that promote safe viewing and reduce risk of head, neck, or back strain. Furthermore, the hardware selected for the joints was chosen to have a knurled thumb-screw knob to allow for ease of tightening and limited strain for user operation. All the above considerations were prioritized during the design, prototyping, and manufacture of the ASCAP mount.

Conclusions

The team learned better techniques for printing with TPU. Through repeated printing and iteration, they discovered that TPU sticks to the print bed better when laid on a PLA raft instead of a TPU one. By extension, the TPU used at the end of the Phone Clamp firmly embeds into the PLA model.

The Adjustable Surface-Clamping Articulated Phone (ASCAP) Mount solves the problem it was designed for: being able to hold and orient devices securely and safely. The team promised and delivered on all significant benchmarks. They designed, tested, and developed a fully functional and competitive product, all at a low cost.