MISSION POSSIBLE

TIPS FOR DESIGNING, BUILDING, AND OPERATING A HIGH-SCORING DEVICE

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These tips outline how to design, build, and operate a high-scoring Mission Possible device. They are not specific to the rules of any particular year, and they **do not** take the place of the rules or clarifications.

Plan Before You Build

Know the rules and how to think about the design.

- Read the rules from start to finish.
- Read the clarifications on your State website and regularly check for new clarifications until the deadline for clarifications has passed.
- Read these tips from start to finish.
- Think about the major scoring elements (start, finish, scorable actions, timing) and operational sequence in comparison to their level of difficulty. Just like with standardized tests, a good design strategy is to work on the higher value / easier parts first and leave the lower value / harder parts for later.
- Outline your design on paper before building anything. If your design is too hard to outline, too hard to put on paper, and too hard to explain, it's too hard to build.
- What are the strengths of your design? What are the weaknesses? How do you plan to address the weaknesses? What are the most important tradeoffs you need to address?

Watch YouTube Videos

- Study the structural and functional designs of championship MP devices. Think about how those devices avoid the common mistakes outlined below. Videos are especially useful in seeing how timing elements are incorporated into championship devices.

The Most Common Procedural Mistakes

Failing to Understand Technical Terms. The rules often include technical terms that are either not in common usage or differ from common usage. For example, Ideal Mechanical Advantage (IMA) applies to simple machines like pulleys, incline planes, and levers but is not in common usage. If you're not sure what IMA means or how to apply it, look it up. The same applies to class 1, 2, and 3 levers. On the other hand, the common meaning of wheel & axle is not the simple machine definition. For example, a toy car may have a "wheel" and an "axle" but rolling a toy car along an incline plane is not a "wheel & axle" simple machine.

Failing to Pay Attention to Clarifications. Some States accept the National clarifications while other States substitute their own clarifications for the National ones. Also, some States may issue clarifications for the regional tournaments AND additional clarifications after the regional tournaments but before the State tournament. Make sure to regularly check the clarifications.

Failing to Understand What Takes Precedence Over What. The rules and clarifications (State or National, as specified by your State) take precedence over the tips in this document, comments made by judges in an open house, and instructions by your coach, parents, or teammates.

The Most Common Design Mistakes

Putting Structural Design Before Functional Design. A very common design mistake is starting with a structure, usually a box, and then filling it with things according to some make-it-up-as-you-go functional design. A better approach is to start with a functional design (i.e., the start, finish, timing & scorable actions) and then determine the best structure for those functions. Your structure may feature a partly open box, a completely open frame, a vertical wall with actions on either side, a series of modules that can be arranged in multiple ways, and so on. Starting with a functional design is the opposite of starting with a box and filling it with things.

Big box. Another common design mistake is starting with a structure very near the dimensional limit (60 cm on each side). The big box mistake comes in two versions. One version starts by cutting three 60 cm panels and then attaching them to form three sides of a cube. This creates a box where two of the three dimensions exceed 60 cm by the thickness of the panels. The other version starts by cutting three panels to slightly less than 60 cm each but then adds objects that protrude from the sides of the device so that the overall device exceeds the dimensional limit even though the frame of the device doesn't.

Large components & and inefficient geometry. Large components and inefficient geometry go hand-in-hand with big boxes. Linear elements (e.g., levers, wedges, and incline planes) can often be positioned parallel to each other or above one another in a two-sided vertical wall rather than on one side each of two perpendicular walls.

Similarly, imagine a string (fishing line, thread, twine, etc.) on a rotating component, like a pulley, wheel & axle, screw, or bearing. A very common mistake is not restricting the motion of the string to be perpendicular to the component's axis of rotation. Off-axis geometry usually causes the string to slide off its bearing or bind to it.

A good strategy is to visualize placing the elements of your device in less space than you have available. Which ones can you make smaller? Which ones can you put closer together? What is the reason for the specific location and orientation of each component? Have you minimized or repositioned any protruding elements? Can you trim the dimensions of the device now that you've improved the size and geometry of the elements within the device?

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Non-measured distances. Many actions are scored by distance. For every action that is scored by distance, a visible measuring element, e.g., a hand-drawn or taped-on ruler, should be on or in the device. The judges and the team members need a reliable, consistent, and easy way to determine whether the moving object travels the required minimum or maximum distance.

Unsuitable materials and inappropriate attachment. Use reliable and robust materials for your device. In decreasing order of robustness, for example,

Plywood → Peg board → Cardboard
Wooden dowels → Balsa wood
Two support points → One support point
Screws → Nails → Duct tape.

Use the right materials to attach and secure components so things only move the way they are supposed to move. Levers, for example, should only move along one axis (end up / end down). Imagine an airplane. It's subject to pitch (nose up / down), roll (wing tip up / down), and yaw (wing tip forward / backward). A properly attached lever will be subject to pitch, not roll or yaw.

A common design mistake is underestimating the effect of force (mass x acceleration) on poorly secured structures, e.g., flimsy cardboard ramps attached to a side of the device with duct tape, pulleys dropping heavy weights against rigid surfaces, and poorly supported, weight-bearing beams dangling from the side of the device.

Finally, think about friction. For example, a pulley using sewing thread or fishing line will have less friction than one using twine or rope. The reduced friction will make the device more reliable and more consistent.

Open pours. An open pour is the movement of an unconfined object in space, e.g., water or sand being poured from one open container to another, marbles rolling off a ramp, dominos falling down, or levers flipping things. First (unless the rules prohibit confinement), confine everything subject to an open pour with some sort of funnel, closed tube, ramp, barrier, container within a container, etc. The objective is to avoid a failed action because the unconfined object went somewhere it wasn't supposed to go with respect to the action. Second, independent of the action, confine whatever is moving from leaving the device. A moving object can successfully complete an action and then, unrelated to the action, incur a penalty for leaving the device. This may require, for example, putting a border around the base of the device.

Insufficient Robustness. Many runs fail because the devices are not robust enough to withstand some usually very predictable variation in force, motion, balance, etc. This variation causes actions to start out of sequence, moving objects to get stuck, sensitive elements to activate at random, and so on. Make sure you address these types of issues. For example, will your device work if the competition table is not perfectly level? What happens if a moving object (like a marble) doesn't stop when it's supposed to, a moving component (like a pulley) stops abruptly

or too soon, or a vibration-sensitive element (like a mousetrap) activates at the wrong time? Do all the actions work consistently and reliably each time?

Inaccessibility. Configure your device so that you can access all the actions during the run, if necessary. If your device fails during operation, you may need to touch it to continue the run.

Parallel actions. Only actions that are part of the sequence leading to the final action are scored. Two actions may not take place at the same time. This restriction also applies to non-scorable actions and the timing action (if the device has a timing action). The rules vary from year to year on whether a scorable action may also be designated as a timer. As always, check the rules.

The Most Common Set-up Mistakes

Not bringing the required materials. Before you come to the tournament, make a checklist of the things you need to bring to the tournament to set-up and run your device. At the top of the list should be the tools and supplies you need, all the removable and consumable items your device requires, and goggles. The judges do not supply these items.

Setting up under off-spec conditions. Conditions at the tournament may differ from those at home. For example, the competition table may not be perfectly level or it may not be perfectly balanced. If your device is sensitive to this, bring a level and some shims to make sure the table is level and stable. Similarly, your device may have elements that are sensitive to light or temperature and the competition may take place in unexpected lighting or temperature conditions.

Not having a set-up checklist. To ensure that you can set-up consistently, reliably, and within the allowable time, make a checklist of your set-up plan, especially the order in which you set up objects that are sensitive to time, vibration, pressure, and so on.

Not knowing how or where to set-up moving objects. Do you know exactly where to put objects that move (e.g., marbles, dominos)? Do you know where objects that are moving should and should not go (e.g., inflated balloons)? Do you know how much water, sand, salt, etc. to put in your timer? Do these moving objects move the same way at the same rate each time you set-up and run your device?

Interference. Starting at impound and especially during set-up and the run, you may not communicate with anyone about MP other than your MP partner. Coaches, parents, other teammates, and outsiders may not communicate with you. You may be assessed an interference penalty without any warning.

Failing to clean the table. Make sure the table is clean during set-up. If you spill sand, water, salt, etc. on the table during set-up and it's on the table after your run is complete, the judges may assess a penalty no matter when you spilled it. Clean it up beforehand.

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The Most Common ASL Mistakes

Failing to follow the rules. There are four very simple ASL rules: on time, legible & in the proper format, accurate, and matching the actions labeled in or on the device with those described in the ASL. (Go to www.soinc.org and enter **ASL** in the query box in the upper-right.) In addition, some States have two judges for MP and require two sets of ASLs. Check your State clarifications.

Failing to explain everything to the judges. The judges are unfamiliar with your device and your ASL. Plan on explaining what your run is going to look like and the key actions the judges should be looking for. The explanation needs to match the ASL, including non-scorable actions. The judges will look at the ASL before and after the run and look at the device during the run. If the ASL, the explanation, the markings on the device, and the run don't all match, you may not receive the score you expected.

Failing to identify the timing-related start & stop points. It will be obvious to the judges when the start action takes place (3-2-1-go is a good approach) but it will be less obvious to the judges when the final action is about to take place. Point this out. Depending on the rules, many devices will have a separate timing action inside the overall action sequence. This requires the judges to time the overall action sequence (i.e., the target operation time) AND time the separate timing action inside the overall action sequence. It will not be obvious to the judges when the separate timing action (if present) starts and stops. Point this out also.

The Most Common Operational Mistakes

Starting too far away from the device or at an awkward angle. Whether the start action starts inside the device or outside the device, you always want to start as close to the action element as possible. "Outside," means not inside, it doesn't mean so far away that you need to aim or throw something into the device from a long distance or need to reach over the device at an awkward angle. If the competition table is high and your device is tall, ask if you may set-up on the floor.

Not understanding the touch rule. There are three parts to the touch rule. First, you may touch the device no more than three times before scoring stops and all points for the target time are lost. You may touch an action in the device multiple times for a single touch but when you touch another action, that's a separate touch. Second, if you need to touch the device to restart the run, touch the failed action so it initiates the subsequent action. Do not initiate the subsequent action by hand unless you have no alternative. If you initiate the subsequent action by hand, you won't get credit for the failed action or the subsequent action. Third, if your device fails during operation, the judges will not tell you what to do or not do. So long as the judges don't think you're purposely wasting time to reach the target time, you may do whatever you want.

Other Tips

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Test your device and rehearse your tournament-day presentation

- Plan and practice your set-up, not just the operation of your device.
- Video your practice runs and replay them to see where your device fails or operates with excessive variability. It's often impossible to figure this out in real-time at operational speed.
- Practice adjusting your timing action. If the rules offer points for a timing action (separate from the points for the target time) and you have a separate timing action, you may want it to take up most of the target time and have everything else take very little time. If the target time is announced at impound, you need to show how you adjust the timing action to meet the target time.
- Explain your action sequence to your teammates and your coach the same way you plan to explain it to the judges at the tournament.

Recheck your device against the rules and clarifications.

- Recheck construction parameters and operational requirements.
- Recheck for unallowable materials.

Final clean-up. If you plan to leave your device for later retrieval or because you are protesting, return it to the impound area. Make sure to take your device and all materials by the end of the day and leave the room as clean as you found it.