THE ROTARY DRIVER SYSTEM (11/15/06)

By Harley Michaelis, e-mail harleym@bmi.net

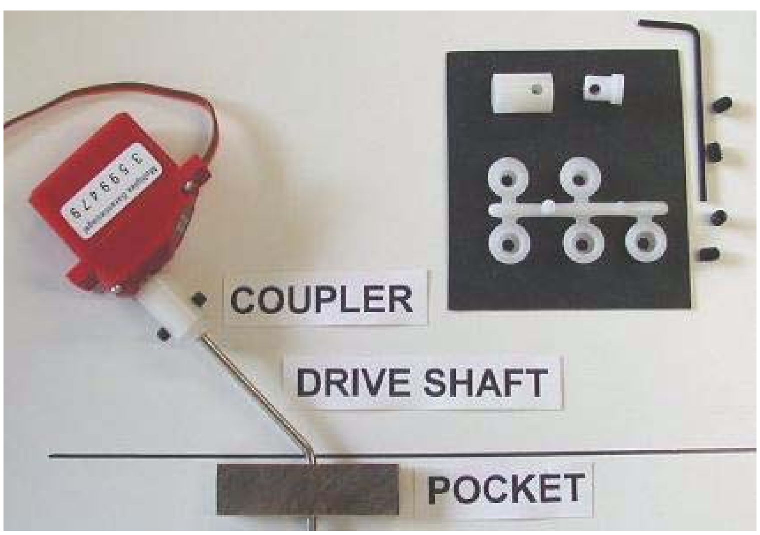
The RDS is an all-internal method of moving hinged surfaces. It can be adapted to a wide variety of sizes and types of fixed wing R/C aircraft. These pages give a general overview. The RDS section in File 3, starting at page 17, provides extensive installation details.

The RDS involves no output arms, horns, clevises, threaded rods, protruding well covers, etc. Surfaces are totally free of unsightly hardware to catch on things and cause drag and noise. Properly fabricated and installed, no slop or bind is contributed by the system. Full expected deflections are provided for positive control. It can be used to move flaps, ailerons, flaperons, elevator, rudder, etc. Servos commonly used for a particular application are fine here if they can be fully recessed in structure ahead of and near the hingeline.

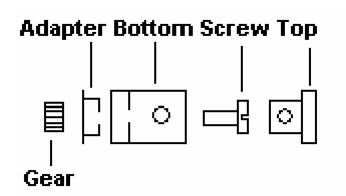
Installation is made practical using an adaptable, injection-molded servo accessory along with simple, inexpensive and easily made "drive shafts" and "pockets".

The servo accessory is Kimbrough Products (the R/C car gear people) item #500, a 3-part "coupler" shown in the picture below. It attaches to the output gear with the servo screw. It receives and secures a "drive shaft" that enters a "pocket" in the movable surface.

The coupler parts (white) are shown below on the black background. Top right is the coupler top that has a pilot hole. To enlarge it for various shaft sizes, seat it in a ¼" hole in a board. Progressively enlarge the hole using a drill press. For a 1/16" shaft, open the hole with a #51 bit. For the most commonly used 3/32" shaft, lastly use a #41 bit. Top left is the splined coupler bottom. It receives a double-splined adapter from the 5 adapter tree. One or the other fits the output gear of most popular servos. Setscrews secure the top inside the bottom and seat to flats ground on the shaft to lock it in place. <u>The #500 package includes a pair of the molded parts shown, plus four setscrews and an Allen wrench</u>. Two pair are needed for a four servo wing.



This exploded view shows how parts go together. An adapter slips inside the coupler bottom, seating to its internal flange. These fasten to the output gear with the servo screw. The top is secured with setscrews that also secure the drive shaft. Drive shafts have flats on them.



Shafts and pockets vary with airframe size and application. No one size fits all, but 3/32" shown in the picture fits most. The picture depicts an aileron application. Particularly note that the elbow of the bend is at the hingeline and that the pocket front edge is a little behind the hingeline. 1/16" works well in practice. Pockets have a top and bottom, spaced in parallel planes for a "slightly snug" fit with the shaft. Pockets and shafts are easily, precisely and inexpensively modeler-fabricated from common materials as detailed further on. Shafts, pockets and tempered aluminum coupler tops are commercially available from modeler-machinist Walt Dimick. See pg. 8.

With servo oriented 45 degrees to the hingeline, as shown above, deflection available either way is similar to the bend angle. This orientation and a 90 degree bend will provide full down flap. For ailerons, with the shaft bent no more than 45 degrees, the servo and shaft may be squared to the hingeline as illustrated with the shaft segment on the right in the drawing on page 4.

Smaller bend angles equate to moving a clevis closer in on an output arm. An analysis by an engineer who designs guidance systems for rockets and space craft showed, for example, that a 32 degree bend allows 30 degrees deflection while doubling effective servo power and resolution.

"Pockets" slip over the bent end of the drive shaft. Hinging stabilizes the shaft in the vertical. If hinges fail, the surface can slip off undamaged, unlike when tethered by a horn, clevis and pushrod. Unlike a pushrod, the rotary action doesn't impart forces at right angles to the axis of the output gear and so is much easier on servo gear trains and pin sockets in servo cases.

DOUBLE SPLINED ADAPTERS: Which is known to fit which servos is shown below. To attach the coupler, usually seat an adapter first in the coupler bottom. Some fit very tightly. Then, using the servo output arm screw, fully seat the assembly on the servo output gear.

LEFT TOP: Hitec 60/80/85/101, etc. Volz Alu-Star

LEFT CENTER: Std. Airtronics including 94761Z, JR, Multiplex, Sanwa.

LEFT BOTTOM: Std. Futaba, FMA series 300, Critter bits, some larger ACE, Dymond.

RIGHT TOP: Std. VOLZ, Airt. 557 (very tight). See bordered paragraph below about using this on the JR 168 and Hitec 125 thin wing servos.
RIGHT BOTTOM: FMA 88/90/95/100 etc. ACE 8112, Cirrus CS20/21, MPI MX 30.

To prepare the Volz adapter to go on the JR or Hitec thin wing servos, drill a 5/16" hole in a board. Put the adapter in it. Using a sharp 3/16" bit in a drill press, gently widen a little of the adapter opening. Square up the adapter and gently press it over the output gear with a bench vise.

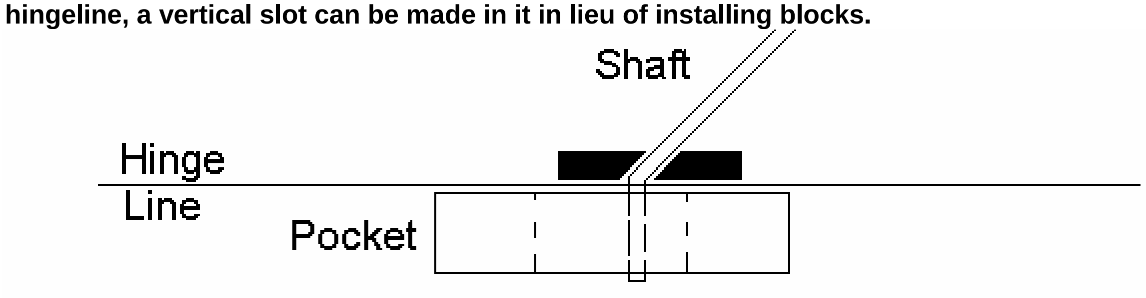
CUSTOM SPLINING: Any of the three standard adapters on the left can be fitted to a smaller output gear as follows: Plug the output gear screw hole with paste wax. Wax the gear and case or coat with PVA release agent. Put clear tape over the hole for the servo screw in the adapter. Almost fill the adapter with epoxy. Press it, visually centered, over the output gear. Let the epoxy cure well. Pry off the adapter. Clean off wax and excess epoxy. Open the servo screw hole.

The splined coupler bottom itself can be custom splined. From an adhesive backed paper, cut a disc to cover the screw hole at its bottom. With a pin, punch a hole in the center of the paper. Almost fill the splined bottom with epoxy. As closely as possible, center the bottom over the output gear. Run a waxed round toothpick into the pinhole and find the screw hole in the gear to finalize the centering. When cured, pull out the toothpick. Open the hole for the servo screw. For heavier duty applications a filled epoxy is recommended.

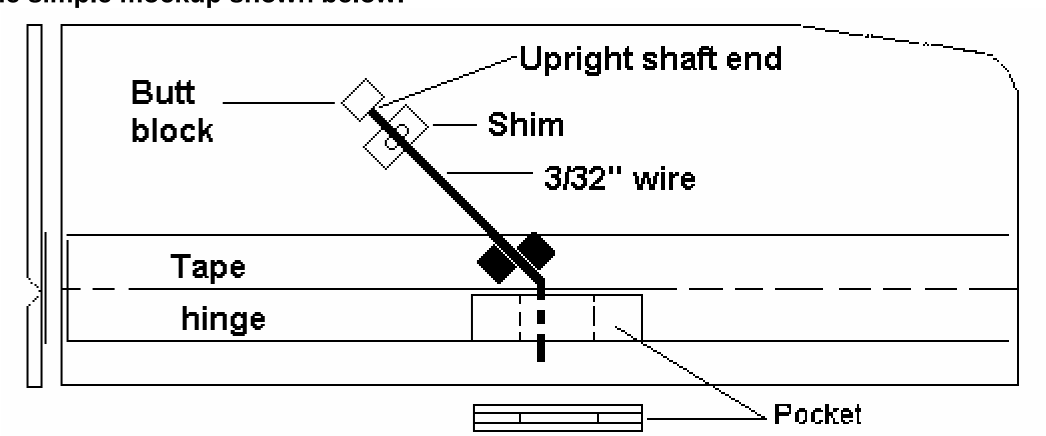
The #500 package sells for $5. Order from Harley Michaelis, 26 S. Roosevelt, Walla Walla, WA 99362. Add a flat $4 for shipping any size order. Specify "pair" not "sets". Send check or money order please. Inquire about non-USA orders at harleym@bmi.net. If ordering other things from Tower Hobbies or Walt Dimick (page 8), they also carry the couplers.

RDS KINEMATICS: During deflection, 3 motions take place. (1) The bent section of the shaft works in a fan pattern within the pocket. (2) The pocket moves slightly fore and aft on the fixed shaft. (3) The shaft "floats" slightly up and down at the hingeline. These motions enable the RDS to work.

The three motions take place simultaneously to avoid bind or pulling on hinges not in the same geometrical plane as the pockets. Snug fitting tubes by the hinge line <u>should not</u> be used as they interfere with the "float". Lateral movement is to be restrained. Blocks either side of the shaft, as shown black in the drawing below, are a simple solution. In a wing with a sub-spar just ahead of the hingeline, a vertical slot can be made in it in lieu of installing blocks.



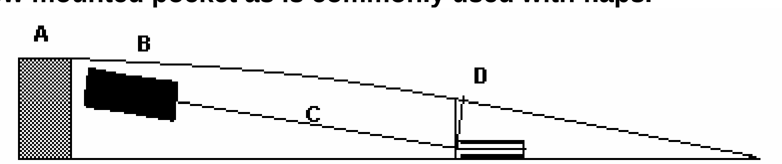
To see and feel what's happening during deflection and to dispel misconceptions, it's helpful to make the simple mockup shown below.



From 1/8" balsa sheet, make a "wing" and an "aileron". 12" span by 3" to 4" chord is fine. Bevel edges as shown on the left to allow down deflection. With aileron spaced slightly at the hinge line, apply a clear tape on top that sticks well. From 3/32" softer wire (coat hanger, etc.) make a low radius bend. Bend the front end to point vertically with the rear bend horizontal.

From harder balsa make a pocket to nicely fit the shaft, neither too tight nor sloppy. Cut away some of the hinge to glue the pocket to the top of the aileron, placed 1/16" behind the hingeline.

It's not uncommon for a servo to require tilting under the top skin to direct the bent end of the shaft into the pocket, as illustrated below. "A" represents the spar, "B" the servo, "C" the drive shaft and "D", a low mounted pocket as is commonly used with flaps.

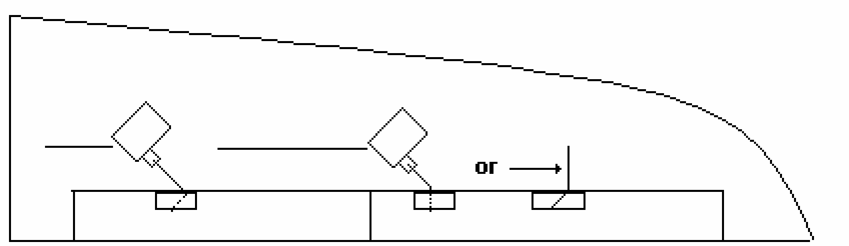


To simulate tilt on the mockup, raise the shaft 1/8" with a piece of ply glued in the "shim" spot. Glue the whole assembly to a block ¾" or so thick placed under the wing. Drive some small nails through the shim either side of the shaft to allow only rotary movement there. Glue blocks (shown in black) either side of the shaft to restrain lateral motion. Find the "sweet" spot for the elbow that allows smooth, easy deflection. Then glue a "butt block" to the wing that puts the elbow at that exact position. Operate the mockup with the upright shaft end against the block.

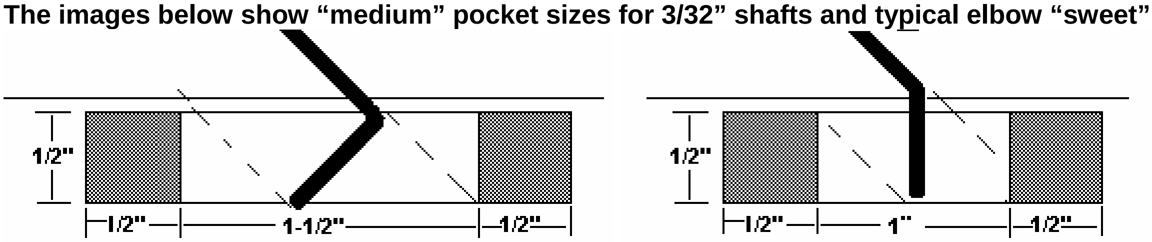
Note what makes the RDS work well. The servo must be firmly mounted, possibly with a tilt, to (1) direct the shaft into the pocket and (2) keep the elbow in the “sweet” spot. (3) The pocket needs to be located a little behind the hingeline, say 1/16”. (4) It needs to fit the shaft without bind or slop. (5) Restraints are needed to prevent lateral play, but allow slight vertical “float”. In a real installation, there is enough flex in the coupler and shaft to allow the “float”.

SERVO ORIENTATION

The drawing immediately below illustrates 45 degree servo orientation for plug-in panels or a one-piece wing. If a panel has a foam core, tunnels go from the hingeline to the servo well. As shown in the larger individual drawings, the front edges of the pockets go a little behind the hingeline. The elbow of the bend for flaps goes a little behind the hingeline and for ailerons, a little ahead. The actual elbow locations are those manually found to be the “sweet” spots in a particular installation as the shafts are sized to length. See File 3 about sizing shafts to length.



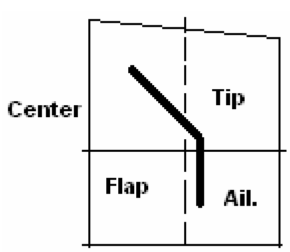
The images below show “medium” pocket sizes for 3/32” shafts and typical elbow “sweet” spots.



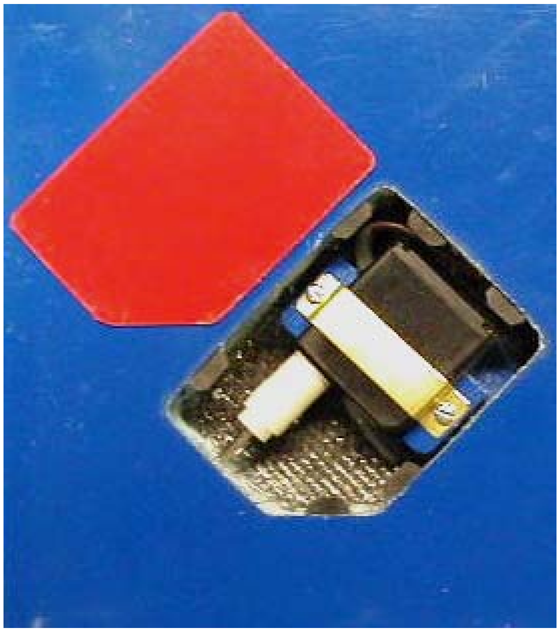
Keeping the servo, pocket and shaft near the thicker inboard end of tapered surfaces provides more vertical pocket space and keeps mass more centered for good roll response.

MOUNTING SERVOS

The RDS requires easy attach/detach of servos and drive shafts during installation and after hinging. Fore-aft shiftability of a mounted servo is essential and if tilt is needed to direct shafts into pockets, the mounting system must also allow it. Harley’s Easy Mounting System (HEMS), a dedicated one for RDS shown in the picture on the next page, meets the criteria in the simplest and least expensive manner. See File 3, pg. 18 about making and installing these unique mounts.



3-PIECE WINGS: Aileron servos can be mounted inside the ends of the center section. The shaft can protrude from the endcap to slip into a slot in the aileron. Center to tip wiring/connectors are eliminated. In File 3, see the drawing, pg. 17 and picture on page 21.



Using "HEMS", the servo fits snugly between rails on a base. The base mounts to the top skin which is reinforced inside with a layer of CF cloth to prevent "oil-canning". A bracket secures the servo, but allows it to be shifted on the mount.

With surface hinged, the bent end of a sized shaft is <u>inside</u> the pocket, not shown here. To get a mounted servo out, it must be detached from the shaft. ¼" well clearance by the case bottom allows the servo to be shifted rearward. With setscrews loosened from the shaft, needle-nosed pliers can be used to <u>slide the shaft further into the pocket and fully out of the coupler.</u>

Shifting also allows some leeway to cinch down the servo at the "sweet spot" for the elbow.

In a skinned composite wing, such as the Genie, bits of CF laminate under the skin (gray tabs) will support a cover flush with the skin. Clear tape secures it.

<u>MOLDIES</u>: Molded wings and others that come with tiny wells pre-made for use with traditional hardware may defeat doing an RDS installation. Flap servos must go in angled to get liberal down flap. While aileron servos can go in squared-up there must be space ahead of the hingeline for the coupler and some straight shaft that protrudes out of it. In bagged wings, installation may be feasible if the modeler can cut his own wells as shown above and detailed in File 3. Tunnels for leads to flap and aileron servos need to be located to enter the wells.

<u>COMMERCIAL MOUNTS</u>: Those that prevent shifting the servo can't be used for flaps unless tape hinged. They are okay for ailerons in 3-piece wings like the Genie with the servo oriented at 45 degrees inside the center endcap. See page 21, File 3.

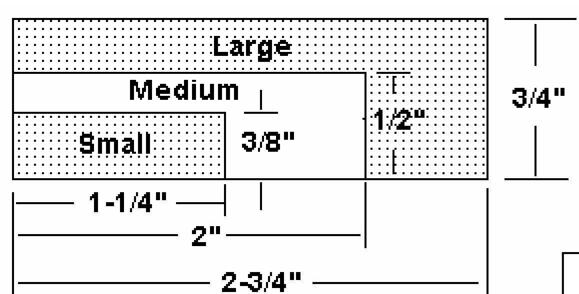
<u>SERVOS WITH SIDE MOUNTING LUGS</u>: if the well is sized to allow shifting, then these, such as (Volz, Hitec 125, JR 168, Airt. 761, etc. can be shifted by removing the mounting screws. To keep the well opening small, a recess could be made under the skin to allow ample shifting.

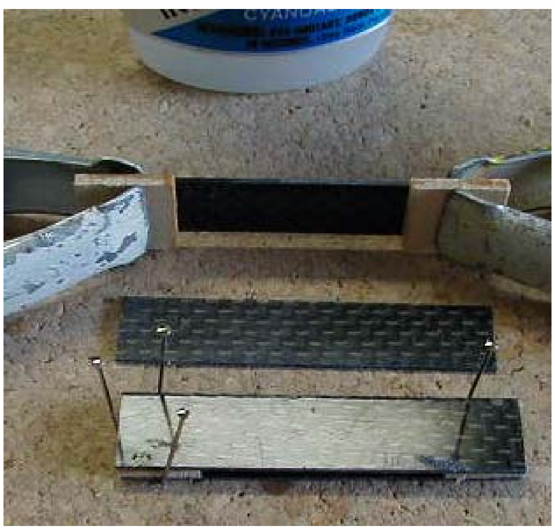
<u>MARK DRELA MOUNTS</u>: For his lightweight designs Mark mounts servos in cantilever fashion to posts between the skins. He uses SS tubing to make stiff drive shafts and has his own, super light "coupler" system. These are intricate and take a delicate touch to install. See http://charlesriverrc.org/articles/supra/supra.htm about it. Page down to the Wing Plans files for FLAP and AILERON RDS. I used the well configuration and cantilever mounting on several airframes, but with the Kimbrough couplers and solid SS shafts, before developing the HEMS.

<u>MAKING SHAFTS FROM STAINLESS STEEL(SS) WELDING RODS</u>: This is a "no brainer" requiring a bench vise and hammer. SS is smooth, uniform, takes a sharp 90 degree bend without cracking and doesn't rust. Cut pieces long enough, say 5"-6". Round an end, Clamp 5/8" horizontally in a bench vise. To make needed <u>low radius</u> bends, pound near the jaws. Jaws do not mar areas that contact the pockets. Four shafts can quickly be made from a 50 cent SS rod. Set aside for later sizing to length as detailed in File 3. After sizing, flats are ground. See pg. 7 below.

<u>MAKING SHAFTS STIFFER</u>: after sizing a SS shaft to length to put the bend in the"sweet spot", it can be stiffened by bonding a brass tube over it with CA glue. Size the tube to length to not interfere with insertion of the shaft into either the coupler or the pocket.

<u>MAKING POCKETS</u>; this is also a "no brainer". Typical sizes for ailerons are shown below for 1/16", 3/32" and 1/8" shafts. The "medium" for 3/32" shafts would be ½" x 2" with a 1" slot. For flaps, pockets need to be longer with a longer slot to allow the broad fan motion and to slide the shaft in and out of the coupler. See File 3. Another ½" length usually works well. Clearance is needed behind a pocket to back the shaft out of the Kimbrough coupler to disengage it from a mounted servo. I've used only the medium size with 3/32" shafts for all my sailplanes from spans from 6 to 12 feet. Larger pockets and shafts would be appropriate for thicker surfaces or heavier duty applications.





Pocket tops/bottoms of smooth Formica, CD, CF plate or CF spar material, spaced to make a slightly snug fit with the shafts, work very well. .032 carbon plate is most rigid & resistant to warping after installation. Cut uniform width strips with table saw, hacksaw, etc. Cut a set to matching length & smooth edges, ready to join to spacers.

For 3/32" shafts, 3/32" bass sheet (Lone Star) works well. Clamp ¾" sq. pieces to a top or bottom. Wick join with thin CA. Trim excess spacers. Clamp on the other piece. Check for "slightly snug" fit with shaft. If loose a few, even swipes with the sanding block will get a fine fit. If too tight, use thicker CA for better fit.

Over cork board, etc., place <u>four</u> pins as shown as guides to position the other piece. Coat fingers with paste wax to avoid bonding them. Dab CA on ends, flip over & press in place.

The pockets here were intended for flaps. The opening was made ½" longer than drawn above for reasons discussed in File 3 in the RDS section.

It's okay to bevel and thin the assembled pockets on a belt or disc sander to get them between the skins. Then wrap ends with Kevlar thread to prevent splitting. When pockets are joined to the skins all becomes very rigid, based on the "bundle of sticks" principle. See File 3 for details about installing pockets.

<u>CAVEATS APPLICABLE TO ALL INSTALLATIONS</u>

1. **Use servos and drive shafts suited to the application. In high speed, heavier duty applications, favor larger shafts if there is space for the pockets between the skins.**

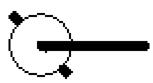
2. **Vertically position the pockets as close as practical to the plane of the hinges to prevent shafts from slipping out of a pocket in extreme deflection. This is not a concern in thin**

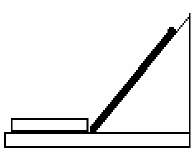
wings, but for example, if you had a top-hinged thick aileron and a low pocket, it could be.

3. Where possible, keep shafts short by using thinner servos that can be mounted closer to the hinge line. Short shafts are less subject to axial flex. Axial flex may be a concern with high speed, heavy duty, high load applications. In contrast, flex would be advantageous in combat foamies.

4. Until shafts have been sized to precise length, flats ground and programming done, there is no need to seat setscrews. When a screw hits the shaft, go easy as too much torque will strip or break the plastic couplers.

5. SETSCREW and FLATS ORIENTATION: After shaft length is finalized, opposing flats can be ground on the long end with a bench grinder. Flats must be located so setscrews are readily accessible through the servo well. The top drawing below illustrates proper location. (Thanks, David Stack, for this suggestion.)





Think of the top drawing as the rear view of the coupler for the right flap servo with the wing inverted. The heavy black line represents the bent end of the drive shaft pointing inboard in its neutral position. The outboard (left) setscrew, pointing up at 45 deg., is then accessible. Upon CCW rotation of the servo to full down flap, the inboard screw will then point up 45 deg. & become accessible
Flats on the shaft must face the setscrews. This requires a suitable holder for grinding. The lower drawing shows a holder cross section. The heavy black line represents the bent end of the shaft. Triangular stock is glued to a base of ply. A ply strip is glued to the base to keep the shaft in position. A flat is made by running the vertical edge of the grinder wheel on the long (horizontal) end of the shaft.

A holder as pictured below with cleat glued at the center stabilizes the shaft during grinding. Then, moved against the vertical segment of a bench grinder wheel, vertical flats can be ground on the protruding horizontal end of the shaft. A support 4" to 5" long will do fine.

A 2nd and opposing flat is made by rotating the holder 180 degrees with the shaft left in its original position.

To get a RIGHT and LEFT set, point the long end of one shaft in the opposite direction to make the flats on it.

With opposing flats, the two setscrews can be seated through the stock plastic coupler top to secure the shafts for typical applications. Just don't overdo the torque and risk stripping threads. For heavy duty, demanding applications, or where time is more important than money, check out the fine RDS accessories by modeler-machinist Walt Dimick at http://www.irfmachineworks.com/rds. The shafts, made from drill stock, have a long single flat, not oriented at 45 degrees as detailed above. They have a feel similar to Allen wrenches.

Walt's tempered aluminum coupler tops for heavier duty applications, used in place of the plastic ones, allow firm seating of four setscrews to shafts without danger of stripping.

If the fit between a shaft and pocket is good (slightly snug) but play is subsequently noted, one or more reasons may be found below.

1. There's slop in the servo gears. 2. The surface itself is flimsy or flexible. 3. The flat is convex. 4. Setscrews are not well seated. 5. The servo or its mount is loose. 6. The shaft used is too springy. 7. Hinging allows play between the fixed and moving surface. 8. The servo screw is not fully seated allowing the adapter to slip on the gear. 9. An adapter may seem to fit, but is the wrong one and allows slippage. 10. The pocket is wiggling around in the surface. 11. The pocket has split. 12. The shaft is not laterally restrained.

What I know about the RDS has been empirically determined. Technically oriented readers can go to http://www.hauninger.gmxhome.de/hobbies/modeling/RDS/RDS.html. Use your pointer to slide the main screen to the right to expose references about other related items.

WINSTON OKERLUND'S RDS MODIFICATIONS

See http://genie.rchomepage.com/RDS%20MODIFICATIONS.pdf Winston details some additional ideas about coupling and about making tubular drive shafts for applications that require more stiffness than typical thermal sailplanes. There is also a section on DLG's.

<<<<>>>>