

## APPENDIX M

### RAMP DESIGN AND ROADWAY DESIGN TOOLS

Ramps are used at roadway intersections to provide greater safety and ease of driving when changing the direction of travel from one roadway to another. Ramps may range from the very basic diamond shape, or variations thereof, to the very complex cloverleaf patterns employed at high volume roadway interchanges.

The horizontal alignment components of a ramp design are the same as those that comprise the roadways to which they connect. In other words, ramps are designed with tangent lines, circular curve, and spirals. However, due to the fact that ramps have greater positional restraints placed on them, as well as more complex shape combinations than that of roadways, they require the use of a special set of graphic tools for their design. To help efficiently design roadway interchange ramps, the general ramp design command permits the interactive design and display of a ramp according to designer specifications.

In addition to the general ramp design command mentioned above, several other commands have been added to the capabilities of IGrds. These provide the designer with the means to efficiently design reverse curve layouts, determine intersection flared areas (radial offsets), design median ends, design left turn lanes, determine alignment intersection data, and generate right-of-way stakeout designs.

### RAMP DESIGN TOOLS

#### General Ramp Design Command Capabilities

The general ramp design command of IGrds actually provides users with the capability to design most, if not all, of the usual ramp configurations found at roadway intersections or interchanges. Among its specific capabilities is one that permits the design of a three-center compound curve used for inner loop ramp configurations. Another permits the design of a three-center curve, with the center curve reversed. This type of configuration is used for a ramp that passes around the outside of an inner loop ramp. A third capability, similar to the foregoing, consists of a five-center curve ramp, with the middle curve reversed and fitted a set distance from the middle arc of the inner loop ramp configuration it is designed to straddle. An additional capability allows the use of reverse curves within a ramp alignment, with radii that may either be specified or computed as a best fit. Figure M-1 shows examples of these capabilities.

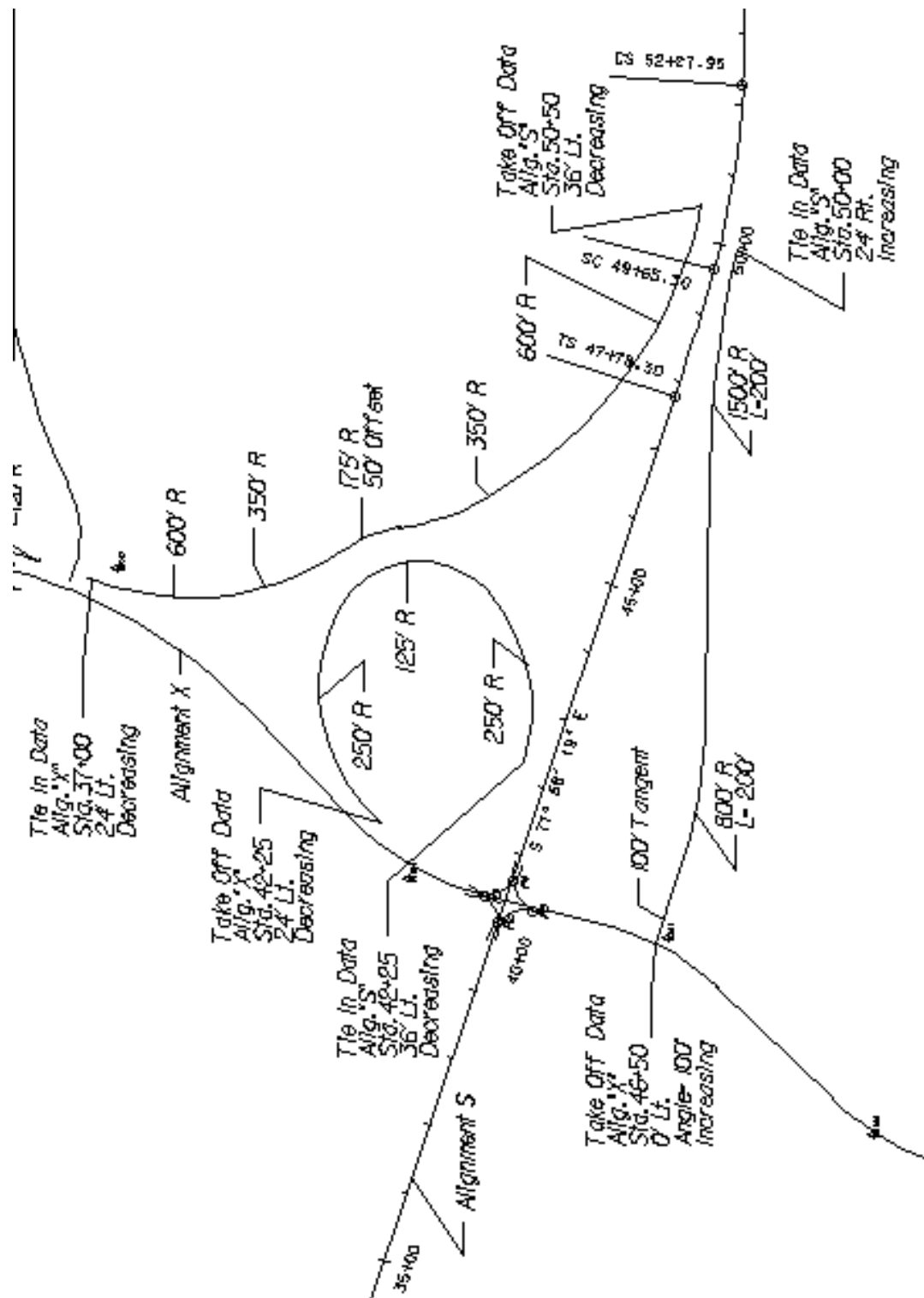


Figure M-1. Example of General Ramp Design Capabilities

While the command does solve the special inner loop and outer connecting ramp configurations mentioned above, its structure also permits the designer to create the design of any other type of ramp on a segment-by-segment basis, until a closure segment is required. A ramp segment is simply a user defined length of tangent or curved alignment. A closure segment is that section of ramp alignment used to close the final gap in the design. Closure segments may, however, actually consist of more than one section of alignment, as will be seen later. If a particular segment does not meet the designer's expectation after it has been displayed, it may be rejected and deleted, thus reverting the design to its condition prior to the addition of the deleted segment. If need be, each additional rejection will remove the next most recent segment added.

To begin the ramp design process, two items of information must be given in order to define the starting and ending points of the ramp. These points are known as the take-off or tie-in points. The first point is referenced to the roadway at the start of the ramp, while the second is referenced to the roadway at the end of the ramp. An alternate method is to select a MicroStation or IGrds geometry element to determine either or both of these points. The selected element would also become the first or last element of the ramp.

With the take-off and tie-in points for the ramp established, ramp design begins by determining the direction in which the design is to proceed. Will it move forward from the take-off point, or backward from the tie-in point? In actual practice during the design process, both of these options will most likely have to be used. After a starting point and direction are set, the designer next determines what type of segment to put in place. The segment type may be a tangent line, a circular curve, or a closure segment. The choice depends on the type of ramp being designed; i.e., inner loop, outer connection, or other special configuration.

If an inner loop is being designed, it may be defined as a three-center curve without preceding or trailing tangent lines. Such a case is itself a closure condition because it closes the gap in the design between the take-off point and the tie-in point with three compound curves. Simply defining the radii for the three arcs in the loop causes the resulting design to be displayed on the graphics screen. See Figure M-2. Two other closure types that can be similarly defined are the three-center curve closure where the middle curve is reversed; and the five-center fitted curve closure, where the middle curve is also reversed. Both of these latter types of closures are used for the design of outer connecting ramps that fit around inner loop ramps.

All other ramp types require definition for either tangent or curved alignment segments, on a one-by-one basis, until a final gap in the alignment remains to be closed. Tangent line segments are defined by length and deflection angle. If the current design direction is set to forward, then the tangent will be attached to the current take-off point, and its free end becomes the new take-off point for the next forward segment to be added. Conversely, if the current design direction were set to reverse, the tangent would be attached to the current tie-in point, and its free end would become the tie-in point for any segment to be added in the reverse direction. Of course, if it is desirable to design a loop or outer connection ramp with preceding and terminating tangent lines of several hundred feet and have a deflection of some minor degree relative to their respective roadways, these may be added to each end of the design first, and the subsequent gap may then be closed with one of the multi-center closure types.

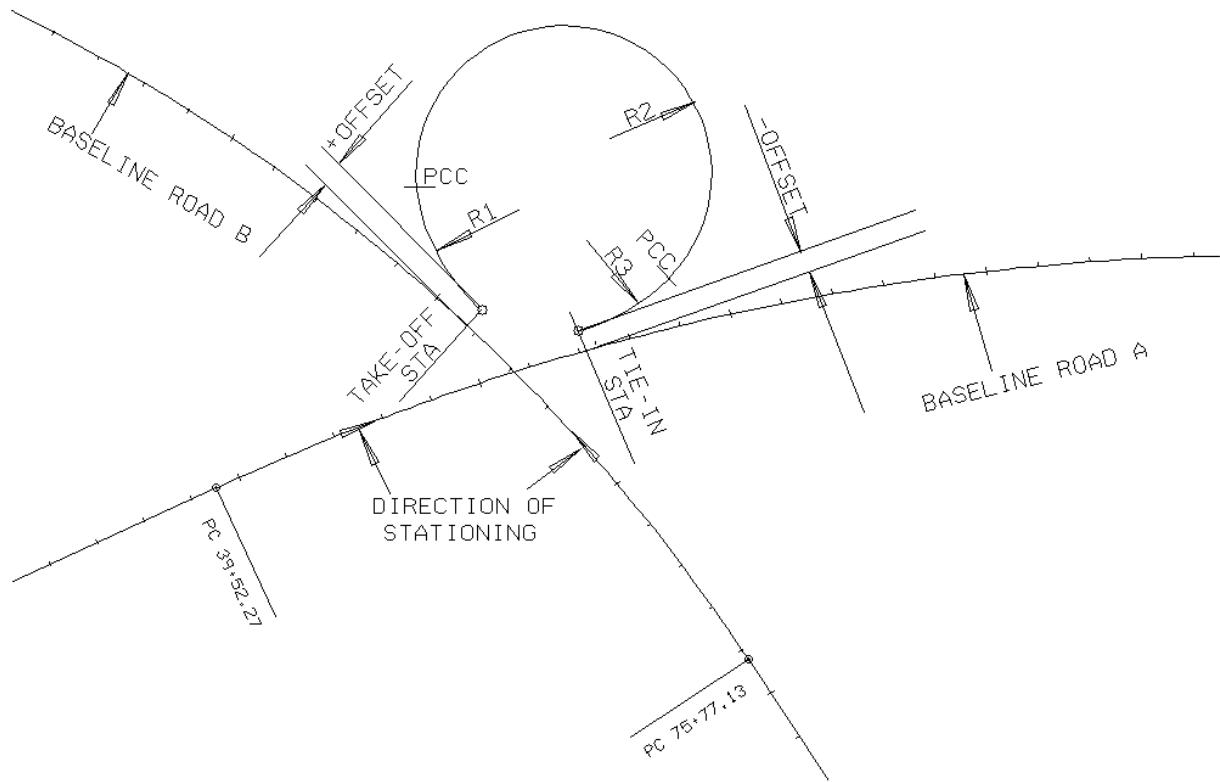


Figure M-2. Three-Center Curve Loop Design

Unlike tangent lines which can be defined with deflection angles or tapers at each take-off or tie-in point, arcs should only be given directions at the initial take-off and tie-in points. Deflection angles to arcs are based on the deflection angle to a tangent to the arc at the point of take-off or tie-in, as the case may be. This arc positioning capability at the initial take-off and/or tie-in points permits the design of curved ramp entrances or exits, oriented at angles up to 90 degrees with the base roadway. At all other locations, arcs must be defined with zero degrees deflection when connecting to adjacent tangent lines.

Under certain conditions, such as the relative position of the take-off and tie-in points, and the size of the radii entered, two mathematically possible solutions may exist for the position of the middle arc of an inner loop ramp configuration. The command permits the user to select the choice of solution required through the use of a toggle switch provided for that purpose. The two choices are either outer or inner, and the switch may be changed from one setting to the other to see both solutions when applicable. See Figure M-3.

## **OTHER ROADWAY DESIGN TOOLS**

### **Reverse Curves Command Capabilities**

The reverse curves command of IGrds is designed to quickly insert a reverse curve alignment section between two specified points. As defined for the preceding commands, these two points represent the take-off and tie-in points that define the location of the start and end of the reverse curves.

Take-off and tie-in points may be defined by stations and offsets that are referenced to one or two existing roadways, or they may be defined by coordinates and a direction azimuth.

Definition for the reverse curves used in the solution may take on one of three forms. In the first form, the radii are not specified, and the command computes a best fit, equal radii, solution that fits exactly between the start and end points. In the second form, the radius of just one curve is specified, and the command computes a best fit solution for the unspecified radius. In the third and last form, other curve radii are specified by the user. Since two user specified radii will create an exact fit between the take-off and tie-in points, the take-off point will be held, and the point of tangency of the second curve will be allowed to slide along an imaginary line passing through the tie-in point and having an azimuth equal to the direction azimuth of the tie-in point.

This command can be used for both alignment ramp design and left turn lane median transition design. Figure M-4 shows an alignment ramp design and Figure M-5 shows a left turn median transition design.

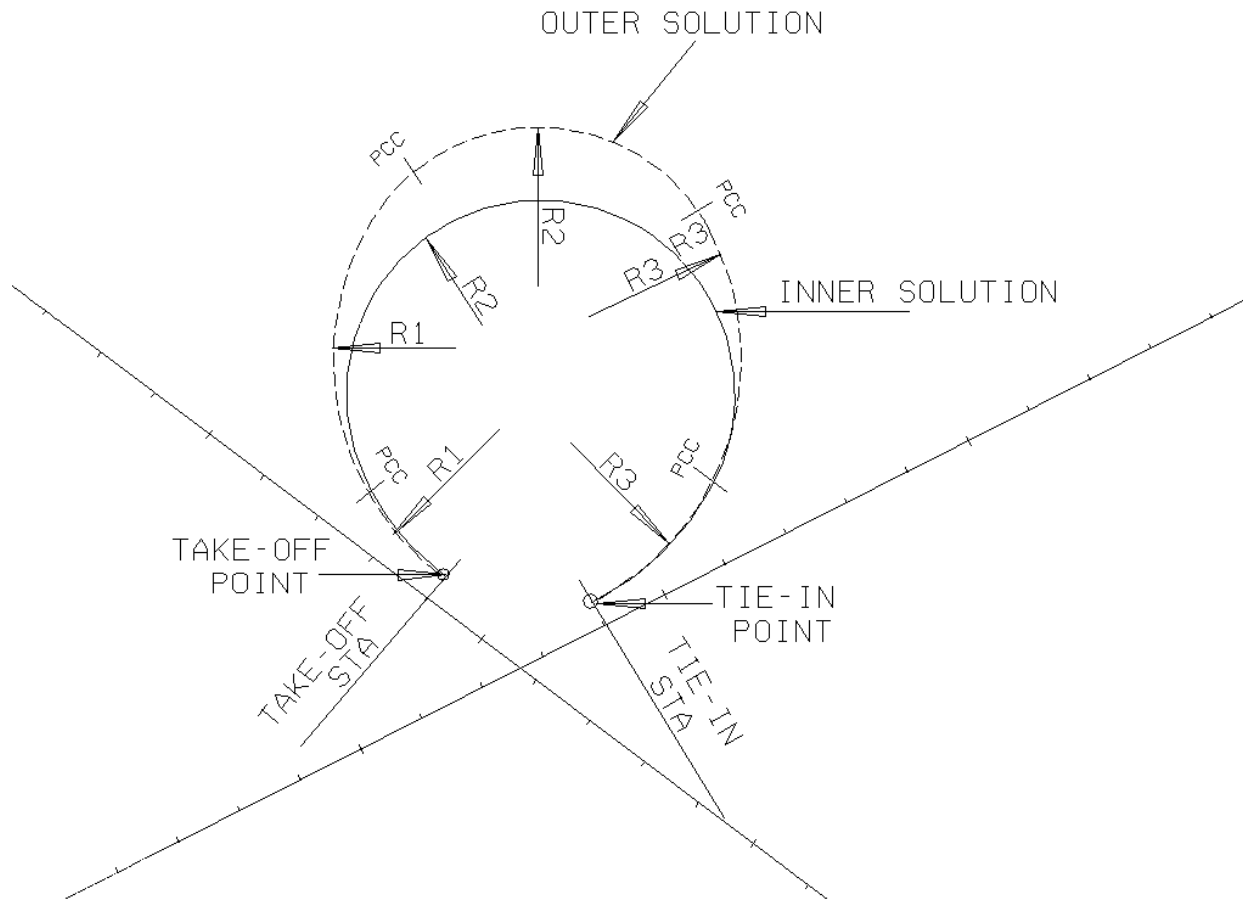


Figure M-3 - Three Center Curve Solution Options

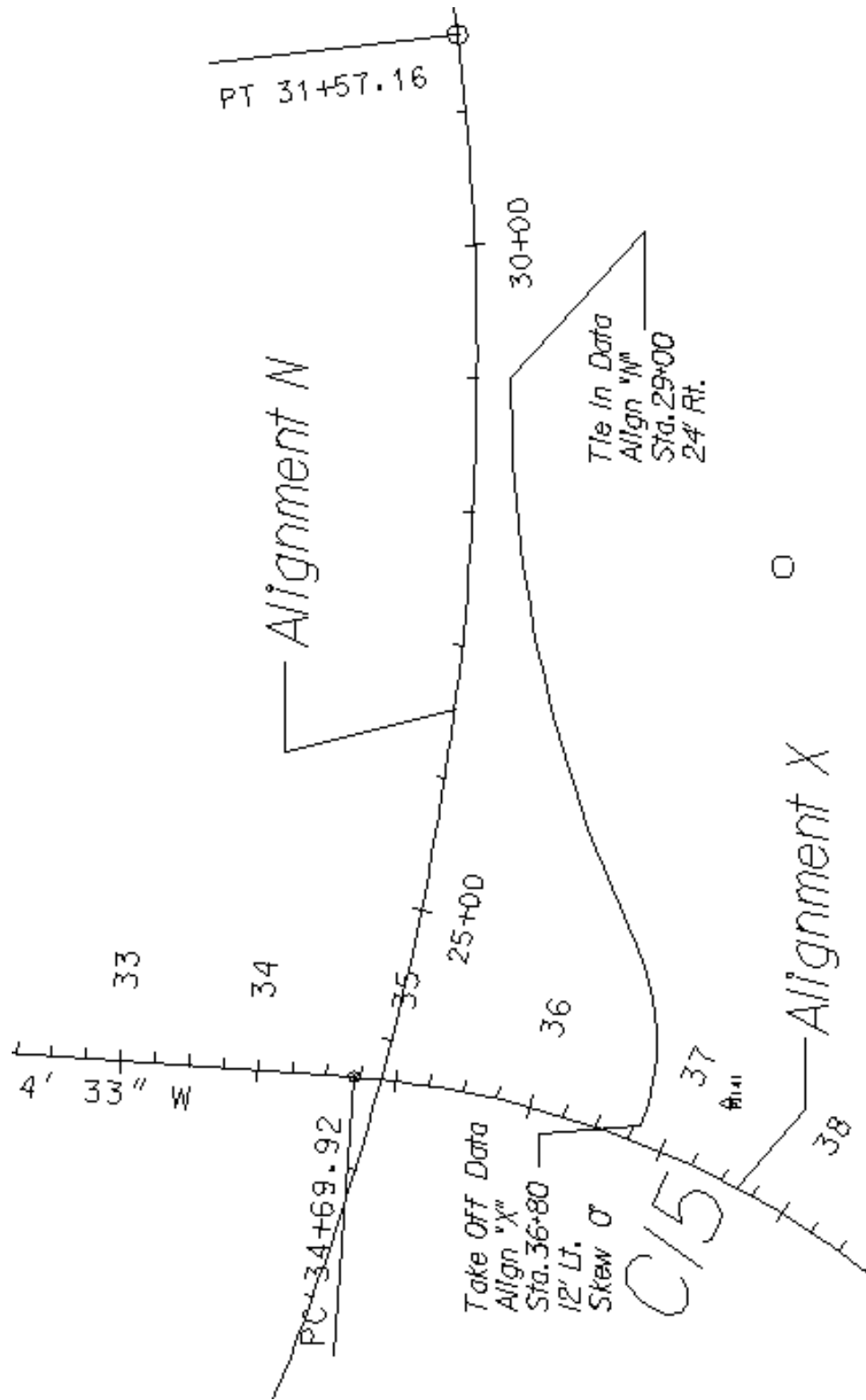


Figure M-4. Reverse Curve Ramp Alignment

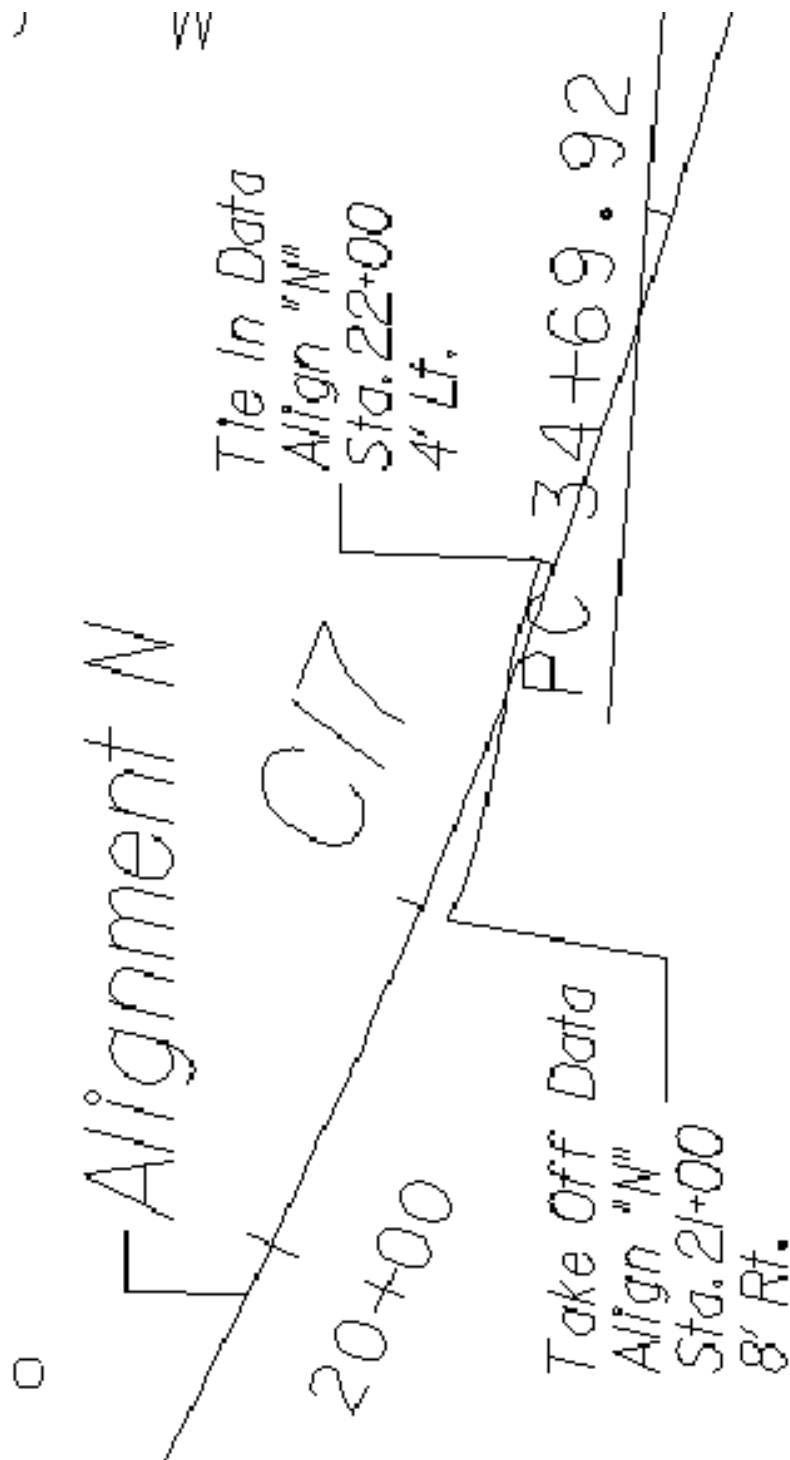


Figure M-5. Reverse Curve Left Turn Lane Transition



### **Radial Offsets Command Capabilities**

The radial offsets command provides a means for quickly designing, displaying and computing the area of a flared area formed by the outside edges of pavement and a turning radius at one of the corners of a cross road intersection. The command begins by requesting the identification of the two roadways where a flared area is to be designed. Next, the quadrant in which the design is to be applied is identified by digitizing any point within that quadrant. Then offset distances locating the pavement edges in that quadrant are entered, followed by the turning radius to be used at that corner.

Upon entry of the final data item, the flared area is displayed on the graphics screen. If the design is not acceptable and needs revision, it can be rejected, whereupon it will be erased and a new set of parameters will be requested. If it is accepted, a closed loop chain will be created for which the area can be computed by the area of shape command. See Figure M-6.

### **Median End Design Command Capabilities**

The median end design command provides a means to quickly define and display one of four possible median end types. The four common types available are:

- Semi-circular - Type 1
- Two-arc taper - Type 2
- Two-arc bullet - Type 3
- Three-arc bullet - Type 4

The command begins by requesting the name of the roadway receiving the median end design. This is followed by a request for the station along the roadway that defines the location of the tip of the nose of the median end. Next, offsets from the roadway that locate the pavement edges, either real or imaginary, adjacent to the median at this location are requested. This is followed by requests for a nose orientation code, a nose type code, taper arc radii and a nose offset, where applicable.

The orientation code of a median end design is specified as either L or R, which reflects its position sense as either a left or right handed design. The correct orientation sense to use depends on the direction of increasing stations. A left oriented end design has its taper arcs beginning at stations less than the station set for its nose, while a right oriented end design has its nose at a lesser station than the termination points of its taper arcs.

The nose type code is the number 1, 2, 3 or 4, corresponding to the type of median end treatment, listed above, that is to be used at the specified location. For all nose types, except number 1, the graphic user interface is extended for the two or three design radii that are required to create the specified median end.

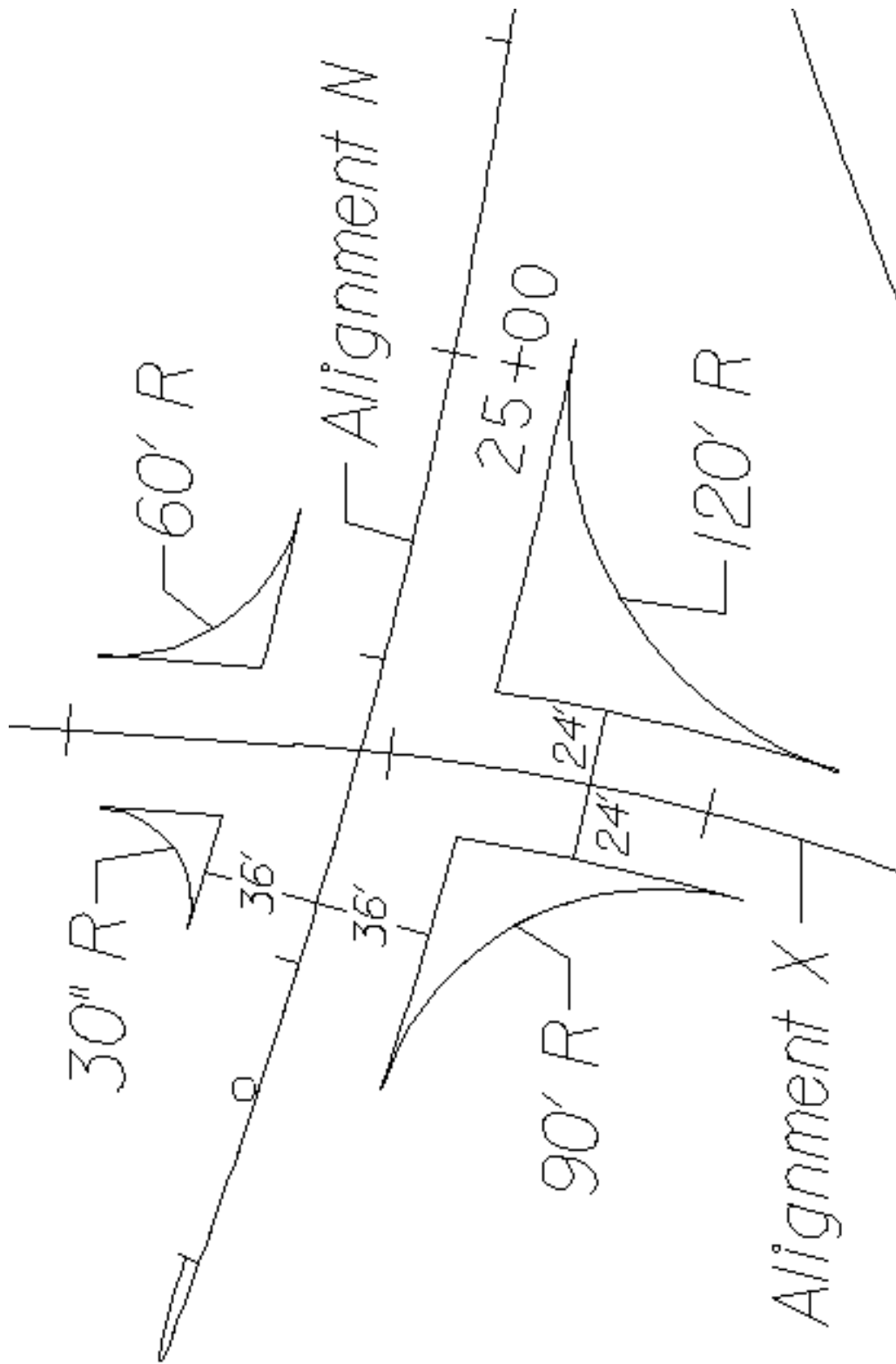


Figure M-6. Radial Offset Command Capabilities

One additional item of information required for median types 2 and 4 is that of an offset distance to the nose, as measured from the referenced roadway.

When data entry is completed, the end design will appear in temporary graphics form at the specified location on the roadway plan displayed on the screen. After visual review, the design must be either accepted or rejected to continue. If it is rejected, the design is erased from the screen, and a new set of design parameters are entered. If the design is accepted, its graphics become part of the roadway design file, and the command is exited. See Figures M-7a and M-7b for examples of median end designs.

### **Alignment Intersection Command Capabilities**

The alignment intersection command computes the coordinates of the point of intersection of two intersecting roadways, the angle of intersection, the station of the intersection on both alignments, and the azimuths of the alignments at the point of intersection. If requested, the command will perform the described action for all such intersections found along any roadway specified to be the mainline roadway by input.

The command begins by requesting the name of the mainline roadway or selecting it with the cursor. It continues with a request for the name of the cross road, or a cursor selection of the cross road, or by selecting the cursor reset button which will cause data for all cross roads found along the specified mainline alignment to be generated.

IGrds puts all generated intersection information in the temporary report file (.tmp). See Figure M-8 for an example of the alignment intersection command capabilities.

### **Right-of-Way Stakeout Command Capabilities**

This command generates staking points along right-of-way chains on one or both sides of a horizontal alignment. IGrds prompts for the station range and staking interval along each of the right-of-way chains. Extra points will be computed at all breaks in the right-of-way chains and at all key points along the horizontal alignment. The output consists of a geometry point at each stake position and a report showing the station and coordinates of the right-of-way stakes.

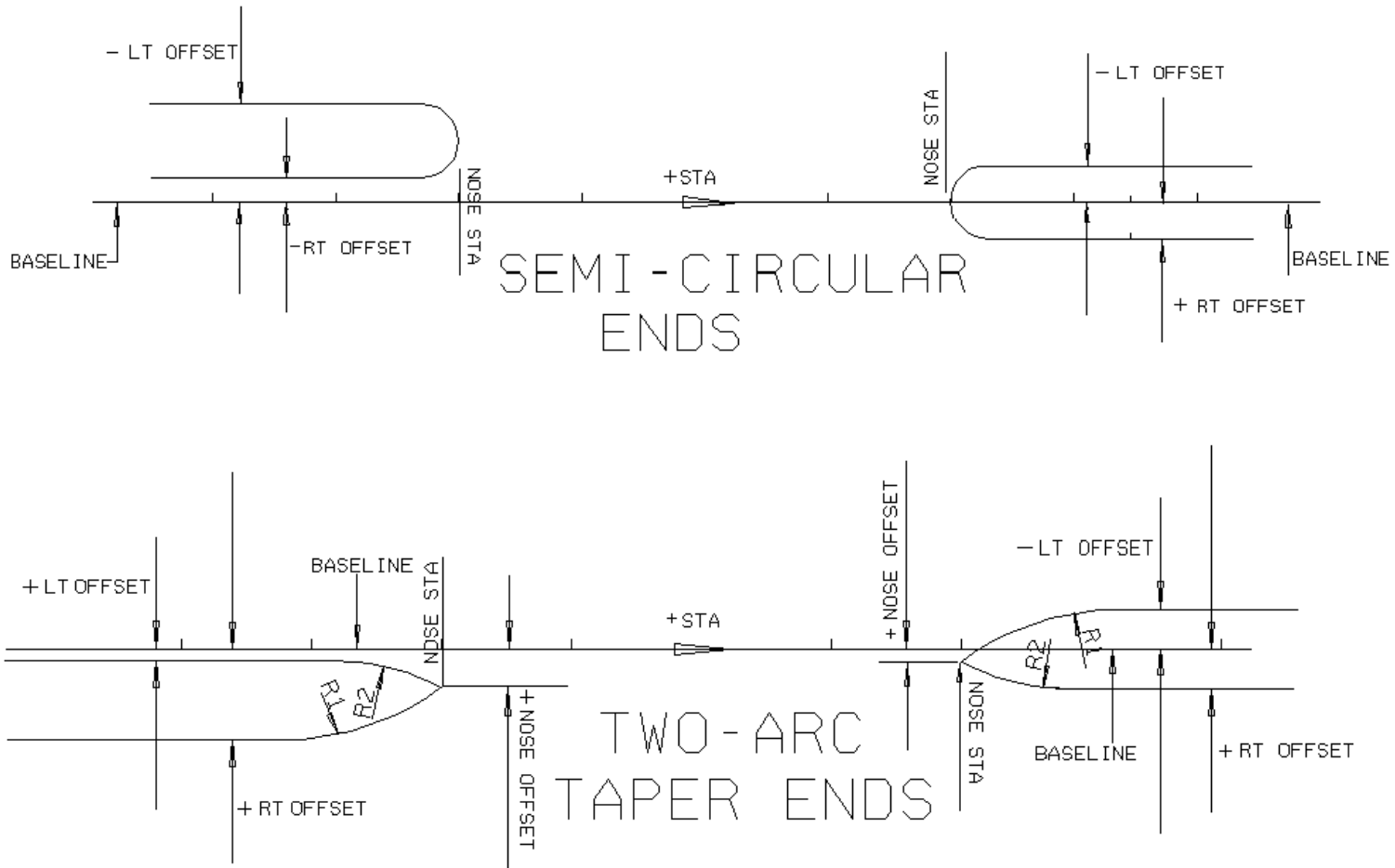


Figure M-7a - Median End Design Parameters

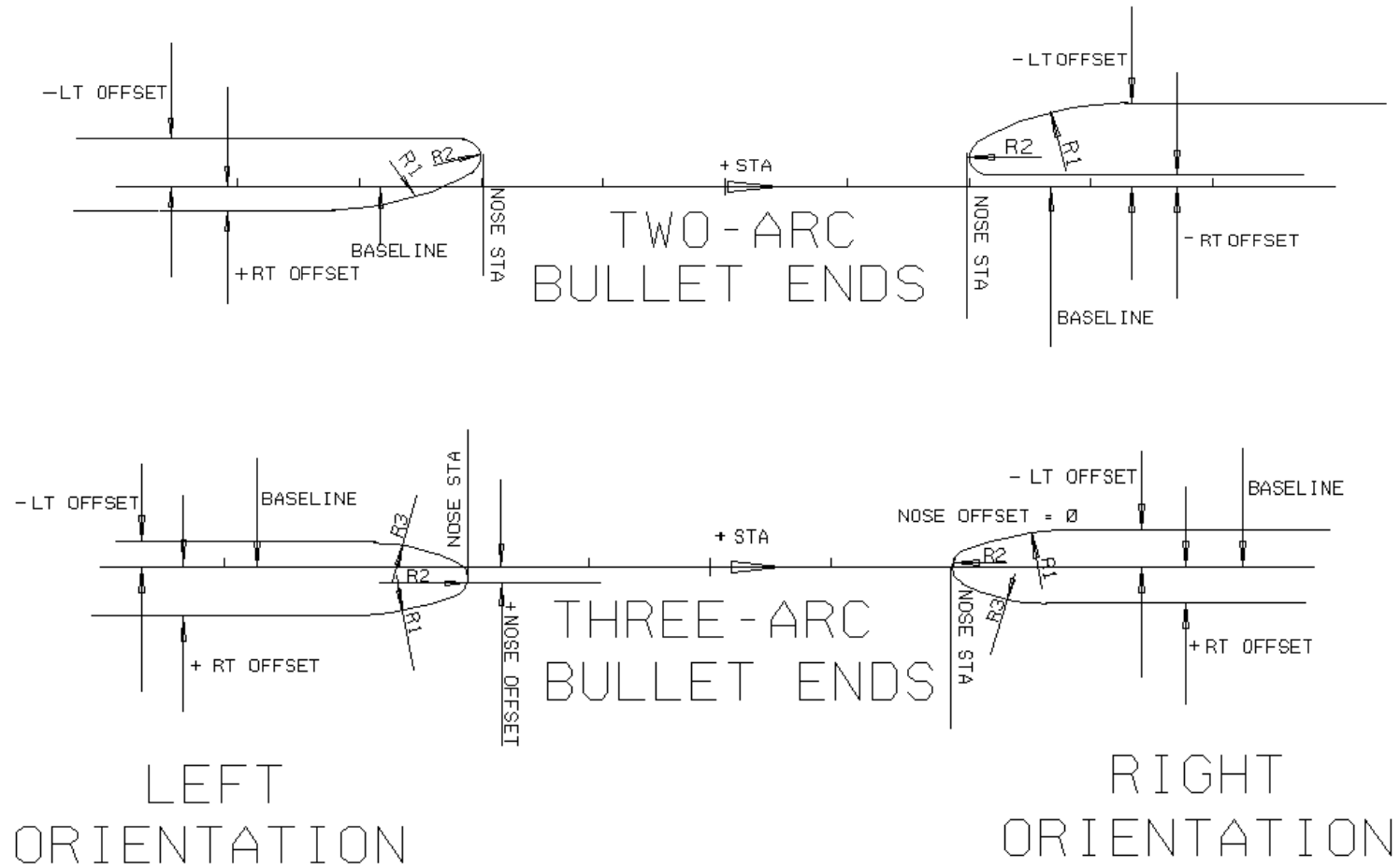


Figure M-7b - Median End Design Parameters

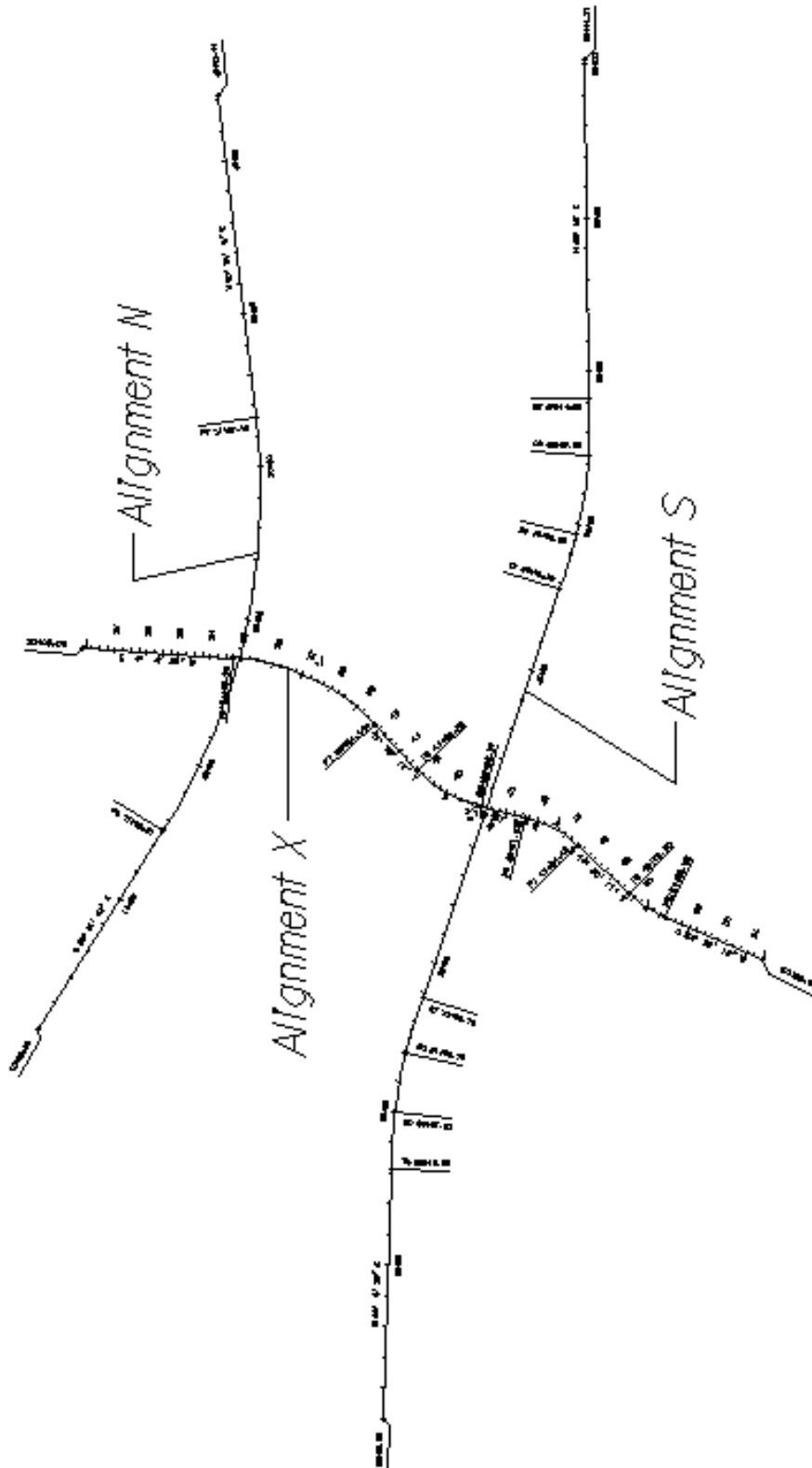


Figure M-8 - Alignment Intersection Command Example