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COLOSSUS Memo #203, Spacecraft Autopilot Development Memo # 28-69

TO: Distribution
FROM: J. F. Turnbull
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SUBJECT: PCR815/V79/R64/PTC - ORBRATE Routine

In response to PCR815, a new routine, R64, has been added to COLOSSUS 2C. This routine enables the crew to perform PTC (X AXIS roll), a restricted form of ORB RATE, and deadband changing without having to do direct erasable loading. The restriction on ORB RATE is that CDUX should be close to 7.25 deg and CDUZ should be close to zero. If these two conditions are met, the Y RCS control axis and the CDUY axis (i.e. inner gimbal axis) will be aligned. Such an alignment is necessary because the ORB RATE option is implemented by incrementing the desired CDUY value every DAP cycle and commanding a corresponding rate about the Y RCS control axis.

R64 will be described as an operational mode in Section 4 of the COLOSSUS 2C GSOP. Briefly the routine is as follows:

> If no other extended verb is active, keying V79E results in flashing V06 N79 display. N79 has three decimal components.
>
> The first component of N79 is rate displayed to .0001 deg/sec. The second component is deadband displayed to .01 deg. The third component is axis code. ±00000 implies X axis (i.e. PTC option), non-zero implies Y axis (i.e. ORB RATE option).
>
> The erasable locations used for N79 are shared locations so data in N79 is not necessarily saved from the previous use of V79. Therefore, in general, it will be necessary to load data using

V25. Once N79 is configured as desired, PROCEEDing on the flashing V06N79 will:

1) change the DAP deadband to that specified by component two of N79;
2) a) if PTC option is selected, generate a commanded rate about the vehicle X axis equal to that specified in component one of N79 and also generate the appropriate increment to be added every DAP cycle to desired CDUX, or
   b) if ORBRATE option is selected, generate a commanded rate about the Y RCS control axis equal to that specified in component one of N79 and also generate the appropriate increment to be added every DAP cycle to desired CDUY; and
3) configure a DAP erasable location such that,
   a) if the PTC option is selected, a roll firing will be forced during the next DAP cycle independent of whether the DAP phase plane point is outside the roll deadzone, or
   b) if the ORB RATE option is selected, a pitch firing will be forced during the next DAP cycle independent of whether the DAP phase plane point is outside the pitch deadzone.

As is the case with all routines and programs involving automatic maneuvering, the maneuvering commands will be communicated to the DAP only if the S/C CONT switch is in CMC and the CMC MODE switch is in AUTO. If such is the case, the physical response to PROCEEDing on V06N79 will be an immediate forced roll or forced pitch firing (depending on the axis option in N79) which will reduce the difference between commanded rate and actual rate by about 80%. Additional firings to further refine the S/C rate will be commanded when the phase plane point eventually leaves the deadzone. If a large deadband has been chosen the time between the initial forced firing and the first additional firing may be very long - perhaps 10 or 20 minutes.

When component one of N79 is zero, the commanded rates and CDU increments generated by PROCEEDing on V06N79 are identically zero. In this situation the effect of doing R64 will be to set the deadband to the value specified in the second component of N79.

Having once executed R64, the mode of operation established by it can be altered in various ways. In Table I the possible actions and their respective effects are presented.

	Zero Commanded Rate	Return to Deadband Specified by Rate 03	Zero DAP Attitude Error
V46E	√	√	√
S/C Control Switch cycled CMC—SCS—CMC	√	√	√
CMC Switch to Hold	√		√
Rotational Hand Controller Activity	√		√
V37E XXE	√	√	
KALCMANU	*		√

* KALCMANU generates new commanded rates.

Operationally, several potential uses of R64 are envisioned.

1) Automatic PTC Initiation.

The availibility of R64 means that direct loading of erasable memory in order to initiate PTC or widen deadband is no longer necessary. Also, the V49 auto maneuver to PTC attitude, which in addition to maneuvering the S/C assured that various erasables were properly configured prior to direct erasable loading, is no longer essential since R64 properly initializes all the necessary erasable locations. Still required, however, is the wait period between maneuvering to PTC attitude and PTC initiation so that residual rates will be damped out before PTC is begun.

The roll forced firing will bring the S/C up to about 80% of the rate specificed in component one of N79. If a wide deadband is used, it will be a long time before the next roll firing occurs. Consequently, it may be desirable procedurally to load a rate in N79 25 to 30 percent higher than the desired PTC rate. The single forced firing then should produce a rate rather close to the actually desired PTC rate. The rest of the PTC checklist (disabling roll jets, etc) can then be executed without waiting for additional firings to bring the S/C up to desired rate.

2. Deadband Changing.

If all zeros are loaded in N79, the effect of executing R64 will be to change the DAP deadband to that specified in component two of N79. R64 does not change the attitude reference, thus if R64 were used to decrease the deadband, an attitude maneuver would result, in general, to get the S/C to within the new decreased deadband of the reference.

Also, the logic involved with R64 will produce one forced firing about either the roll or pitch axis (depending on the axis option in N79) even if the command rate is zero. This forced firing can be inhibited external to the DAP by switching the roll or pitch MANUAL ATTITUDE switch to ACCEL CMD before PROCEEDing on V06N79. The switch can be returned to RATE CMD almost immediately (0.1 sec) after keying PROCEED.

3. Y Axis Rate Drive.

Program COLOSSUS does not have a local vertical tracking routine. As a substitute for such a routine, R64 can be used to drive the S/C at orbital rate. The long term integrated accuracy of the drive at orbital rate is influenced by several factors which are more appropriately discussed with reference to a particular use of R64 for driving at orbital rate. Use of R64 to control a Y axis rate may also be of help elsewhere as for example for landmark tracking during P22.

Verification of R64.

Four all digital simulations using COMANCHE, Rev. 65 were set up and run successfully. One simulation, run by John Laird, used the X axis option with a .15 deg/sec commanded rate and 30 deg deadband. The three other simulations, run by Roy Whittridge, used the Y axis option at 4 deg/sec with a 2 deg deadband, 0.3 deg/sec with a 1 deg deadband and 0.05 deg/sec with a 0.8 deg deadband.

These simulations demonstrated that the axis selection, rate command, deadband changing, and forced firing aspects of R64 all functioned as desired.

In addition, I ran an afternoon of hybrid testing on R64 using COMANCHE Rev. 67. This testing independently verified those aspects already verified in the all digital simulations and in addition verified that the effects of various actions subsequent to R64 is as presented in Table 1.