Precision Telescope Control System

PTCS/SN/7: PTCS Observing Scenarios

Version:	3
Date:	March 26th 2003
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Filename:	PTCSObservingScenarios
GBT Archive:	PR009
GBT File:	PROJECTS
GBT keywords:	PTCS, control, observing

Revision History

Ver.	Changes	Date	Initials
1	Created	3/11/03	KTC
2	Elaborated	3/22/03	RMP
3	Revised after discussions between KTC & RMP	3/26/03	RMP

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Abstract

This document presents a series of observing scenarios to test the functional adequacy of the Precision Telescope Control System (PTCS).design discussed in PTCS/SN/6 and elaborated in GBT drawing D44002K001.

1 Introduction

This document describes a variety of different types of observations which might be performed with the GBT, and in each case specifies in some detail how the Precision Telescope Control System (PTCS) would be configured and the observation executed. The intent is to ensure that the Precision Control System (PCS) design, interfaces and control strategies are capable of executing as many different observing modes as we can anticipate, in a correct, complete and consistent manner. Our hope would then be that the system would be easily adaptable to future observing modes not currently anticipated. The PTCS system design is intended to include control of a tertiary chopper if/when this becomes available. Although this device does not yet exist, it is assumed in some of the following scenarios. So far, only a limited number of scenarios have been elaborated. Some additional proposed test cases are included in Section 6.

As the system design proceeds, we will chose a number of these scenarios to be the standard test cases and continue to elaborate them to ensure that, as detailed design work proceeds, these observations can explicitly be supported.

These scenarios are intended to probe two main classes of observing: standard operation and engineering/commissioning observations. We also illustrate how the system might behave in the presence of various failure conditions.

This document assumes a reasonable familiarity with the contents of PTCS/SN/5 “The High Frequency Observing System” and PTCS/SN/6 “PTCS System Design”.

2 Standard Observing

This section describes the behavior of the PCS during normal operation.

2.1 S1. Double-beamswitching on a point source using the subreflector

This is probably one of the simplest configurations for the PTCS – at the frequencies that require the PTCS, almost all observations will require switching of some form.

The receiver is assumed to have two feed-horns oriented such that they are at the same elevation (although this is not critical to the operation of the PTCS). The receiver has an electronic transfer switch to allow signals from alternate feed-horns to be directed to the “signal” and “reference” bins of the spectrometer. The intention is to track a point source at a specified J2000 position, and to perform an observation that consists of a single scan of five minutes duration. During the scan, the electronic feed-horn switching will be run at a 10Hz rate, and the beams “nodded” so that alternate horns are placed on the source once every 10 seconds. For this scenario, we assume that the tertiary either does not exist, or is not used.

Setup: The High Frequency Observing System (HFOS) will configure the overall system (receiver, IF path, backend, etc) appropriately. The HFOS will configure the backend to be the switching signal master, with a 10Hz switch rate, and enable feed-horn switching in the receiver.

Observing Strategy: The HFOS will configure the observing strategy as follows:

Primary: Adopt Best Fit Parabola; no offset.

Subreflector: Adopt minimum aberration/maximum efficiency strategy based on fiducial feed position (mid-point of the two feeds).

Error Allocation: Error allocation to main drives and subreflector enabled, tertiary disabled.

Commanded Track: The HFOS will generate track segments for main drives, subreflector, tertiary and feed horns as follows:

Main drives: Track: a single track segment of five minutes duration with the position the source position in J2000 co-ordinates, the velocities and accelerations set to zero. Offset: set to zero.

Subreflector: Track (offset from focus-tracking position): set to zero.

Tertiary: Zero offset.

Feed-horns: A sequence of 30 ten-second segments with alternate feeds specified.

Earliest Guaranteed Start Time (EGST): The antenna manager will estimate the time required to slew from the current position to the target position of the source at the time of the end of the slew, and return this to the scan coordinator as the EGST. Note that this calculation will need to include the slew speeds of the subreflector and active surface, to reflect those cases (rare, but not impossible in the case of the active surface) in which they are the limiting factor.

Execution prior to "Running": The Scan-Coordinator will activate all participating devices, with the scan start time as provided by the Antenna Manager. The Antenna Manager will transition to the activating state, and generate a stream of 10Hz (az,el) demands, which will cause the antenna to slew to the source position. The PCS will use these (az,el) demands to position main drives, active surface and subreflector accordingly. Assuming that the main drives have the furthest to travel, the active surface and subreflector will slowly be moving into position throughout the slew. The on-source and aligned flags will normally be TRUE (since the demands to all of the optical elements will be within their achievable range) but data acquisition will not commence since the devices are all still in the activating state. As the antenna gets close to source, the Antenna Manager will transition to the committed state. When the slew is complete, the Antenna Manager will transition to the Running state, and switch from generating slew demands to interpreting the scan segments provided by the HFOS.

Execution During "Running": throughout the five-minute scan, the Antenna Manager will generate (az,el) demands which will cause the antenna to track the source at the sidereal rate. The main drives will receive these as their command positions. The active surface will drive to the desired shape (the best fit parabola) for that elevation. The sub-reflector will receive the "focus-tracking" demand generated from the LUT for this observing strategy as a function of the primary shape and selected feed. The tertiary will receive a zero command input. For the first 10 seconds, Feed 1 will be selected. The Precision Measurement System (PMS) will monitor the positions of all optical elements, and these will be used by the Optical Model to calculate the actual position of the wavefront normal; this will be compared to the demand to generate an error signal. The error triplexor will apportion the wavefront normal error between the main drives and the subreflector. The PCS will use the command and error signals to control the individual servo systems. The PMS will calculate the actual position on the sky of the two feeds, to be written to the file. (The position of the on-source feed should always be close to the source (ra,dec). The position of the off-source feed will vary according to the LST of the observation). If for any reason, the PCS cannot achieve the commanded positions, the on-source and/or aligned flags will be set false, causing the data to be blanked and the antenna positions to be flagged as off-source.

At the end of the first 10 seconds, the demand feed will switch to Feed 2. This will cause the Optical Model to generate a large error signal, corresponding to the azimuth offset between the two feeds. The on-source flag will go false, antenna positions determined during this time will be flagged and data acquisition in the backend will be paused. Both the main drives and sub-reflector will respond to the error signal. For a 10 second switch rate most (all) of this error will be allocated to the subreflector, and it will drive to bring the beam from the second feed on to the specified source position. As the subreflector approaches this position the error will become zero, the on-source flag will become true, antenna positions will be flagged as correct, and data acquisition will continue. This sequence will continue until the five minutes are complete.

Post Scan: The default feed will be selected, and the Antenna Manager will continue to generate (az,el) demands which will cause the antenna to track the source at the sidereal rate. The active surface and subreflector will track the elevation demand accordingly.

2.2 S2. Double-beamswitching on a point source using the tertiary

This scenario is identical to Scenario S1 above, with the exception that we use the tertiary rather than the main antenna to perform the double-beamswitching. We assume that only a single-axis tertiary is available, but that this is aligned so that it can switch the beam between the two feeds as required. In this case, the electronic feed-horn switch rate is set to 1kHz, the tertiary chop rate is set to 10Hz.

Setup: The HFOS will configure the overall system (receiver, IF path, backend, etc) appropriately. The HFOS will configure the backend to be the switching signal master, with a 1kHz switch rate, and enable feed-horn switching in the receiver.

Observing Strategy: The HFOS will configure the observing strategy as follows:

Primary: Adopt Best Fit Parabola; no offset

Subreflector: Adopt minimum aberration/maximum efficiency strategy based on fiducial feed position.

Error Allocation: Error allocation to main drives, sub-reflector and tertiary enabled.

Commanded Track: The HFOS will generate track segments for main drives, subreflector, tertiary and feed horns as follows:

Main drives: Track: a single track segment of five minutes duration with the position the source position in J2000 co-ordinates, the velocities and accelerations set to zero. Offset: set to +/– half the feed separation in azimuth, with a 100ms period.

Subreflector: Track (offset from focus-tracking position): set to zero.

Tertiary: Offset set to zero.

Feed-horns: A virtual position corresponding to the mid-point of the two feeds is selected.

Earliest Guaranteed Start Time: As for scenario S1.

Execution prior to "Running": As for scenario S1.

Execution During "Running": throughout the five-minute scan, the Antenna Manager will generate (az,el) demands which will cause the antenna to track the source at the sidereal rate. The main drives will receive these as their command positions. The active surface will drive to the desired shape (the best fit parabola) for that elevation. The sub-reflector will receive the "focus-tracking" demand generated from the LUT for this observing strategy as a function of the primary shape and selected feed. The tertiary will receive a zero command input. The Antenna Manager will also generate a main drives offset demand which will correspond to offsetting in azimuth between the two feeds at the required rate.

Since the antenna will have slewed to the source position with no additional azimuth offset, the negative azimuth offset generate at the start of running will result in a difference between the estimated wavefront normal position and the total demand. Due to the error allocation strategy, all of this error will appear at the tertiary, and so it will drive such that the beam from the first feed appears on source. After 100ms, the azimuth offset demand will switch sign, the error signal will reverse, and the tertiary will drive to the second feed. At the same time, all of the main drives, subreflector and tertiary will be able to compensate for any additional tracking errors. While the tertiary is slewing between positions, the on-source flag will be set false, data acquisition will be blanked, and reported antenna positions will be flagged.

Post Scan: The default feed will be selected, and the Antenna Manager will continue to generate (az,el) demands which will cause the antenna to track the source at the sidereal rate. The active surface and subreflector will track the elevation demand accordingly.

2.3 S3. Wide field continuum imaging with a focal plane array (on-the-fly augmented by tertiary chopping)

In this scenario, we track a fiducial (J2000) position on the sky with a fiducial feed of the array, and superimpose upon this on-the-fly mapping. To suppress atmosphere contamination on large angular scales, and offer many redundant samples of a given sky pixel, we would like the beams to move as rapidly as feasible across the sky, subject to the constraint that we know the position of the beams at each point in time ("know the position" and "point in time" are clarified below). Generally the OTF requirements tabulated in PTCS/SN/3 pertain: we would like to slew at up to say 10'/sec with a loss of less than 10% or so in the aperture efficiency. One way to achieve this would be to raster the telescope nominal pointing direction at a rate of a few arcminutes per second or more, and concurrently superimpose on this motion an additional, faster raster with the tertiary. This would substantially increase the effective slew rate of the beams on the sky in comparison to that achievable by rastering the primary alone.

The slew of the primary could be fairly conventional e.g. scan along rows in RA, stepping in Dec between rows; and then the converse to average down systematic map artifacts. To avoid the need for rapid accelerations in the main drives, we might choose a more sophisticated strategy such as a spiral scan. The rate and amplitude of the fast raster should be configurable within mechanical limits. Tertiary chop amplitudes of up to a degree or so are desirable but may not be mechanically feasible at reasonable cost; if that is the case, a more limited chop is still very useful, even if the chop is smaller than the array FOV. The speed of the modulation should be up to ~ 1 Hz at the maximum throw of ~ 1 degree. At 1 ms time resolution, the position of a fiducial feed's beam on the sky should be determinable (from logged data) to within the tracking spec (~1.5"). The "acquired" and "not acquired" criterion for wide field imaging is very broad and somewhat arbitrary. Only very loose/low-bandwidth coordination between PTCS and the receiver/backend systems are required, such as that which the scan coordinator already provides.

The 1ms time resolution corresponds to Nyquist sampling the sky (as filtered by the GBT optics) when the telescope is slewing at 40 arcmin/sec, its nominal maximum. This gives roughly one sample every 3 arcseconds, and the 1 ms minimum required integration period is likely to be "wired" into a number of receivers. This is an important mode with fairly modest requirements. It is ok that the observer doesn't get to choose the chop direction, and if the chop direction does not line up with the scan direction.

Setup: The HFOS will configure the overall system (bolometer array, etc) appropriately.

Observing Strategy: The HFOS will configure the observing strategy as follows:

Primary: Adopt Best Fit Parabola; no offset

Subreflector: Adopt minimum aberration/maximum efficiency strategy based on fiducial feed position.

Error Allocation: Error allocation to main drives, sub-reflector and tertiary enabled.

Commanded Track: The HFOS will generate track segments for main drives, subreflector, tertiary and feed horns as follows:

Main drives: Track: a series of track segments which cover the area to be mapped, with a typical velocity of 10 arcmin/sec. As noted, this might be a series of raster rows, or a spiral pattern. Offset: the offset will be used to superpose the rapid modulation (which will be performed by the tertiary); it will therefore be specified as a saw-tooth in azimuth, with the amplitude corresponding to the maximum throw of the tertiary, and the period corresponding to the maximum "chop" frequency for that throw.

Subreflector: Track (offset from focus-tracking position): set to zero.

Tertiary: Offset set to zero.

Feed-horns: A virtual position corresponding to the mid-point of the bolometer array is selected.

Earliest Guaranteed Start Time: As for scenario S1.

Execution prior to "Running": As for scenario S1.

Execution During "Running": Throughout the scan, the Antenna Manager will generate (az,el) demands, which will cause the antenna to raster along the specified track, at the specified rate. The main drives will receive these as their command positions. The active surface will drive to the desired shape (the best fit parabola) for the (varying) elevation. The subreflector will receive the "focus-tracking" demand generated from the LUT for this observing strategy as a function of the primary shape and selected feed. The tertiary will receive a zero command input. The Antenna Manager will also generate (az,el) offset demands, which will correspond to performing the saw-tooth in azimuth at the maximum rate supported by the tertiary.

The commanded wavefront normal will be rapidly varying. Since the optical elements will not respond instantaneously, there will be a difference between the command and actual wavefront normal calculated by the Optical Model. The resulting error will be distributed by the error triplexor such that the main drives receive the low frequency components (and execute the large scanning pattern) and the tertiary the high frequency components (and executes the saw-tooth raster). The secondary will receive uncompensated errors in the intermediate frequency regime, and attempt to correct these.

Post Scan: The default feed will be selected, and the Antenna Manager will continue to generate (az,el) demands which will cause the antenna to track the source at the sidereal rate. The active surface and subreflector will track the elevation demand accordingly.

3 Engineering Scenarios

3.1 E1. Checking sub-reflector collimation values

The intent of this scenario is to deliberately drive the sub-reflector through a range of travel in one of the collimation directions (say cross-elevation for example), and measure signal strength as a function of subreflector position, to ensure that the PTCS is correctly commanding the subreflector to the nominal position for normal observing. The idea is that the PTCS will use the main drives to compensate for the deviation of the wavefront normal caused by offsetting the subreflector positions. The correctness of this operation could be checked by driving the subreflector to a single offset position, and then performing a separate "peak" observation. Since the PTCS will be used for high-frequency operation, electronic feed-horn switching should be performed during the scan. This scenario assumes the tertiary is not available.

Setup: The HFOS will configure the overall system (receiver, IF path, backend, etc) appropriately. The HFOS will configure the backend to be the switching signal master, with a 10Hz switch rate, and enable feed-horn switching in the receiver.

Observing Strategy: The HFOS will configure the observing strategy as follows:

Primary: Adopt Best Fit Parabola; no offset

Subreflector position: Adopt minimum aberration/maximum efficiency strategy

Error Allocation: Error allocation to main drives enabled, subreflector and tertiary disabled.

Commanded Track: The HFOS will generate scan segments for main drives, subreflector, tertiary and feed horns as follows:

Main drives: Track: a single track segment of one minute duration with the position the source position in J2000 co-ordinates, the velocities and accelerations set to zero. Offset: set to zero.

Subreflector: A single track segment with the initial position set to –30mm, velocity set to +60mm/min, and acceleration set to zero. Note that these are with respect to the nominal focus-tracking position.

Tertiary: N/A.

Feed-horns: The default feed will be selected.

Earliest Guaranteed Start Time: The antenna manager will estimate the time required to slew from the current position to the target position of the source at the time of the end of the slew, and return this to the scan coordinator as the EGST. Note that this in this case the time required to get the subreflector into position is explicitly required; it is quite likely that the main drives will already be tracking the source position at this time.

Execution prior to "Running": The Scan-Coordinator will activate all participating devices, with the scan start time as provided by the Antenna Manager. The Antenna Manager will transition to the activating state, and generate a stream of 10Hz (az,el) demands that will cause the antenna to slew to the source position. The PCS will use these (az,el) demands to position main drives, active surface and subreflector accordingly. The Antenna Manager will also be generating a stream of subreflector offsets, which will cause the subreflector to ramp up to the desired start position, moving with the desired velocity, at the EGST. Since the subreflector will be displaced from its nominal position, the Optical Model will determine a wavefront normal which is different from that commanded to the main drives. This will result in an error signal being generated, and allocated to the main drives, which will cause the beam to remain on source even as the subreflector collimation is changed. The on-source and aligned flags will normally be TRUE (since the demands to all of the optical elements will be within their achievable range) but data acquisition will not commence since the devices are all still in the activating state. As the antenna/subreflector get close to position, the Antenna Manager will transition to the committed state. When the slew is complete, the Antenna Manager will transition to the Running state, and switch from generating slew demands to interpreting the scan segments provided by the HFOS.

Execution During "Running": Throughout the one minute scan, the Antenna Manager will generate (az,el) demands, which will cause the antenna to track the source at the sidereal rate. The main drives and active surface will receive these as their command positions. The subreflector will receive the "focus-tracking" demand generated from the LUT for this observing strategy as a function of the primary and feed positions. In addition, the Antenna Manager will generate subreflector offset demands which will cause the subreflector to move from –30mm to +30mm about the focus-tracking position. These will be added to the command used to control the subreflector servos.

The PMS will monitor the positions of all optical elements, and these will be used by the Optical Model to calculate the actual position of the wavefront normal. The error triplexor will apportion all of the wavefront normal error to the main drives, since wave-front normal errors to the subreflector are disabled. The PCS will use the command and error signals to control the individual servo systems. If for any reason, the PCS cannot achieve the commanded positions, the on-source and/or aligned flags will be set false, causing the data to be blanked and the antenna positions to be flagged.

Post Scan: The default feed will be selected, and the Antenna Manager will continue to generate (az,el) demands which will cause the antenna to track the source at the sidereal rate. The active surface and subreflector will track the elevation demand accordingly.

3.2 E2. Fixed primary-subreflector position for baseline observations.

The intent of this scenario is to perform a series off "Off-On" observations with the distance from the inner vertex of the primary to the inner edge of the subreflector held at a constant value throughout the observation. This is an example of when the more sophisticated control strategies of the PTCS might be used in a low-frequency observing application; in this case the L-band receiver is assumed.

Setup: The HFOS will configure the overall system (receiver, IF path, backend, etc) appropriately. The HFOS will configure the backend to be the switching signal master, and "total power with cal" switching is enabled. Each "On" and "Off" will be performed as a separate scan. The majority of the PTCS set-up will be performed by the standard mechanism, but the default strategy for subreflector control will be overridden.

Observing Strategy: The HFOS will configure the observing strategy as follows:

Primary: Adopt Best Fit Parabola; no offset

Subreflector position: Since the BFP as a function of elevation for the active surface is known in advance, we can generate and supply a look-up table for subreflector position/orientation as a function of elevation which will cause it to maintain a single fixed distance from the vertex of the primary over all elevations. However, since the focal length of the BFP will change as a function of elevation, this would not be optimal. The subreflector position could therefore be adjusted by performing in advance a radial focus check at the source elevation, determining the best offset from the (non-standard) focus-tracking position, and supply this as an offset for the current observation. This offset would remain in effect for both the "On" and the "Off" scans.

Error Allocation: Error allocation to main drives enabled, subreflector disabled, tertiary enabled.

Commanded Track: The HFOS will generate scan segments for main drives, subreflector, tertiary and feed horns for the first scan as follows:

Main drives: Track: a single track segment of five minute duration with the position the source position in J2000 co-ordinates, the velocities and accelerations set to zero. Offset: set to zero.

Subreflector: Track (offset from focus-tracking position): set to a predetermined offset from the focus-tracking position.

Tertiary: Offset set to zero.

Feed-horns: The default (only) feed will be selected.

Earliest Guaranteed Start Time: The antenna manager will estimate the time required to slew from the current position to the target position of the source at the time of the end of the slew, and return this to the scan coordinator as the EGST.

Execution prior to "Running": The Scan-Coordinator will activate all participating devices, with the scan start time as provided by the Antenna Manager. The Antenna Manager will transition to the activating state, and generate a stream of 10Hz (az,el) demands, which will cause the antenna to slew to the source position. The PCS will use these (az,el) demands to position main drives, active surface and sub-reflector accordingly. The on-source and aligned flags will normally be TRUE (since the demands to all of the optical elements will be within their achievable range) but data acquisition will not commence since the devices are all still in the activating state. As the antenna/subreflector get close to position, the Antenna Manager will transition to the committed state. When the slew is complete, the Antenna Manager will transition to the Running state, and switch from generating slew demands to interpreting the scan segments provided by the HFOS.

Execution During "Running": Throughout the five minute scan, the Antenna Manager will generate (az,el) demands that will cause the antenna to track the source at the sidereal rate. The main drives and active surface will receive these as their command positions. The subreflector will receive the "focus-tracking" demand generated from the LUT for this observing strategy as a function of the command levation, plus the offset. This will result in the subreflector tracking the slowly varying BFP and the gravitational distortion of the feed-arm so that the primary-subreflector distance will remain constant.

The PMS will monitor the positions of all optical elements, and these will be used by the Optical Model to calculate the actual position of the wavefront normal. The error triplexor will apportion the wavefront normal error between the main drives and the tertiary.

Post Scan: The HFOS will calculate a new scan segment for the main drives which will cause the antenna to slew to the "Off" position. The "Off" scan will then be performed as for the "On" scan. At the end of the second scan, the Antenna Manager will continue to generate (az,el) demands which will cause the antenna to track the source at the sidereal rate. The subreflector will continue to track according to the "fixed-distance" strategy until the default LUT is re-loaded when the HFOS is re-configured for "standard" operation.

4 Failure-Mode Scenarios

4.1 F1. Subreflector disabled

This scenario covers attempting to perform any sort of observing with the subreflector in a fixed (link encoder) position. This would be for the case of when the subreflector was broken, or had been turned off, say to investigate it's RFI contribution.

In this case, control of the subreflector, and allocation of error signals to the subreflector would be disabled. The PMS would continue to monitor the position of the subreflector, and so the Optical Model would generate the actual position of the wave-front normal resulting from the fixed subreflector position, and this error would be removed via the main drives. The PTCS would report achieved efficiency values, etc, which would include the fact that the subreflector was not in its optimal position.

In the case of a broken subreflector, this would most likely be parked at the "stow" position. In the case of investigating RFI conditions, the observer could first drive the subreflector to the correct position (by asking the HFOS to slew to source using the default observing strategy) and then disable the subreflector in that position. A more sophisticated strategy would be to estimate the elevation of the mid-point of the observation, drive the antenna to this position, disable the subreflector at that point, and then perform the observation.

5 List of Acronyms

EGST	Earliest Guaranteed Start Time
HFOS	High Frequency Observing System
PCS	Precision Control System
PMS	Precision Measurement System
PTCS	Precision Telescope Control System

6 Additional Scenarios

The following scenarios have been suggested for further elaboration; as the project proceeds, we will continue to explore either these or other, more informative cases.

6.1 Contributed by Brian Mason

Narrow Field Continuum Imaging with a Focal Plane Array

Track a fiducial point on the sky [(ra,dec) --> az(t),el(t)] with a fiducial feed of the array. Concurrently superpose on this motion a chop. The rate and throw (amplitude) of the chop should be configurable within mechanical limits. For the Penn Array, an amplitude of 1' end-to-end is sufficient; for envisaged larger arrays, >6' would be required. A chop rate of ~10 Hz is desirable to cancel atmospheric noise effectively, thus, it takes 0.1 sec to complete a dwell on the ON (src) position, a dwell on the REFERENCE position, and the two implied slews in between. A duty cycle [(dwell_on +dwell_off)/0.1 sec] of 50% or greater is desired. A "dwell" is subject to the same pointing requirements as a point source observation, i.e. Jim Condon's tracking spec of ~1.5". It should be possible to reconstruct from the recorded data when the fiducial beam had the ON position acquired, when it had the REFERENCE position acquired, and when no well-defined position was acquired. For a single-axis chopper the observer does not get to specify the REFERENCE coordinates as such (beyond specifying the chop parameters, and perhaps influencing the LST of the observation). It should then be possible in this case to infer the celestial coordinates of the REFERENCE position for any time that the REFERENCE position was acquired. This inference is subject to the usual tracking spec.

Not more than 10% of the on-source integration time should be lost as "not acquired" due to lack of coordination between the receiver/backend integrations and the chop. This can be achieved by making the backend integrations <= t_dwell/10. 0% loss can be achieved by coordinating the chop with the backend by some mechanism so that the backend is beginning a new integration each time the telescope acquires the ON or REFERENCE positions.

Continuum Point Source Observation with Double Beamswitching via the Tertiary

Similar to Scenario O2. In this case, however, we are measuring switched continuum flux as a function of, say, x-axis subreflector displacement to get a focus curve (really a slice of the focus surface). For continuum measurements a chop of 1-3 Hz is sufficient if you are already electronically beamswitching. The specifications of case O2 apply, but should also hold at a series of x-axis SR displacements. Ideally you would not need to do anything special such as recalculate or reload look-up tables. Is the behavior in this case the same as the behavior during double-beamswitch observation where we move the SR or Primary instead of the tertiary? The same requirements hold in that case, although the switching rate will have to be significantly lower.

Tertiary freezes up in the middle of an observation

The control system should not try to do bad things with the rest of the telescope. An alarm condition should be generated, and some record of the alarm condition should appear in the data.

6.2 Contributed by Dana Balser

On-the-fly Maps

One common observing mode at high frequencies is to map a region on the sky by driving the telescope in a raster mode while constantly taking data. In general the sampling will not be uniform. The goal is to move fast to cover the region quickly. Sensitivity is built up by adding together many maps of the same region. In most cases it will only be important to know where the telescope was pointing after the observation.

How does the control system handle this type of observing? In particular, what happens at the edges of the map? One could imagine small maps that are within the capabilities of the sub-reflector motion and larger maps which require the main drives. So if the user specifies a region to be mapped and a desired rate how will the control system respond? I suspect the current M&C implementation will produce a commanded track that the main drives can accommodate.

It has been argued that dithering the beam at the higher frequencies while mapping can be a good thing. Presumably once could achieve this by disabling the sub-reflector module which is compensating for feed-arm motion. We would still want to be in focus, however. There are probably several ways to achieve this effect but would this method pose any problems for the control system?

Defocused Beam Maps

Perform a raster map centered towards a calibration source while offsetting the focus from the nominal value by some specified amount, while maintaining the pointing. These are the out of focus beam maps ala Richard Hills.

High Frequency Observing with Metrology Problems

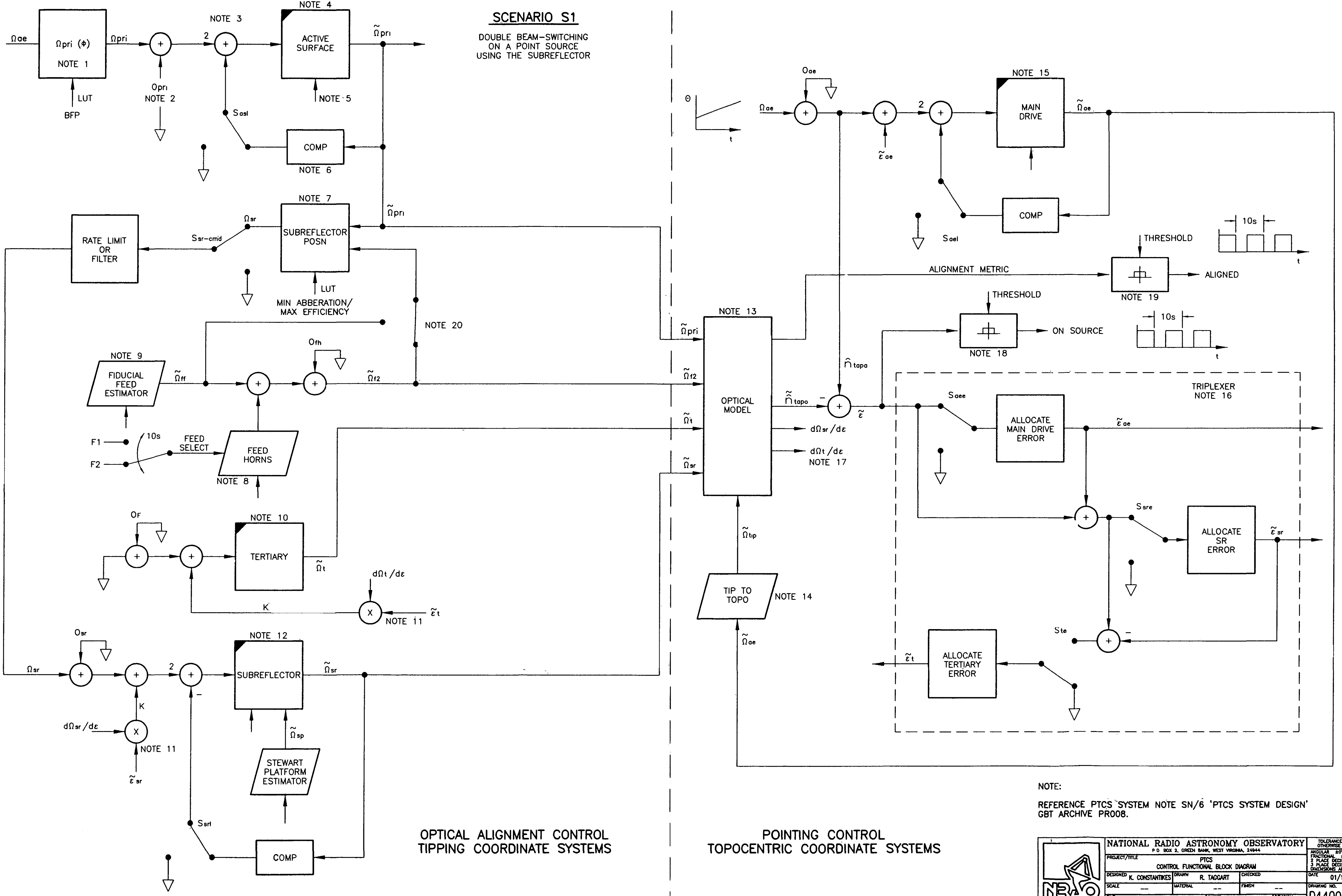
While performing a high frequency observing program some of the metrology information is corrupted. For example, let's say that the quadrant detector fails for some reason. How does the control system respond? How does the telescope performance degrade with time?

7 Figures

1. PCS functional block diagram marked up to indicate the behavior for scenario S1.
2. PCS functional block diagram marked up to indicate the behavior for scenario S2.
3. PCS functional block diagram marked up to indicate the behavior for scenario S3.
4. PCS functional block diagram marked up to indicate the behavior for scenario E1.
5. PCS functional block diagram marked up to indicate the behavior for scenario E2.

SCENARIO S1

DOUBLE BEAM-SWITCHING
ON A POINT SOURCE
USING THE SUBREFLECTOR



NOTE:

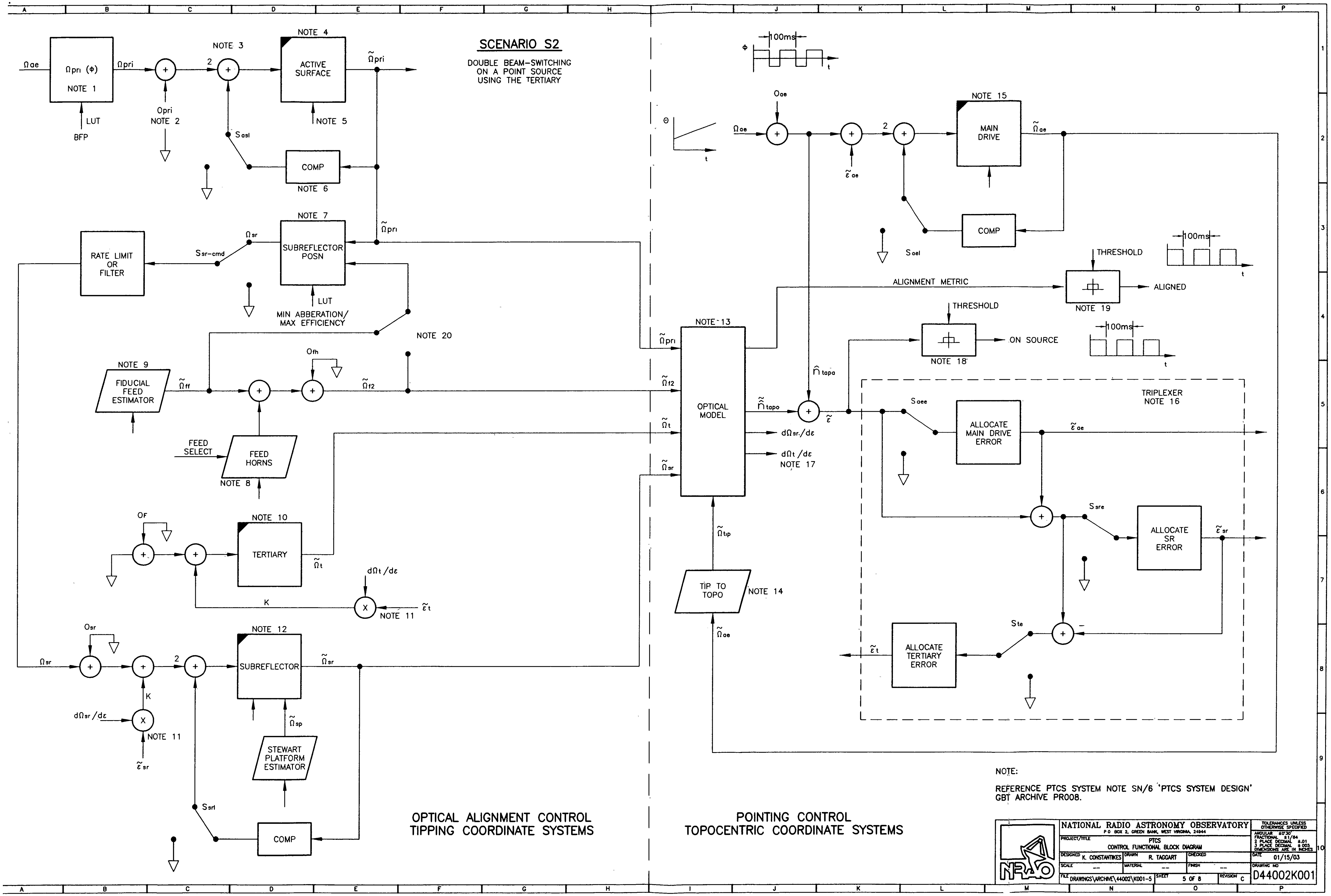
REFERENCE PTCS SYSTEM NOTE SN/6 'PTCS SYSTEM DESIGN'
GBT ARCHIVE PR008.

NATIONAL RADIO ASTRONOMY OBSERVATORY
P O BOX 2, GREEN BANK, WEST VIRGINIA, 24944

PROJECT/TITLE
PTCS
CONTROL FUNCTIONAL BLOCK DIAGRAM

DESIGNED K. CONSTANTIKES	DRAWN R. TAGGART	CHECKED	DATE 01/15/03
SCALE --	MATERIAL --	FINISH --	DRAWING NO.
FILE DRAWINGS\ARCHIVE\44002\K001-4	SHEET 4 OF 8	REVISION C	D44002K001

TOLERANCES UNLESS OTHERWISE SPECIFIED
ANGULAR ±0°30'
FRACTIONAL ±1/64
2 PLACE DECIMAL ±.01
3 PLACE DECIMAL ±.005
DIMENSIONS ARE IN INCHES



SCENARIO S2

DOUBLE BEAM-SWITCHING
ON A POINT SOURCE
USING THE TERTIARY

OPTICAL ALIGNMENT CONTROL
TIPPING COORDINATE SYSTEMS

POINTING CONTROL
TOPOCENTRIC COORDINATE SYSTEMS

NOTE:

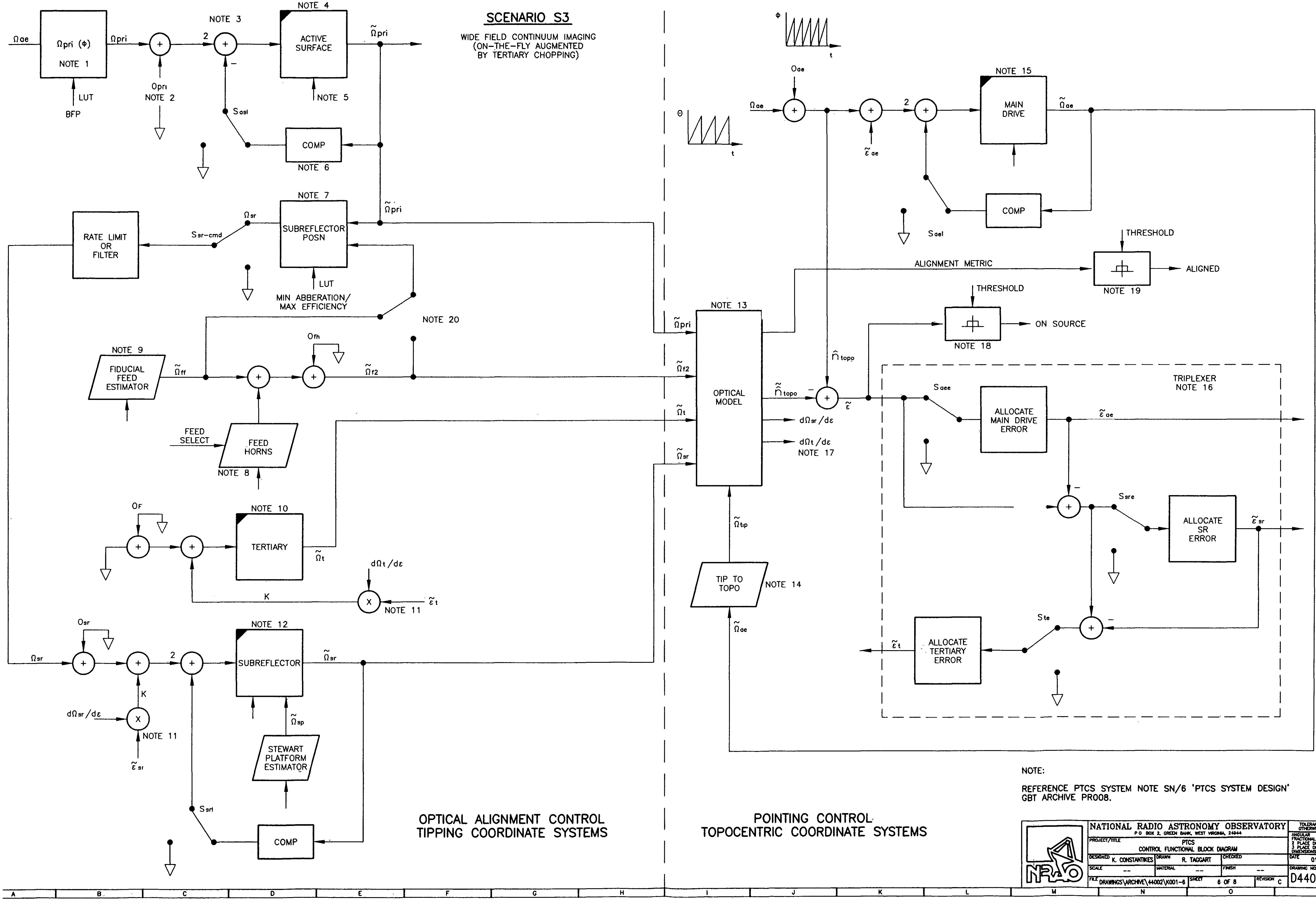
REFERENCE PTCS SYSTEM NOTE SN/6 'PTCS SYSTEM DESIGN'
GBT ARCHIVE PR008.

NATIONAL RADIO ASTRONOMY OBSERVATORY
P O BOX 2, GREEN BANK, WEST VIRGINIA, 24944

PROJECT/TITLE PTCS CONTROL FUNCTIONAL BLOCK DIAGRAM			TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR ±0°30' FRACTIONAL ±1/64 2 PLACE DECIMAL ±.01 3 PLACE DECIMAL ±.005 DIMENSIONS ARE IN INCHES
DESIGNED K. CONSTANTIKES	DRAWN R. TAGGART	CHECKED	DATE 01/15/03
SCALE --	MATERIAL --	FINISH --	DRAWING NO
FILE DRAWINGS\ARCHIVE\44002\K001-5	SHEET 5 OF 8	REVISION C	D44002K001

SCENARIO S3

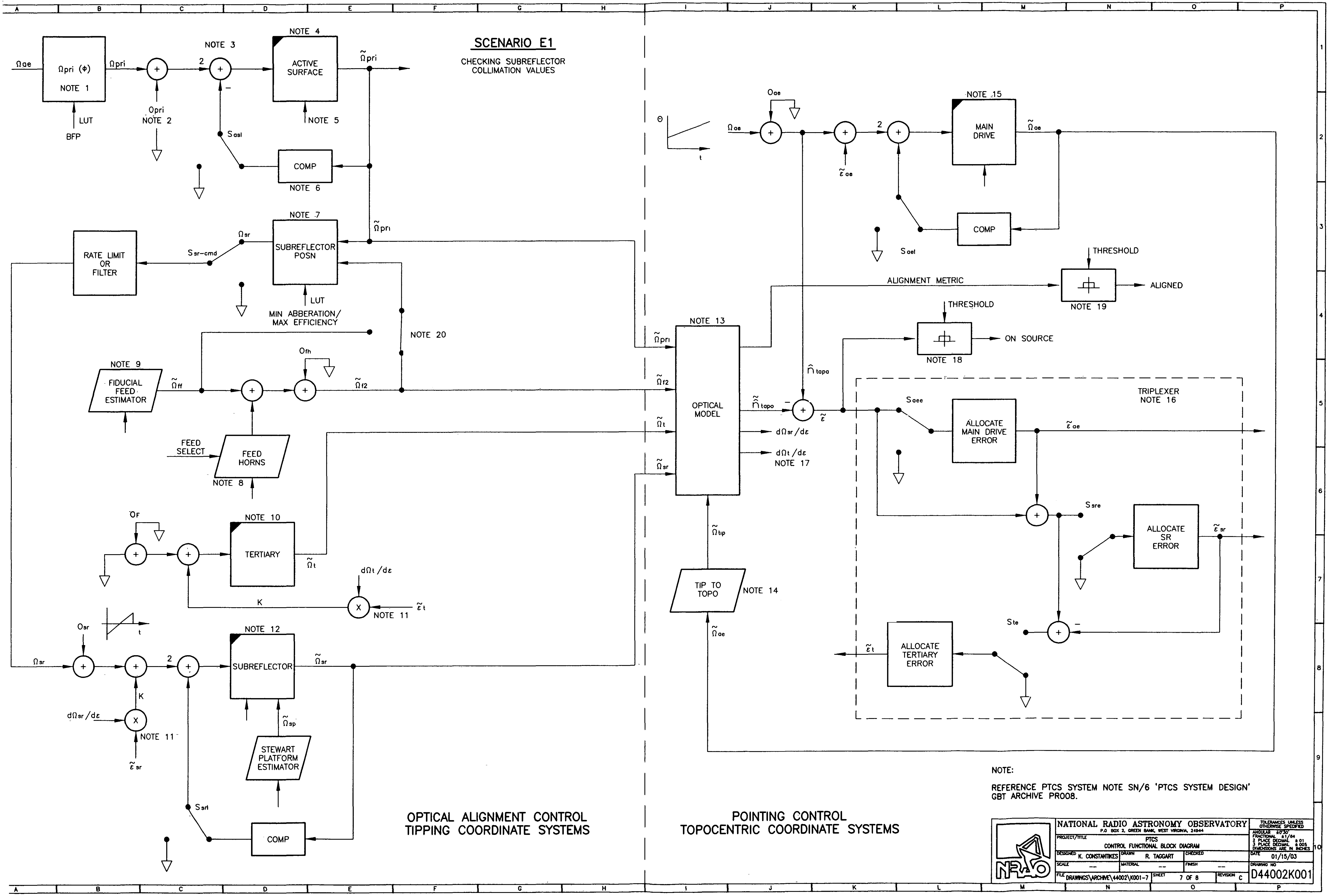
WIDE FIELD CONTINUUM IMAGING
(ON–THE–FLY AUGMENTED
BY TERTIARY CHOPPING)



NOTE:

REFERENCE PTCS SYSTEM NOTE SN/6 'PTCS SYSTEM DESIGN'
GBT ARCHIVE PR008.

NATIONAL RADIO ASTRONOMY OBSERVATORY P O BOX 2, GREEN BANK, WEST VIRGINIA, 24944			TOLERANCES UNLESS OTHERWISE SPECIFIED
PROJECT/TITLE PTCS CONTROL FUNCTIONAL BLOCK DIAGRAM			ANGULAR ±0°30' FRACTIONAL ±1/64 2 PLACE DECIMAL ±.01 3 PLACE DECIMAL ±.005 DIMENSIONS ARE IN INCHES
DESIGNED K. CONSTANTIKES	DRAWN R. TAGGART	CHECKED	DATE 01/15/03
SCALE --	MATERIAL --	FINISH --	DRAWING NO
FILE DRAWINGS\ARCHIVE\44002\K001-6	SHEET 6 OF 8	REVISION C	D44002K001

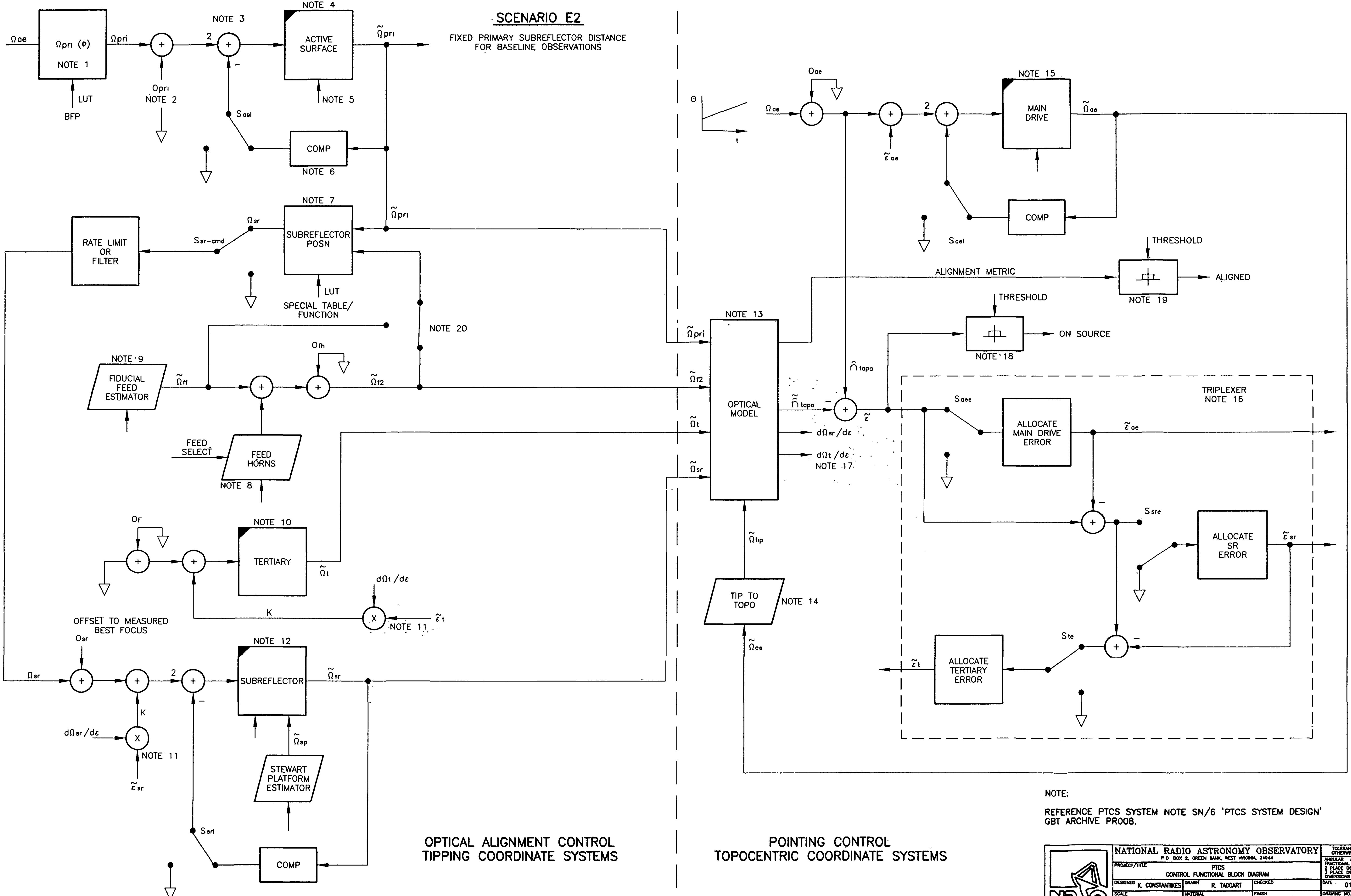


NOTE:

REFERENCE PTCS SYSTEM NOTE SN/6 'PTCS SYSTEM DESIGN' GBT ARCHIVE PR008.

NATIONAL RADIO ASTRONOMY OBSERVATORY
P.O BOX 2, GREEN BANK, WEST VIRGINIA, 24944

PROJECT/TITLE	PTCS CONTROL FUNCTIONAL BLOCK DIAGRAM			TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR ±0°30' FRACTIONAL ±1/64 2 PLACE DECIMAL ±.01 3 PLACE DECIMAL ±.005 DIMENSIONS ARE IN INCHES
DESIGNED K. CONSTANTIKES	DRAWN R. TAGGART	CHECKED		DATE 01/15/03
SCALE --	MATERIAL --	FINISH --		DRAWING NO
FILE DRAWINGS\ARCHIVE\44002\K001-7	SHEET 7 OF 8	REVISION C		D44002K001



SCENARIO E2

FIXED PRIMARY SUBREFLECTOR DISTANCE FOR BASELINE OBSERVATIONS

OPTICAL ALIGNMENT CONTROL
TIPPING COORDINATE SYSTEMS

POINTING CONTROL
TOPOCENTRIC COORDINATE SYSTEMS

NOTE:

REFERENCE PTCS SYSTEM NOTE SN/6 'PTCS SYSTEM DESIGN' GBT ARCHIVE PR008.

NATIONAL RADIO ASTRONOMY OBSERVATORY
P O BOX 2, GREEN BANK, WEST VIRGINIA, 24944

PROJECT/TITLE	PTCS CONTROL FUNCTIONAL BLOCK DIAGRAM		TOLERANCES UNLESS OTHERWISE SPECIFIED ANGULAR ±0°30' FRACTIONAL ±1/64 2 PLACE DECIMAL ±.01 3 PLACE DECIMAL ±.005 DIMENSIONS ARE IN INCHES
DESIGNED K. CONSTANTIKES	DRAWN R. TAGGART	CHECKED	DATE 01/15/03
SCALE --	MATERIAL --	FINISH --	DRAWING NO.
FILE DRAWINGS\ARCHIVE\44002\K001-8	SHEET 8 OF 8	REVISION C	D44002K001