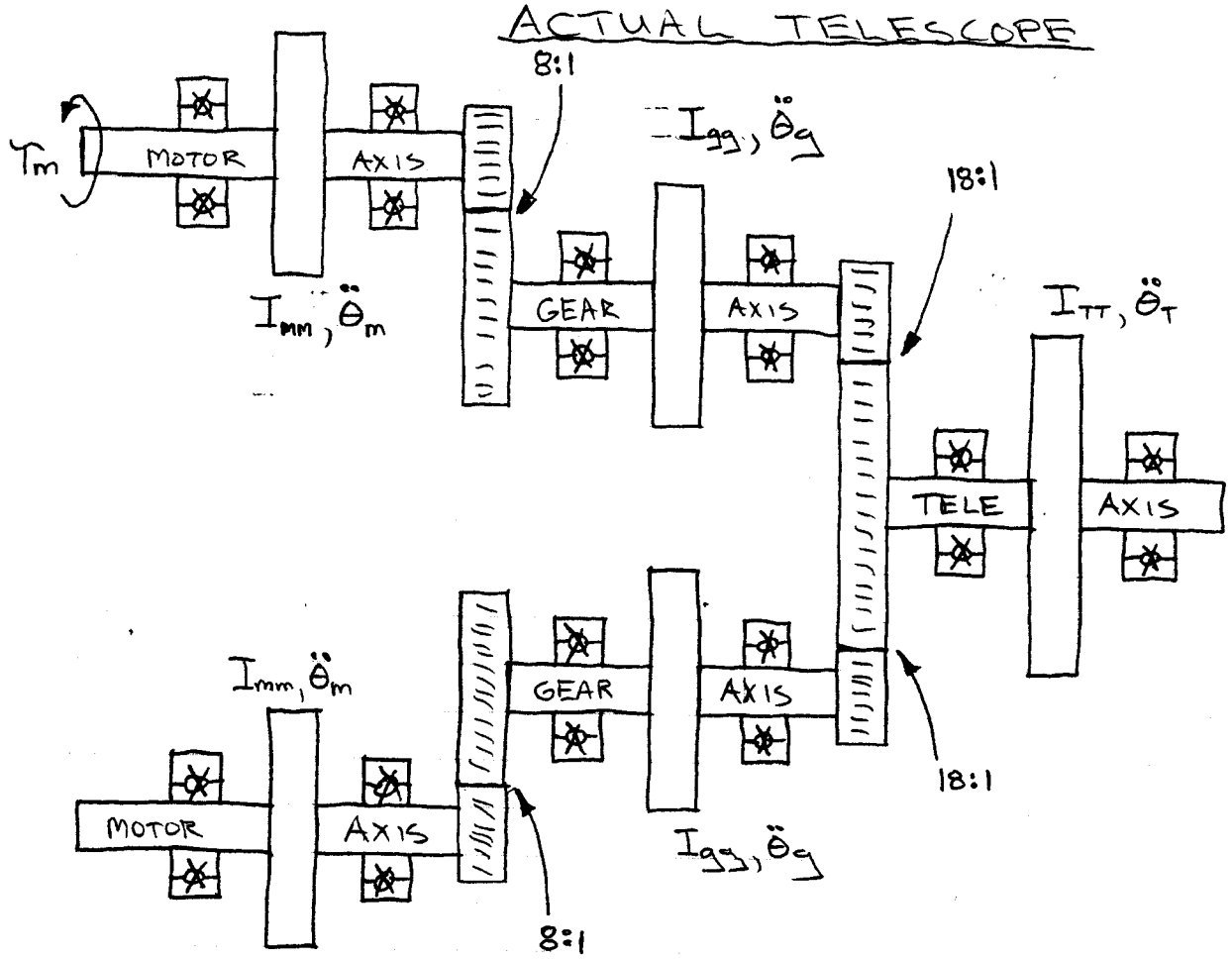
ACTUAL TELESCOPE



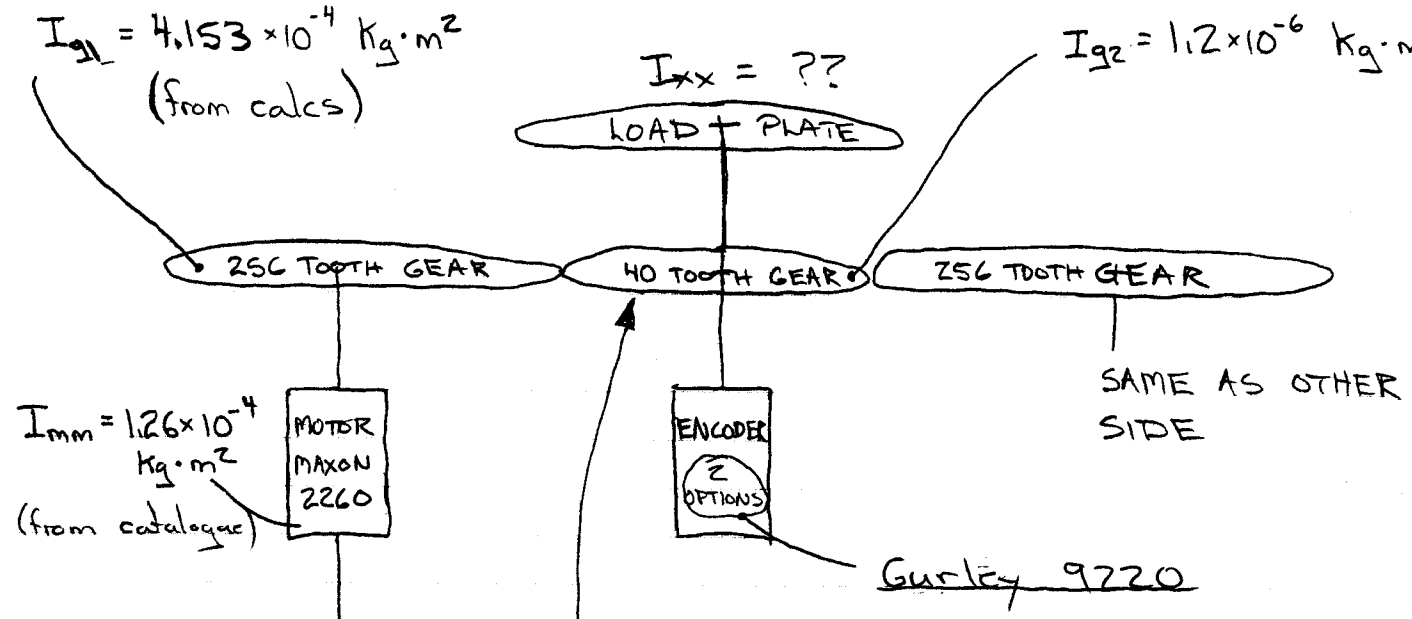
$$T_m = \left\{ 2 \times I_{mm} + 2 \times \left(\frac{1}{8}\right)^2 I_{gg} + \left(\frac{1}{8}\right)^2 \left(\frac{1}{18}\right)^2 I_{TT} \right\} \ddot{\theta}_m$$

* $T_m = 271$ N·m [max torque of telescope drive motors]
* $I_{mm} = 0.727$ Kg·m² [from shop dwgs - shaft, coupling and motor rotor]
* $I_{gg} = 8.002$ Kg·m² [from shop dwgs - 2 gears and shaft]
* $I_{TT} = 532\,716$ Kg·m² [from JPL estimates]

$$\therefore \ddot{\theta}_m = \frac{271}{\{ 1.454 + .250 + 25.690 \}}$$

$$= 9.893 \text{ rad/s} \quad [\text{of motor axis}]$$

MODEL SETUP



TEETH	RATIO
40	6.4 : 1
48	5.3 : 1
56	4.57 : 1

$I_{E2} = 2.1 \times 10^{-6}$ kg·m²
163 000 counts / rev
*REQ 5.52:1 gear ratio

Gurley 9225

$I_{E3} = 6.32 \times 10^{-6}$ kg·m²
200 000 counts / rev
*REQ 4.5:1 gear ratio

$$\frac{T_m}{\ddot{\theta}_m} = 2\left(I_{mm} + I_{E1} + I_{G1}\right) + \left(\frac{256}{\text{teeth}}\right)^2 \left(I_{G2} + I_{E2} + I_{xx}\right)$$

GURLEY 9220 w 48 tooth gear:

$$\frac{.332}{9.893} = 2\left(1.26\times10^{-4} + 2.1\times10^{-6} + 4.153\times10^{-4}\right) + \left(\frac{256}{48}\right)^2\left(1.2\times10^{-6} + 2.1\times10^{-6} + I_{xx}\right)$$

$$I_{xx} = 1.142 \times 10^{-3} \text{ kg·m}^2$$

GURLEY 9225 w 56 tooth gear:

$$\frac{.332}{9.893} = 2\left(1.26\times10^{-4} + 2.1\times10^{-6} + 4.153\times10^{-4}\right) + \left(\frac{256}{56}\right)^2\left(1.2\times10^{-6} + 6.32\times10^{-6} + I_{xx}\right)$$

$$I_{xx} = 1.554 \times 10^{-3} \text{ kg·m}^2$$

SOME Ixx Calcs for size of table

A disk : Aluminum ($\rho = 2700\ kg/m^3$)

dia = 150 mm (approx 6")
th = 6.35 mm (exact $\frac{1}{4}$")

$I_{xx} = 0.85 \times 10^{-3}\ kg \cdot m^2$
$m = 0.303\ kg$

A disk : Aluminum

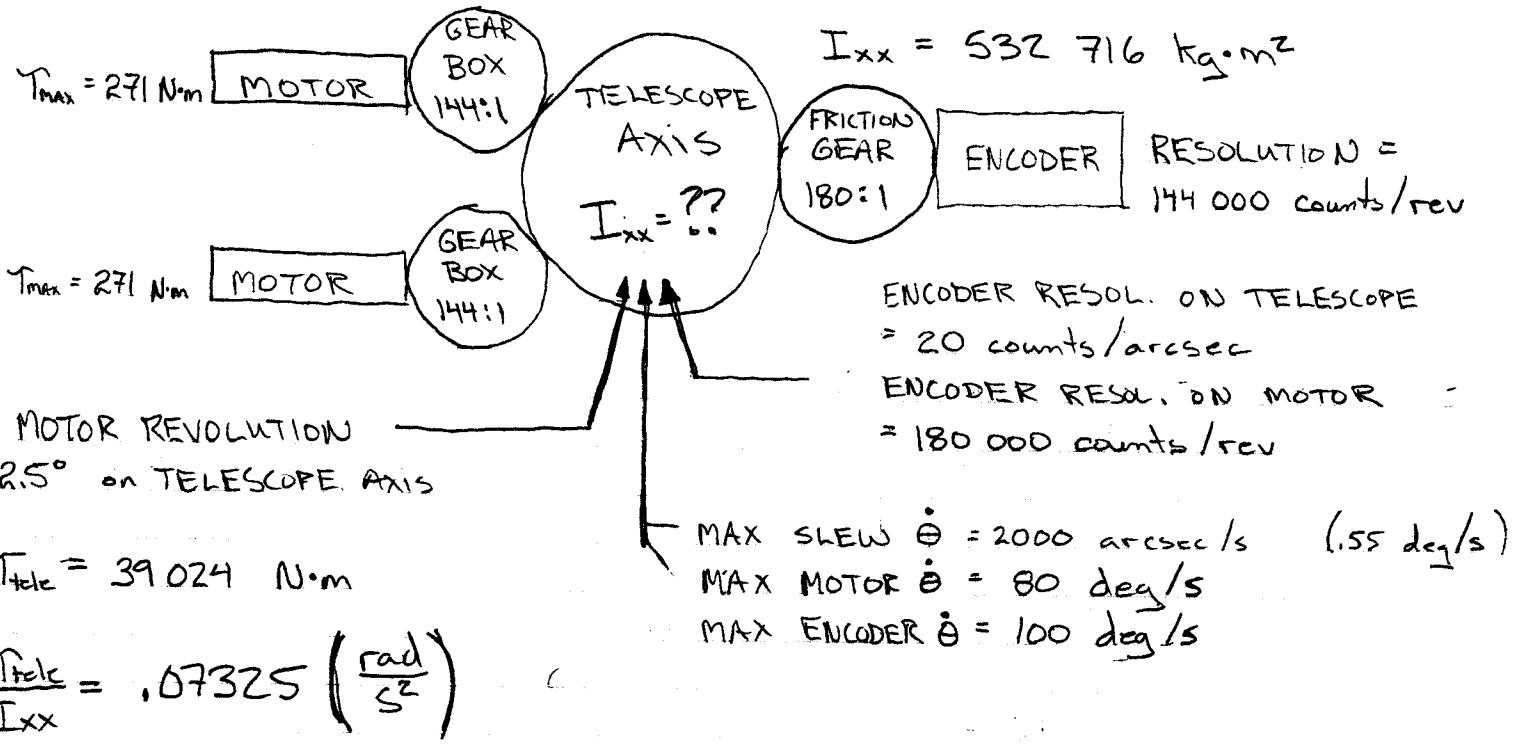
dia = 175 mm (approx 7")
th = 6.35 mm (exact 1/4")

$I_{xx} = 1.58 \times 10^{-3}\ kg \cdot m^2$
$m = 0.412\ kg$

---

* I recommend a 7" alum disk, $\frac{1}{4}$" thick with a bolt circle pattern @ ø6" (maybe 12 holes × $\frac{1}{4}$-20) that you can put SHCS's in to adjust mass.

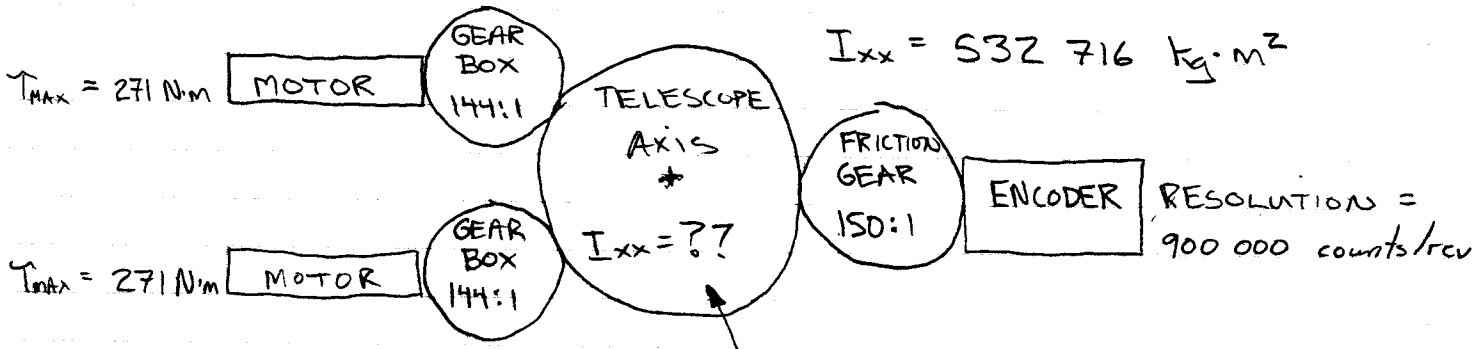
CURRENT CONFIGURATION



T_{tele} = 39 024 N·m

$$\frac{T_{tele}}{I_{xx}} = .07325 \left(\frac{rad}{s^2}\right)$$

PROPOSED CONFIGURATION #1



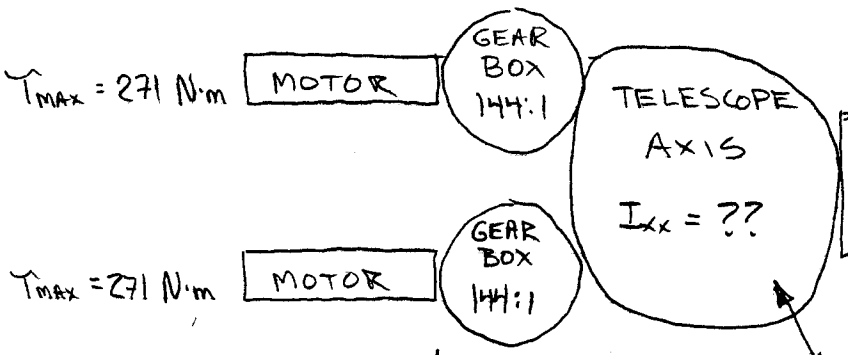
$$\frac{T_{tele}}{I_{xx}} = .07325 \left(\frac{rad}{s^2}\right)$$

∴ ENCODER RESOLUTION ON TELESCOPE = 104 counts/arcsec

∴ ENCODER RESOLUTION ON MOTOR = 937 500 counts/rev

MAX SLEW $\dot{\theta}$ = 2000 arcsec/s
MAX MOTOR $\dot{\theta}$ = 80 deg/s
MAX ENCODER $\dot{\theta}$ = 83.3 deg/s

PROPOSED CONFIGURATION #2



I_{xx} = 532 716 kg·m²

$\frac{T_{tele}}{I_{xx}}$ = .07325 $\left(\frac{rad}{s^2}\right)$

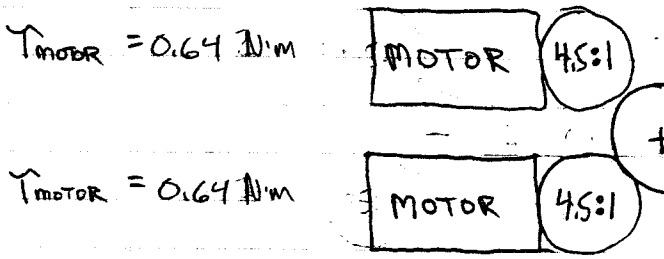
MAX SLEW $\dot{\theta}$ = MAX ENCODER $\dot{\theta}$ = 2000 arcsec/s

MAX MOTOR $\dot{\theta}$ = 80 deg/s

∴ ENCODER RESOL ON TELESCOPE = 72.7 counts/arcsec

ENCODER RESOL ON MOTOR = 436 319 counts/rev

PROPOSED MODEL #1



T_{TELE} = .14222 N·m

I_{xx} = ?? Needs to be 1.942 kg·m²

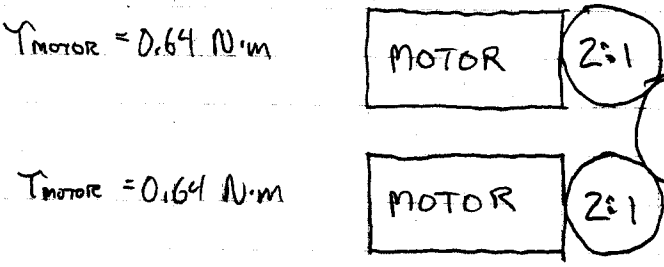
SM2320 (1.1227) SM2310

ENCODER RESOLUTION ON MOTOR = 900 000 counts/rev

MAX MOTOR $\dot{\theta}$ = 80 deg/s

MAX ENCODER $\dot{\theta}$ = 360 deg/s

PROPOSED MODEL #2



T_{TELE} = 0.32 N·m

I_{xx} = ?? Needs to be 4.369 kg·m²

SM2320 (2.525) SM2310

ENCODER RESOLUTION ON MOTOR = 400 000 counts/rev

MAX MOTOR $\dot{\theta}$ = 80 deg/s

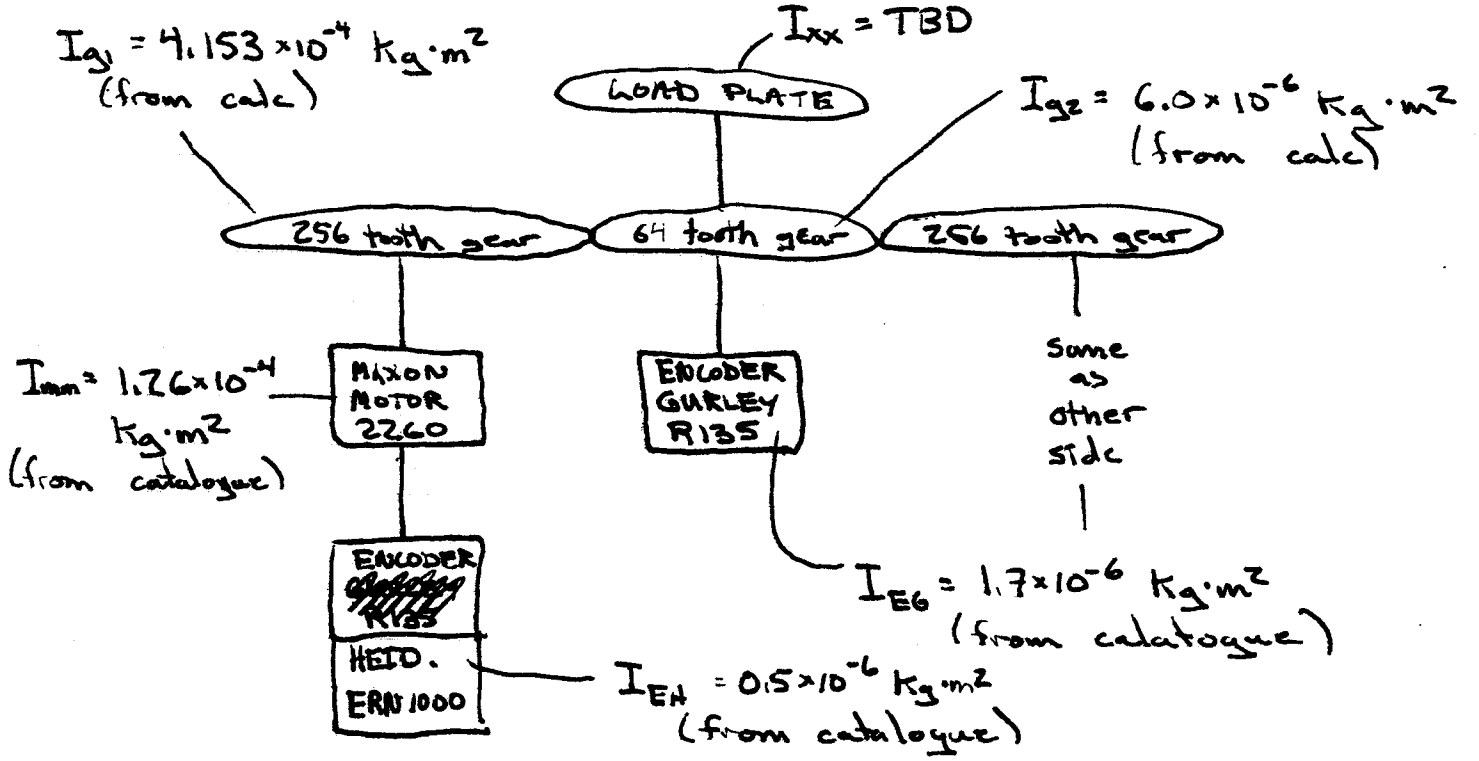
MAX ENCODER $\dot{\theta}$ = 160 deg/s

REVISED MODEL (Oct 27/03)

* now using Gurley R135 encoders for position
* still using Maxon 2260 motors
* now using Heidenhain ERN1000 encoders for velocity
* still using 256 tooth gear on motor axis
* now using 64 tooth gear on load axis

- Gurley R135 has 230 400 counts / rev (@ encoder)

  ∴ has 921 600 counts / rev (@ motor) ✓



$$\frac{.332}{9.893} = 2\left[1.26\times10^{-4} + 0.5\times10^{-6} + 4.153\times10^{-4}\right] + \left(\frac{256}{64}\right)^2\left[6.0\times10^{-6} + 1.7\times10^{-6} + I_{xx}\right]$$

$$I_{xx} = 2.035 \times 10^{-3} \text{ kg·m}^2$$

TACH CALC

Currently : We use TG5714 (Inland)

12 Volts / (rad/s) ⇒ .008 V/(arcsec/sec) ⇐ *ON SKY*

⇒ .000 058 1 V/(arcsec/sec) ⇐ *ON MOTOR*

But our current noise floor is 1.22 mV

⇒ ∴ we currently have 21 arcsec/sec resolution on the motor

⇒ ∴ we currently have .145 arcsec/sec resolution on the telescope

---

⇒ TO GET 20 arcsec/sec resolution on motor

@ 100 Hz readout (.01 s)

we require (.01)(20) = .2 arcsec resolution on encoder

= 5 counts / arcsec

= 6 480 000 counts / rev

ERN 1000 → 3600 lines/rev
IK 220 → 4096 interp
} ⇒ 15 782 400 counts / rev

⇒ TRY @ 150 Hz readout (5 × 30 Hz) ⇒ $\left(\frac{1}{150}\right)$ sec/cycle

15 782 400 counts / rev = 12.178 counts / arcsec

= 0.0821 arcsec / count

∴ we get $\frac{.0821 \text{ arcsec}}{\left(\frac{1}{150}\right) \text{ sec}}$ ⇒ **12.31 arcsec/sec resolution (encoder)**

better than tach