GLAST
Guidance, Navigation & Control System

Jennifer M. Bracken

Code 571/GN&C System Engineering Branch

Assumptions

- **Attitude:** 550 Km
- **Orbit Period:** 5739 sec
- **Inclination:** 28.5 deg

From IMDC Session in August 1998:

- **Inertias:** 2742, 3341, 3363 Kg-m^2
- **CPCG Offset:** .33 m
- **Solar Array Area:** 17.4 m^2

GN&C Component Selection Drivers

- **Star Trackers (attitude knowledge)**
- **Gyros (attitude knowledge)**
- **Coarse Sun Sensors**
- **Reaction Wheels (slew requirements)**
- **Torquer Bars (disturbance torques)**
- **Magnetometers**
- **GPS Receiver/Antennas (orbit knowledge)**

Component Trades

- **Star Trackers**
  - **5 arcsec knowledge requirement in all 3 axes**
  - **2 are necessary to meet requirement**
    - **3 arcsec accuracy along off-boresight axes**
    - **30 arcsec accuracy along boresight**
  - **3 for redundancy**
- **Gyros**
  - **5 arcsec knowledge requirement during slews**
  - **Low noise and minimal drift**

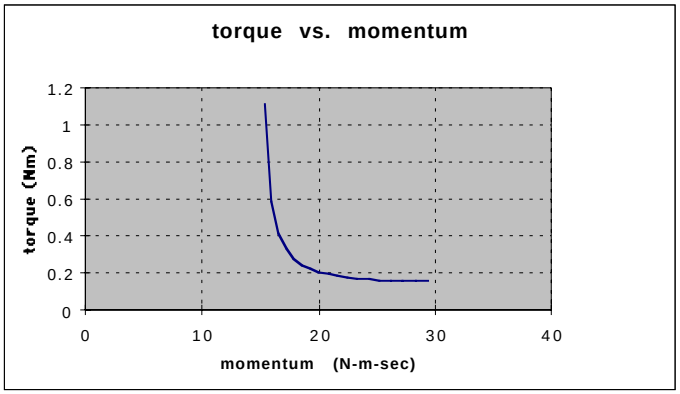
Predicted Kalman Filter Update Performance using Farrenkopf's Equations from AIAA Journal Guidance & Control (July 78)

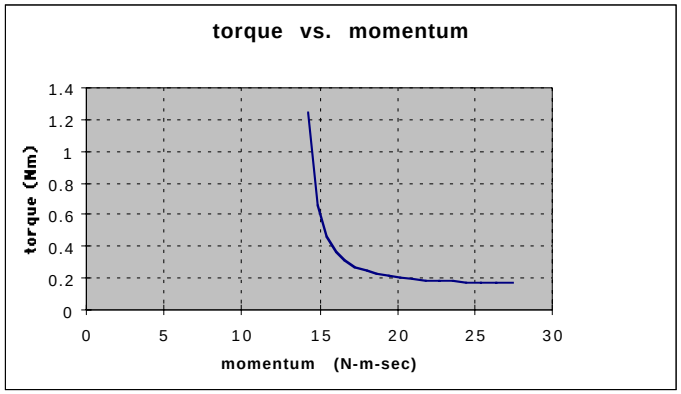
(Note: This is based on SIRU and CT-602 noise specifications only. It does not take into account misalignments)

Kalman Filter Update Time (sec)	0.2	0.5	1	0.2	0.5	1	0.2	0.5	1
Std Dev Attitude Angle (arcsec)	0.87377	0.89116	0.91966	0.87377	0.89116	0.91966	0.87377	0.89116	0.91966
Std Dev Drift Rate Bias (arcsec/sec)	0.00131	0.00132	0.00134	0.00131	0.00132	0.00134	0.00131	0.00132	0.00134
	6 min Slew			**12 min Slew**			**Sun in FOV**		
Time Duration of No Updates (sec)	360	360	360	720	720	720	956.5	956.5	956.5
Angle Buildup during No Update Period (arcsec)	1.09799	1.10008	1.10237	1.71446	1.71981	1.72569	2.10181	2.10951	2.11796

Component Trades (cont.)

- **Reaction Wheels**
  - **Must be able to satisfy slewing requirements**
    - **90 deg in 6 min: .16 N-m, 14.7 (29.4) N-m-s**
    - **70 deg in 5 min: .18 N-m, 13.7 (27.4) N-m-s**





  - **Must be able to accommodate external disturbances**
    - **Gravity Gradient: .0022 N-m, 12.7 N-m-s/orbit**
    - **Aerodynamic: .00027 N-m, 1.5 N-m-s/orbit**
    - **Solar: .000078 N-m, .045 N-m-s/orbit**
    - **Disturbance Totals: .0026 N-m, 14.7 N-m-s/orbit**

Component Trades (cont.)

- **Torquer Bars**
  - **Must be able to accommodate external disturbances**
  - **Required dipole: 107 Am^2, double (even triple) to account for uncertainties**
    - **If inertias and cpcg offset change by 10% for the worse, the external disturbances will increase by about 7 N-m-s/orbit, and the dipole required to unload momentum will increase by about 50 Am^2**
  - **Torquer Bar Size and Momentum Unloading:**
    - **100 Am^2 bars will be able to unload 13.7 N-m-s per orbit.**
    - **230 Am^2 bars will be able to unload 31.6 N-m-s per orbit.**
    - **300 Am^2 bars will be able to unload 41.2 N-m-s per orbit.**

GN&C Mass, Power & Cost Estimates

Components	Qty	Make/Model	Mass per Unit (Kg)	Avg Power per Unit (W)	Peak Power per Unit (W)	Cost per Unit ($K)	Total Mass (Kg)	Total Avg Power (W)	Total Peak Power (W)	Total Cost ($K)
Star Tracker	3	Ball CT-602	5.41	8.0	9.0	650	16.23	24.0	27.0	1950
Inertial Reference Unit (4 Axis)	1	Litton SIRU (HRG)	5.45	22.0	22.0	1200	5.45	22.0	22.0	1200
Coarse Sun Sensors	8	Adcole 11866	0.0046	0.0	0.0	6	0.0368	0.0	0.0	48
Reaction Wheels	4	Ithaco Type E	13.90	40.0	280.0	350	55.60	160.0	1120.0	1400
Torquer Bars (Dual Wound)	3	Ithaco TR230CFR	5.20	3.8	5.4	38	15.60	11.4	16.2	113
Magnatometers	2	Ithaco IM-203	0.704	1.4	1.7	61	1.408	2.8	3.4	122
GPS Receiver/Antenna Bundle	2	Motorola Viceroy	1.83	4.8	4.8	120	3.66	9.6	9.6	240
ACE (2 Units in 1 Housing)	1	TRMM (In-house)	25.00	7.5	12.5	2700	25.00	7.5	12.5	2700
					Grand Totals =		123.0	237.3	1210.7	7773

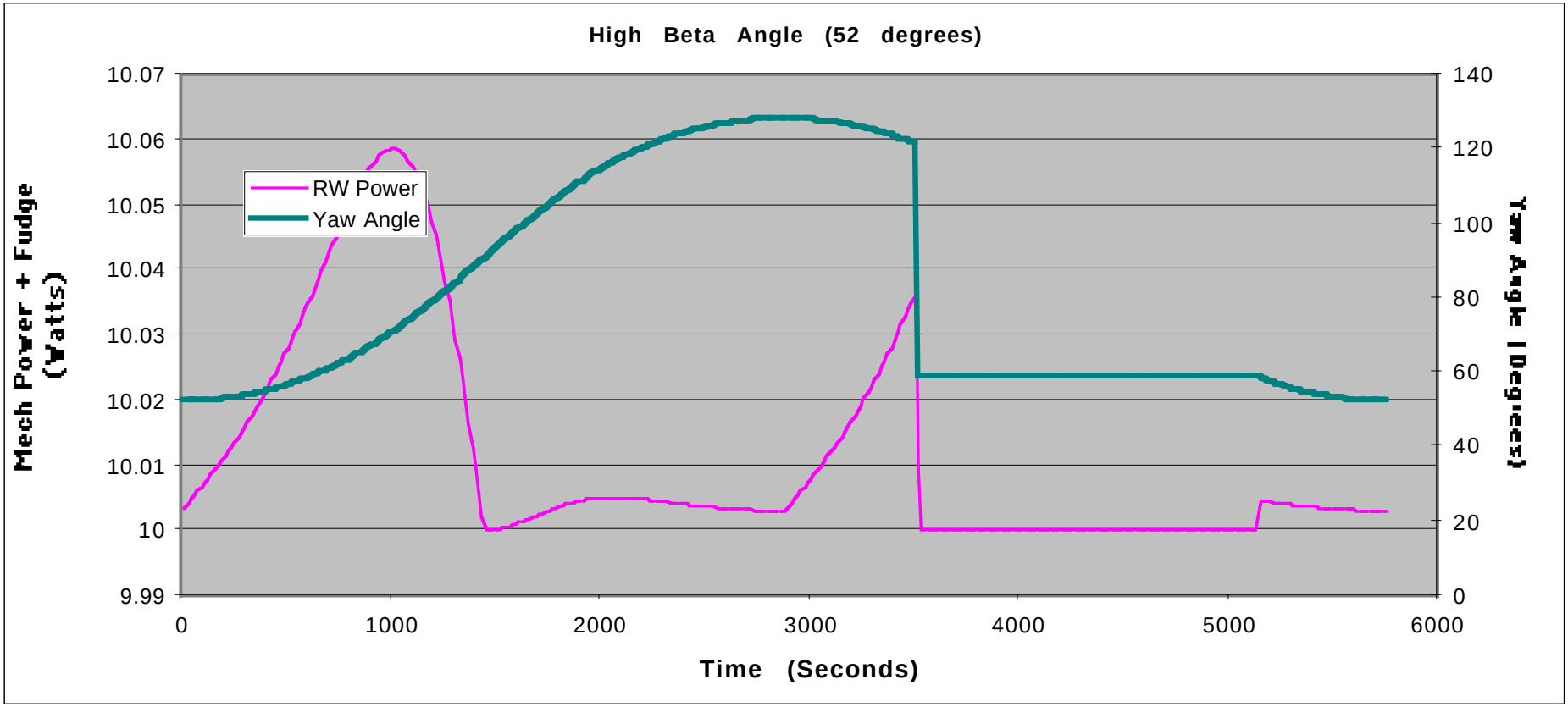
GN&C Mode Requirements

- **Initial Acquisition**
  - **Null rates and acquire sun on solar arrays**

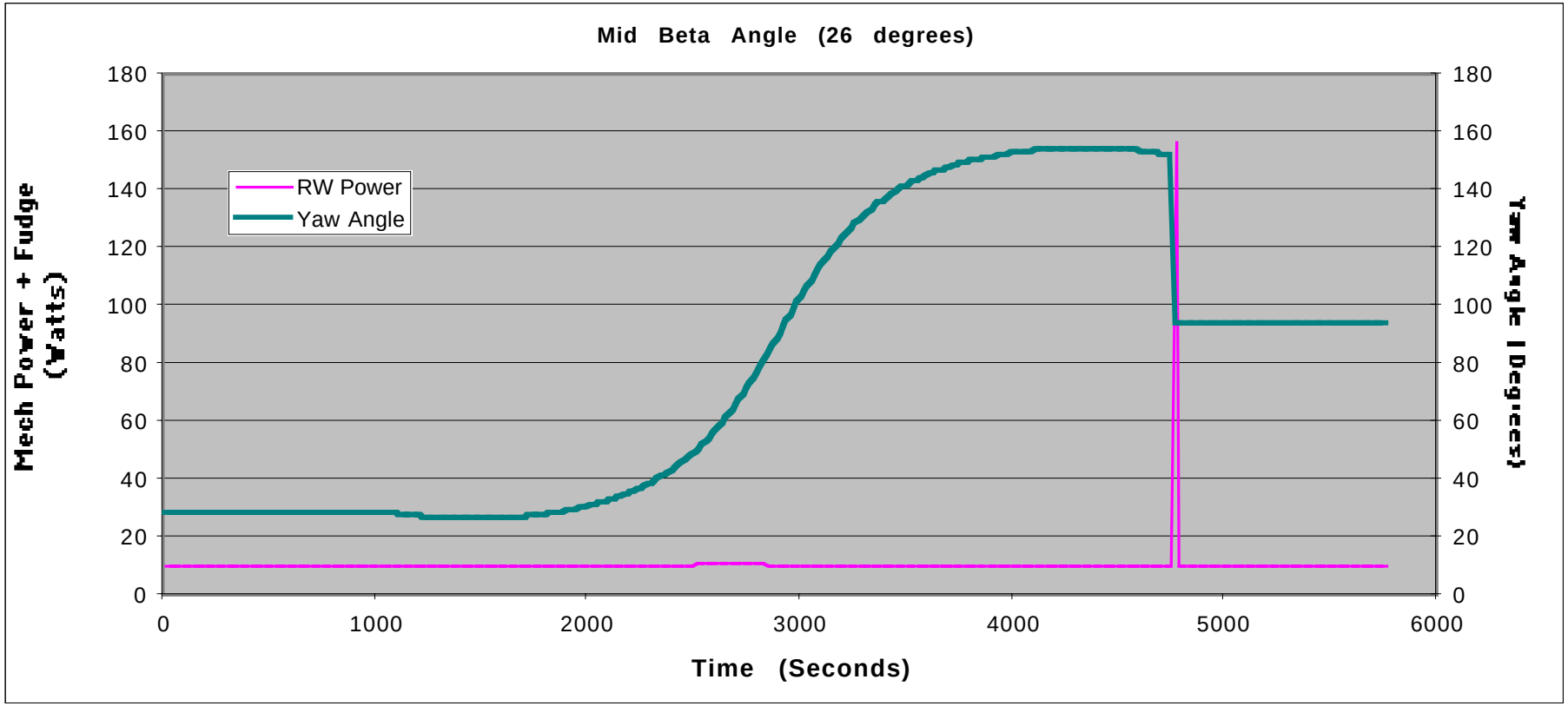
- **Mission Modes**
  - **Maintain roll-canted zenith attitude with varying yaw angle (to accommodate thermal and power) for first year of mission (90 deg slews in 6 min)**
  - **Maneuver and maintain inertial attitudes on selected targets for the remaining years of the mission (70 deg slews in 5 min)**
  - **Accommodate observation of Gamma Ray Bursts when necessary (70 deg slews in 5 min)**

- **Safe Hold**
  - **Provide power and thermally safe independent "safety net" in case of anomalies**

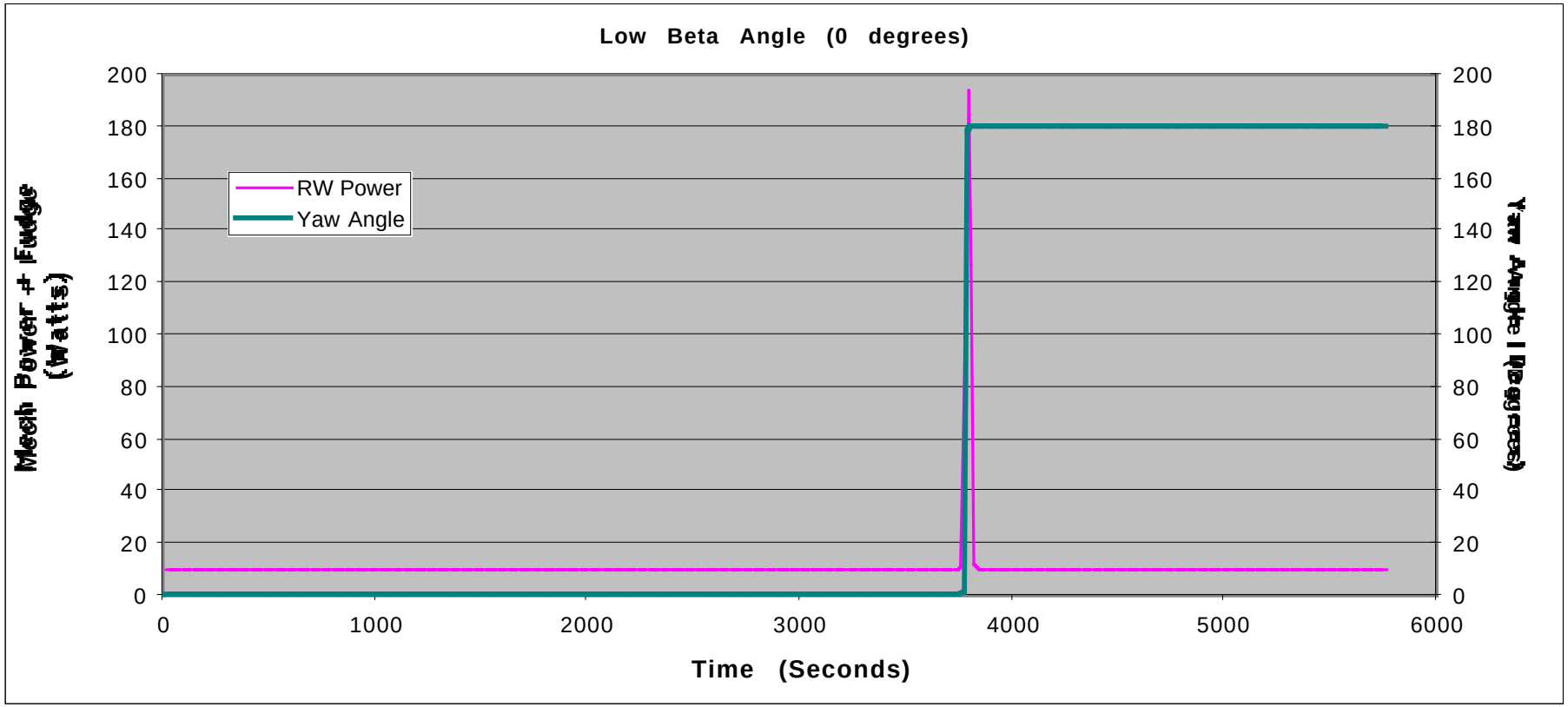
E-Wheel Power Profile during Sky Survey



E-Wheel Power Profile during Sky Survey



E-Wheel Power Profile during Sky Survey



Potential Jitter Sources

- **Reaction wheel imbalances**
  - Imbalance specifications for the Ithaco E wheel results in spacecraft jitter at sub-arcsec level
  - Wheel isolation packages are available if necessary
- **Reaction wheel zero speed crossings**
  - With 4 wheels, zero speed crossings are minimized
  - Will be able to account for this from post processed data
- **Solar array induced jitter**
  - Expect no problem - but will require verification by detailed analysis when spacecraft and instrument structural models are available
- **Gimbaled antenna induced jitter**
  - Expect no problem - but will require verification by detailed analysis when spacecraft and instrument structural models are available