STRAP IV SOUNDING ROCKET ATTITUDE CONTROL SYSTEM

David J. Shrewsberry

I will discuss the STRAP IV sounding rocket attitude control system (Figure 1), which is used on Aerobee class and larger rockets. STRAP IV now provides our experimenters, for the first time, high accuracy pointing – better than ±10 minutes absolute with ±10 arc second stability – at nontrackable scientific objectives such as X-ray sources and diffuse star fields. Bear in mind that sounding rocket attitude control takes place during the coast phase of the flight, after motor burnout.

In the past, the STRAP III system with an experimental boresighted startracker, has been successfully used to stabilize and point the rocket payload to a stellar target within 30 seconds of control initiation.

X-ray astronomy is becoming increasingly active, and since many X-ray sources have been precisely located by rockets and satellites, it is now desirable to study their characteristics by pointing an instrument at them for an extended period of time. To reduce background noise the instruments necessarily must have a narrow field of view, which requires accurate

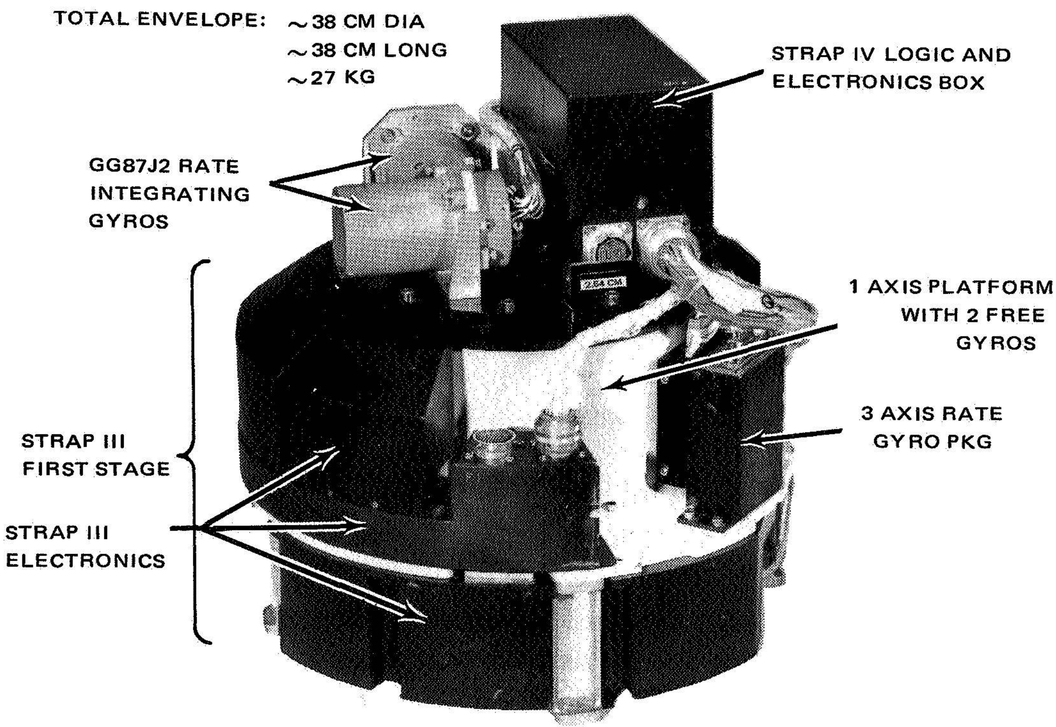

Figure 1. STRAP IV sounding rocket attitude control system.

payload pointing. Currently there are no X-ray source tracking devices similar to a startracker for rocket use. Consequently STRAP IV has been designed, built, and successfully flown as an in-house project of the Sounding Rocket Division to meet the requirement of the X-ray experimenters for high accuracy pointing at X-ray sources.

Because of STRAP III free gyro uncertainties about the coarse axis – mainly drift and torquing rate – it is usually not possible to physically offset either the experiment or the startracker so that a star could be tracked while the experiment viewed a target offset from the star, say by 10 degrees or so. The coarse axis uncertainty would cause a corresponding error to be translated to the experiment boresight axis, if either the startracker or the experiment axis were not parallel to the coarse axis.

STRAP IV utilizes a STRAP III first stage in conjunction with high quality rate integrating gyros (RIGS) operated in both closed loop and open loop modes. The RIGS have accurate torquers and a very low drift rate of less than one arc second of time. In normal operation the RIGS are zeroed on a nearby star and torqued to the proper location in the closed loop mode; that is, the rate output is electronically integrated to provide a position displacement signal. Once RIG closed loop torquing is completed, the caging loop is opened and the RIG is operated as an angular displacement sensor to provide limit cycle control while viewing the target.

The uncertainties about the coarse axis are reduced by first acquiring and tracking an overhead star, then moving to a second star near the first X-ray target. In moving from the first star to the second star an error is generated on the STRAP III free gyros which is proportional to the coarse axis error prior to the maneuver. This signal is used to update the coarse axis gyro and subsequently the vehicle itself, so that coarse axis error will not contribute to experiment pointing error when the vehicle is maneuvered under RIG control to the nearby X-ray target.

A typical flight profile of STRAP IV (shown in Figure 2) is as follows:

- An overhead star is acquired and the free gyros are caged
- A second star is acquired and the coarse axis error is reduced; the RIGS are caged to the star
- The vehicle is maneuvered to the desired location by torquing the RIGS closed loop
- The RIG torquing loop is opened and the fine limit cycle and experiment viewing is begun
- Other targets are acquired in a similar manner
- The payload is recovered by parachute

I want to emphasize the fact that we recover and refly our ACS. The system shown in Figure 1 has been flown four times, and will be flown again in the spring.

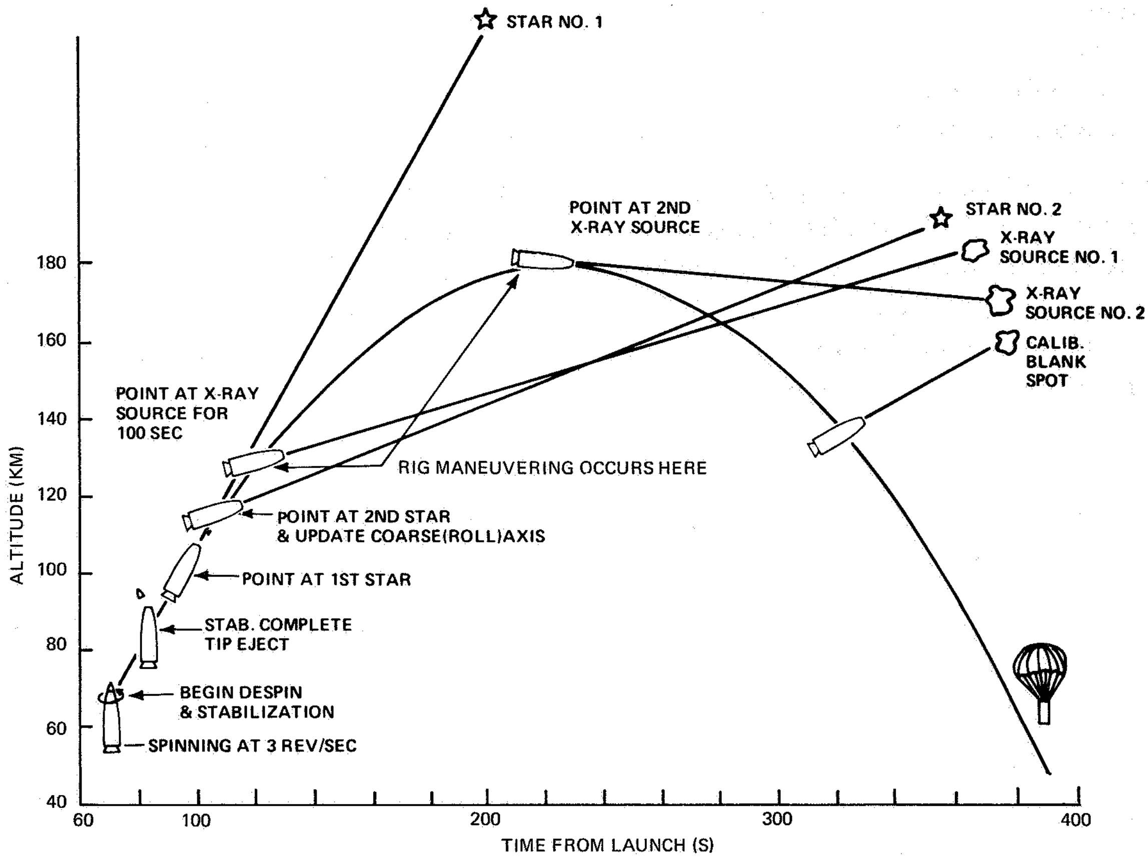

Figure 2. STRAP IV flight profile.

Figure 3 is an actual flight telemetry record from the first launch of STRAP IV in May of this year. For this shot the two fine axes were roll and yaw. The sequence of events is:

- Coarse axis update occurs
- The fine mode startracker signal is received, during which time the RIGS are caged to the star
- The first RIG maneuver is accomplished
- When yaw is within 0.5 arc minute, the second RIG maneuver occurs
- When roll is within 0.5 arc minute, the fine limit cycle is enabled and experiment viewing begins

The magnitude of the fine limit cycle can be seen here to be around 20 arc seconds peak to peak with very low body rates. On this launch, we pointed the payload to within four arc minutes on both X-ray targets.

The ACS Branch has several more STRAP IV launches scheduled in the next year.

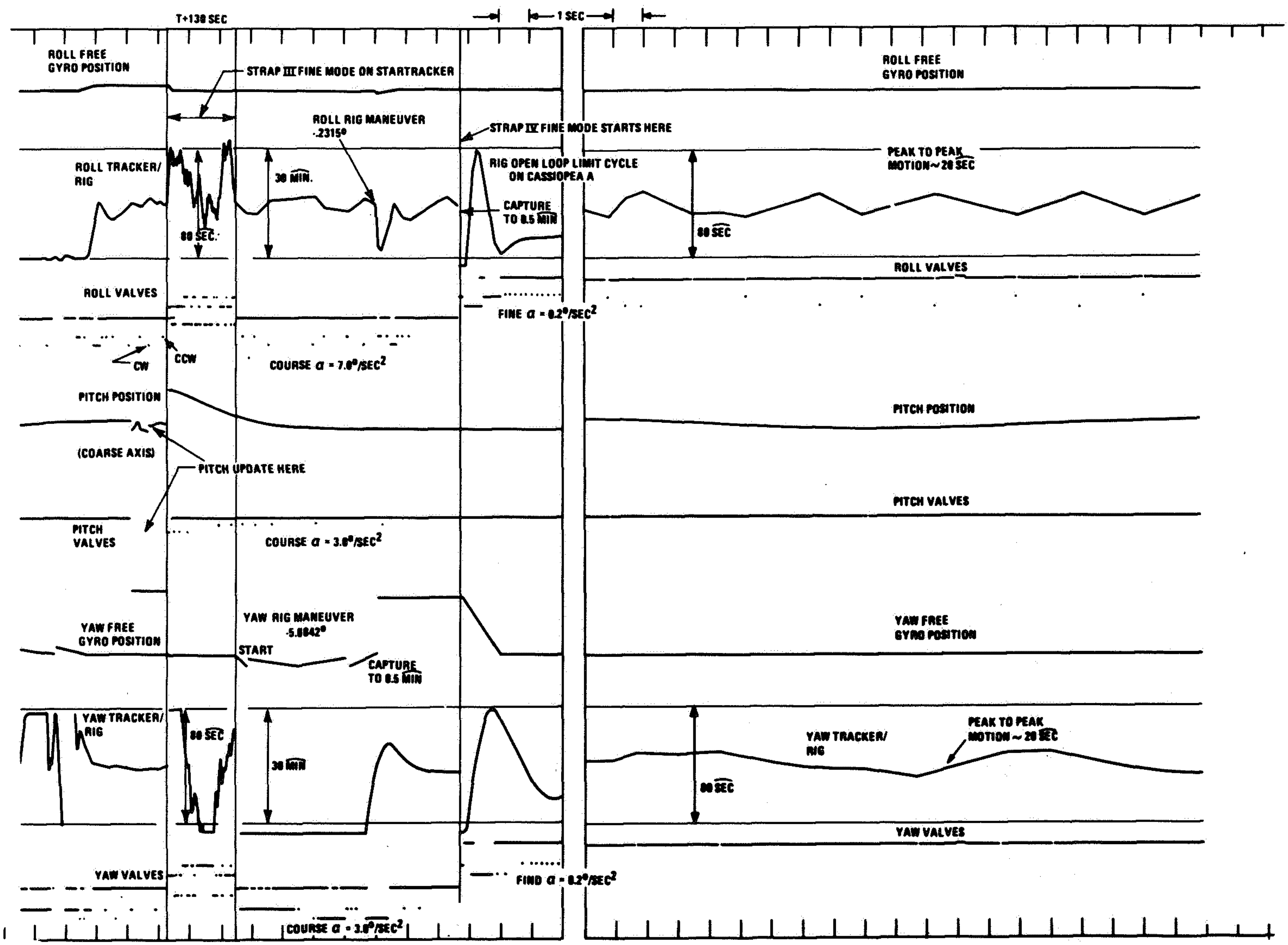

Figure 3. STRAP IV flight telemetry, Aerobee 13.009GG.