# INTEGRAL Users Group #25 - MOC

Richard Southworth

24/11/2020

# Status of MOC

No significant issues

Ground Stations

- Coverage increased to close perigee gap - fast reaction to safe mode entry
  - Safe mode is instable and probably can’t be relied upon for long

Z-flip planning tools deployed to SOC

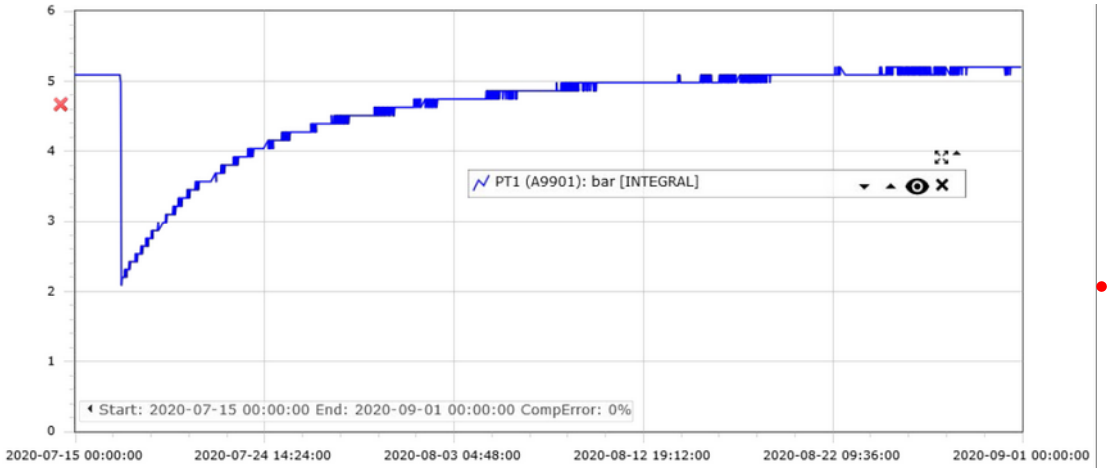
Propulsion failure case tentatively identified – presentation available

- Presentation to IUG if wanted?

# Status of Operations

Use of Propulsion system stopped after wheel bias on 17/7/2020

- Angular momentum controlled purely via Z-flip




- Dramatic Loss of Pressure
- Slow Recovery

Propellant System is hardly usable
=> **Avoid safe mode** at all costs

Software patches to improve slew performance / safety

# Open loop slews modification

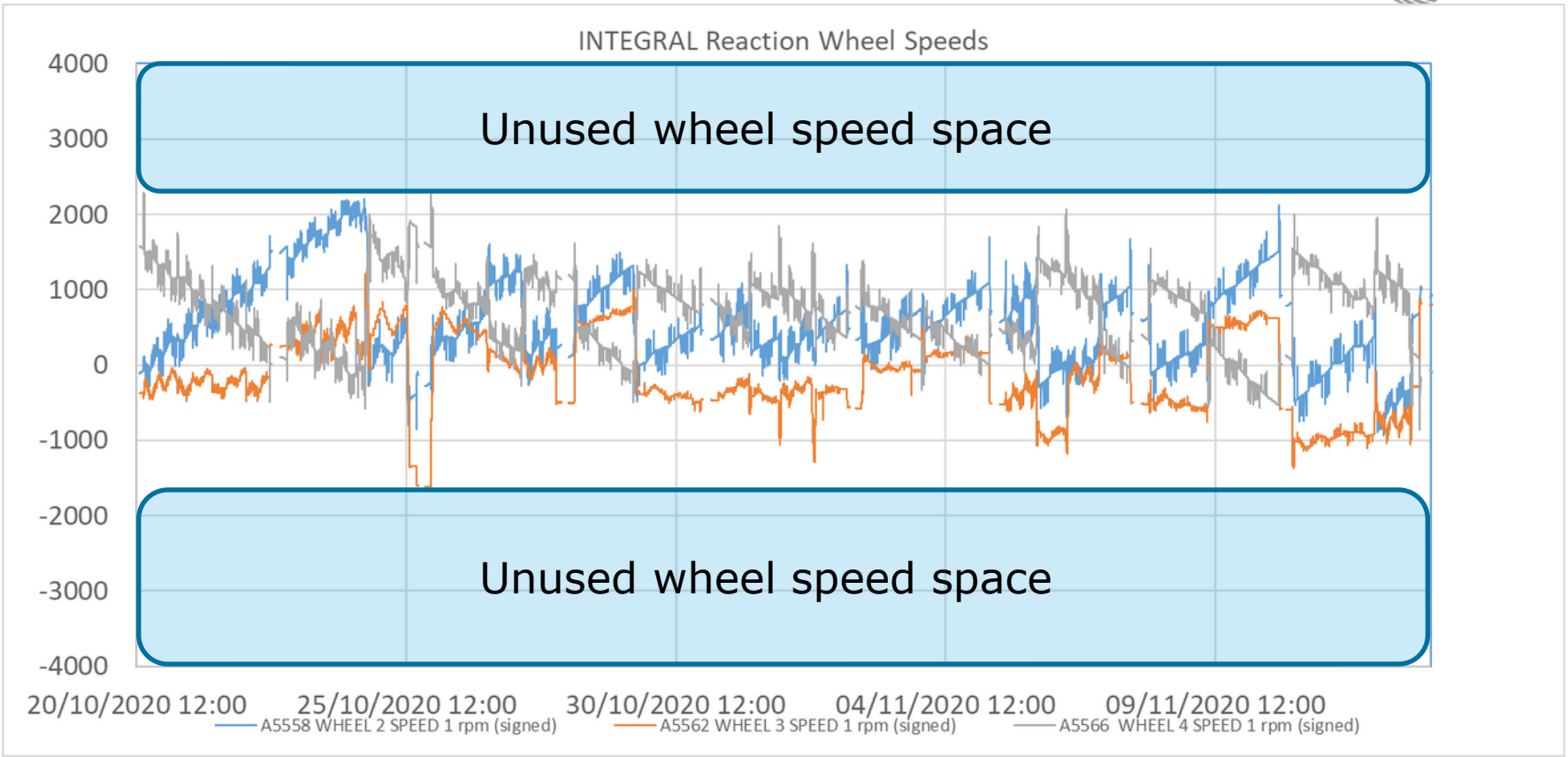
Z-flip concept is proven and is effective

- Can it be improved further?

SOC plan observations to balance system angular momentum over planning period

- Respect wheel speed constraints – 4000rpm non-negotiable (handle with care)
- Respecting slew stability constraints:
    - Slews > 3° are executed Open Loop about Z axis (yaw)
        - Large slews about Z required to balance angular momentum (Z-flip)
    - Large open loop slews (>7DEG) about Z are highly constrained by system angular momentum and can easily become unstable and trigger safe mode
        - Safe mode no longer works reliably
    - Forces SOC to move away from targets early

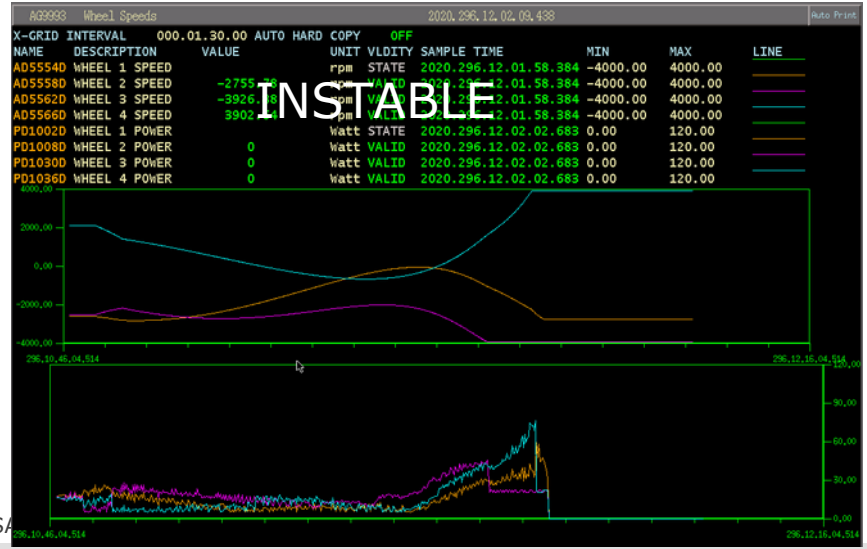
# Open loop slews modification - Wheel Speeds

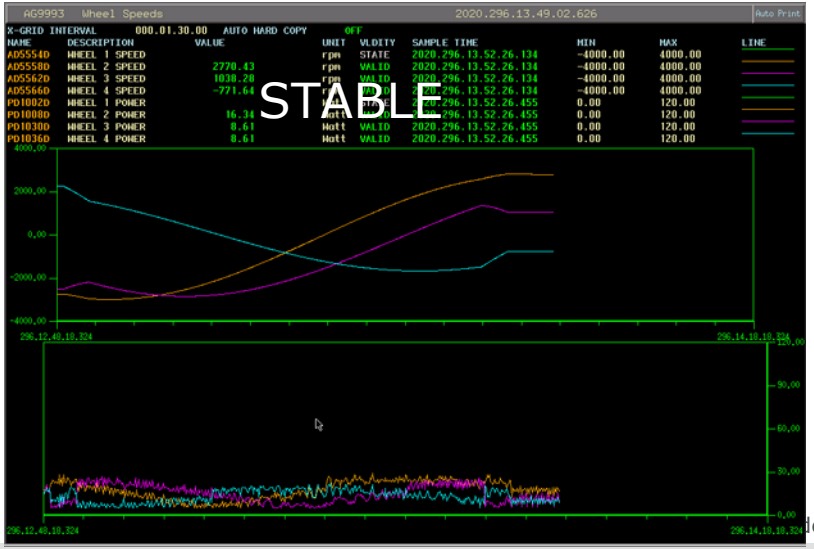


# Open loop slews modification - Modification

Software modification **under prototype testing** to use gyroscope output as yaw (Z) reference

- Slew stability constraint is no longer applicable - increase the momentum space
- De-constrains SOC planning
- => allows longer time on target / better ToO response



# Open loop slews modification - Advantages

- Safety: less chance of safe mode due to unstable slew
  - Patch also includes Star Tracker output filter (safe mode #6)
- Easier Planning: no (short notice) re-plans in case of wheel speed inaccuracies
- Potentially better routine science from utilisation of extra "momentum space"
- Better chance to **implement Target of Opportunity at short notice**
  - Slew + pointing less likely to be constrained

- Deployment + commissioning Q2 2021

- *Implementation of this patch acts also as pathfinding and de-risking exercise for a 4WD or full Open Loop Slew implementation*

# 4WD for INTEGRAL

Based on the experience currently being gathered with the OSL patch a proposal for a possible fast 4WD implementation for INTEGRAL will be made

- Safety: Include fall back to 3WD in case of anomaly (safe mode #2, #3)
- Advantages for momentum management
  - More flexibility for ToO facilitation / longer observations

# Full Open Loop Slew

A further SW patch is proposed:

- Slew without reference on all 3 axes
- Pure dead reckoning by commanding reaction wheel profiles
  - Relies on a well calibrated spacecraft
  - Less reliance on sensors – robust
  - Accuracy tbd, but probably good
  - Possible uses for attitude control during safe mode!!! - safety
  - Minor code change
- Will be developed and commissioned in 2021
  - Can also be used if Gyroscopes degrade

# Ultra Fast ToO

The above changes could allow MOC to implement an “Ultra Fast ToO” procedure

- No bias necessary
- No slew stability constraint applicable
- Is the target unconstrained?, and can wheel speeds accommodate the slew?
- If yes
    - Supply target to MOC, MOC generates slew
- Initial staring, Instruments configured via static command sequences at MOC
- Later resume operations via re-plan
- Time on target may be limited in some cases – angular momentum dependency

# Operations Evolution

- MOC aim is to present a feasible long term prospect for INTEGRAL
  - Z-flip
  - Safe mode Risk reduction
  - Modified slew modes
  - 4WD

To enable the best possible science

Ultra fast ToO