Universität Stuttgart
Institut für Raumfahrtsysteme

Flying Laptop Abschlussworkshop

Missionsplanung und Satellitenbetrieb

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Initial Satellite Operations
LEOP

- Preparation for LEOP phase started in mid 2016
  - Preparation of verified flight procedures for all LEOP tasks
  - Operations lecture and simulator trainings

- LEOP: Launch on 14.07.2017 6:36:49 UTC on-board a Soyuz Fregat from Baikonur
  - Operations performed 20 hours a day in two shifts (9 positions)
  - 60 passes executed within 4 days
    - DLR ground station network (Weilheim - Germany, Inuvik - Canada, O'Higgins - Antarctica)
  - Solar panels deployed on second day
  - Higher attitude control devices and modes checked
    - pointing accuracies below 1°

Initial Satellite Operations
Commissioning

- 2 daily shifts (4 positions) using only passes over ground stations in Germany
- Increasing workload for mission planner
  - shift from live execution to time-tagged execution
- All payload devices were taken into operation
  - First image from PamCam received 5 days after launch
  - AIS antenna deployed and first AIS signals received
- Redundant satellite bus components were checked out
  - On-board computer, IO-Boards, CCSDS-Boards
  - Transmitter
- IRS ground station taken into operation

Transition to Nominal Satellite Operations

- Need for on-board software updates
  - Bug-Fixes (Star tracker handling, TM storage, GPS overflow, Queue …)
  - Improvement of ACS performance

- Problem: Parts of development and operations team share same personal
  - High workload

- Increasing number of requests for payload data and experiment slots
  - Available software tools to handle requests required significant manual work
  - Command stack were created manually by command controller (error prone)
  - Scheduling conflicts and inflexible mission planning
  - On-board queue not used efficiently

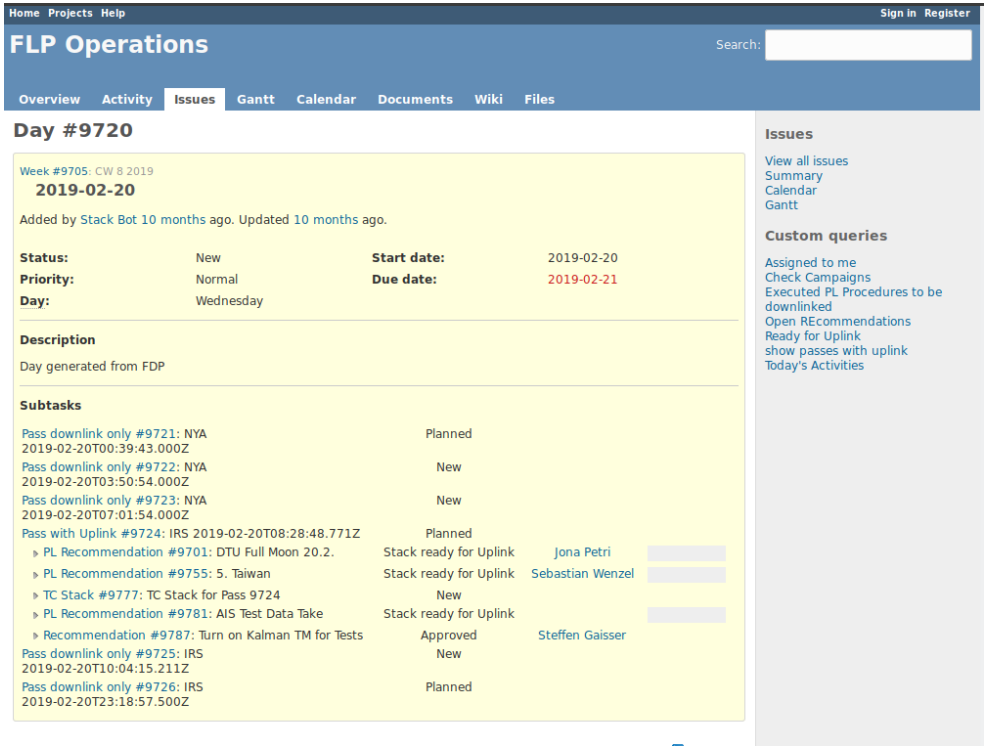
Transition to Nominal Satellite Operations

- Solution: in-house development of ground-based automation software tools
  - Flight dynamics
  - Mission planning (ground station and satellite activity scheduling)
  - Routine and Payload request handling
  - Technology demonstration (OSIRIS pointing pattern)

- Result: Staffing and pass execution reduced drastically
  - Uplink passes reduced to one each working day (5 passes each week)
  - Scheduled downlink only passes (26 passes each week)
  - Passes: only one team member sends pre-defined command stack and monitors live TM and antenna (no “Lights Out” operations due to legal reasons)
  - Flight Director works independently of passes
  - ”Last Minute” changes for satellite activities possible (Uplink – Uplink scheduling)

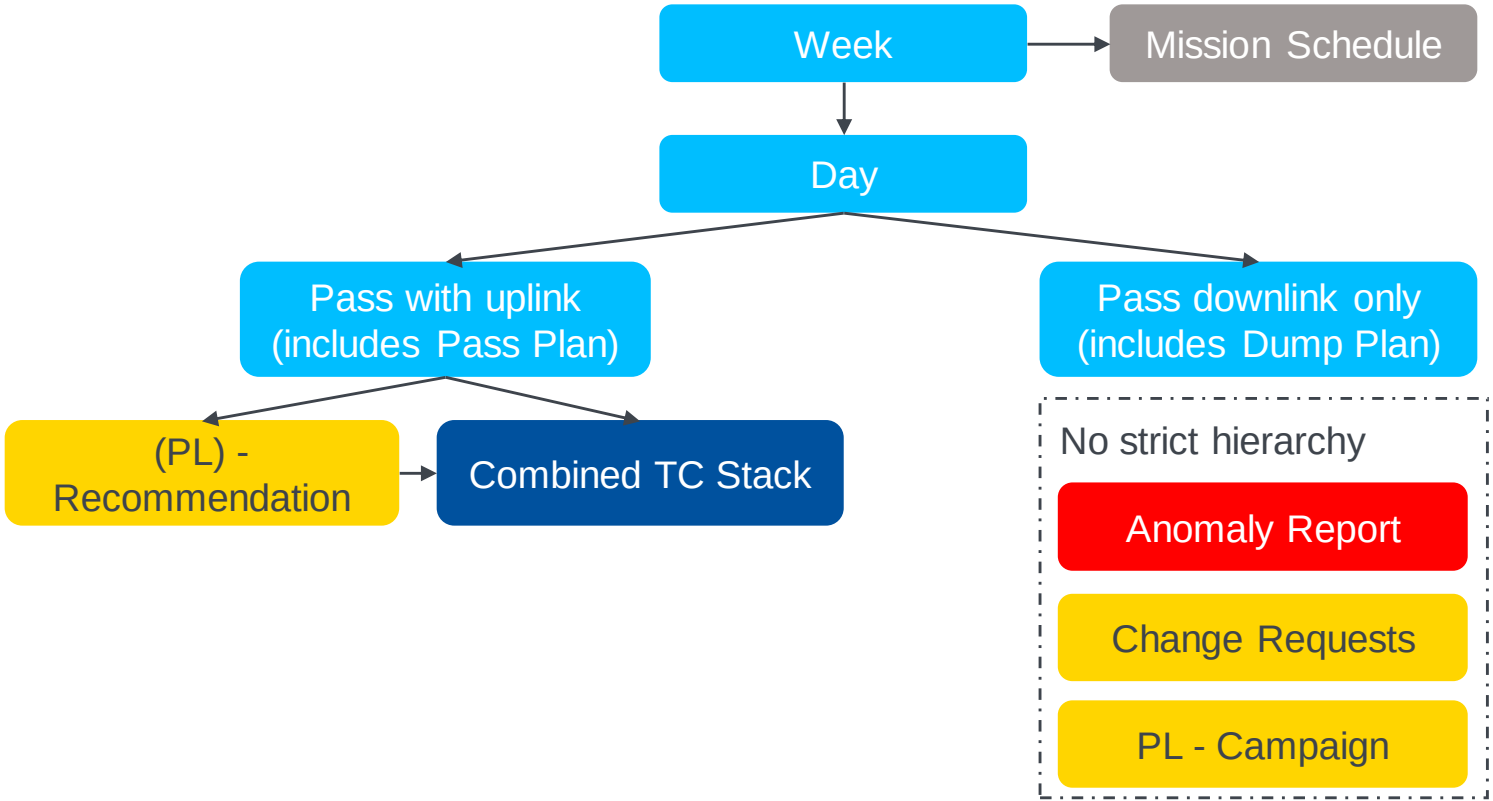
Satellite Operations Documentation and Mission Planning

- activity tracking is done in “redmine”
- browser based tool to track activities
- based on “issues“ (~ “Ticket”)
- each type of issue is like a form to be filled out for a specific operations related action
- Interacts with automation tools

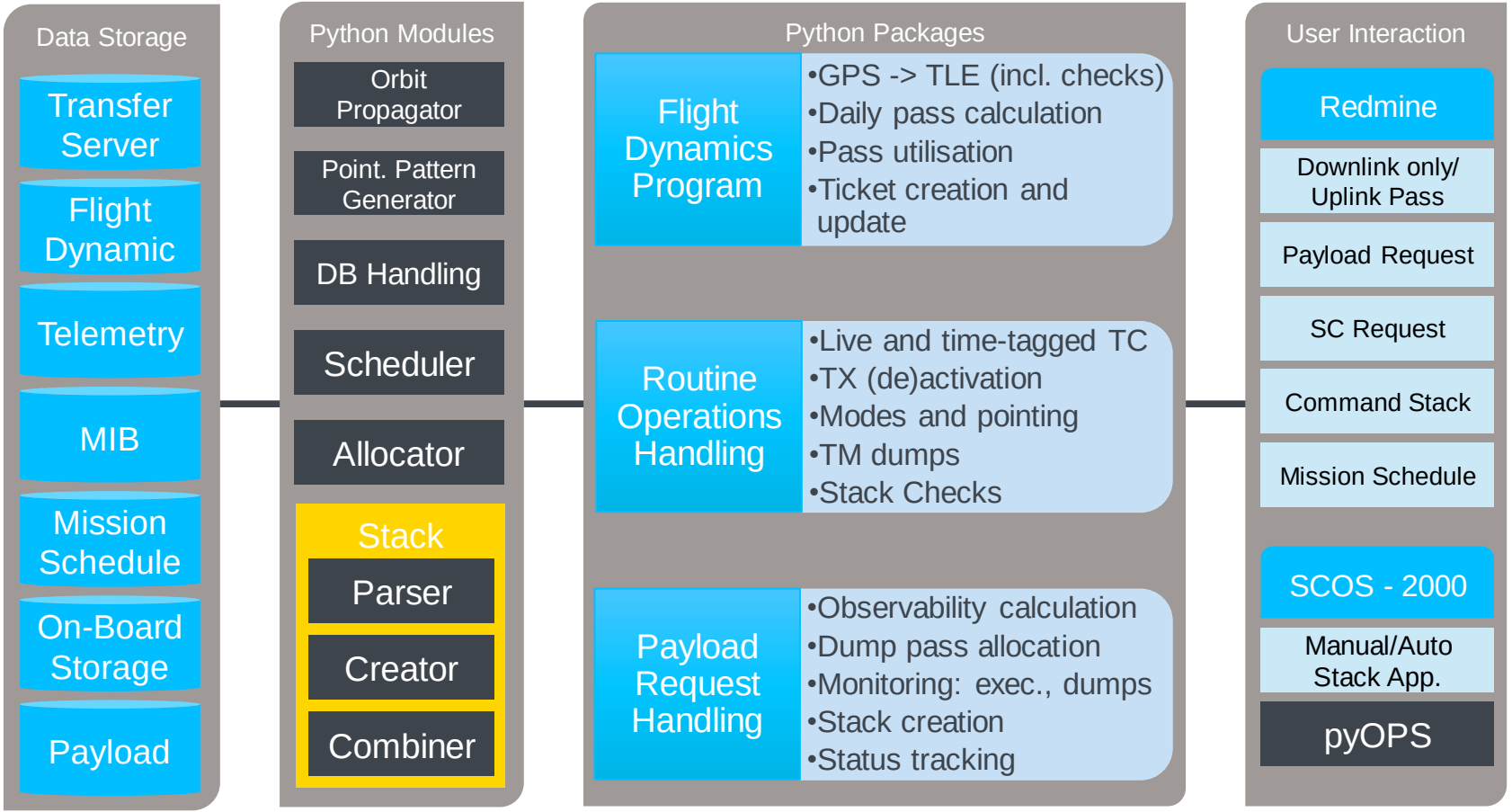


Satellite Operations Documentation and Mission Planning

Redmine Issues Overview and Hierarchy

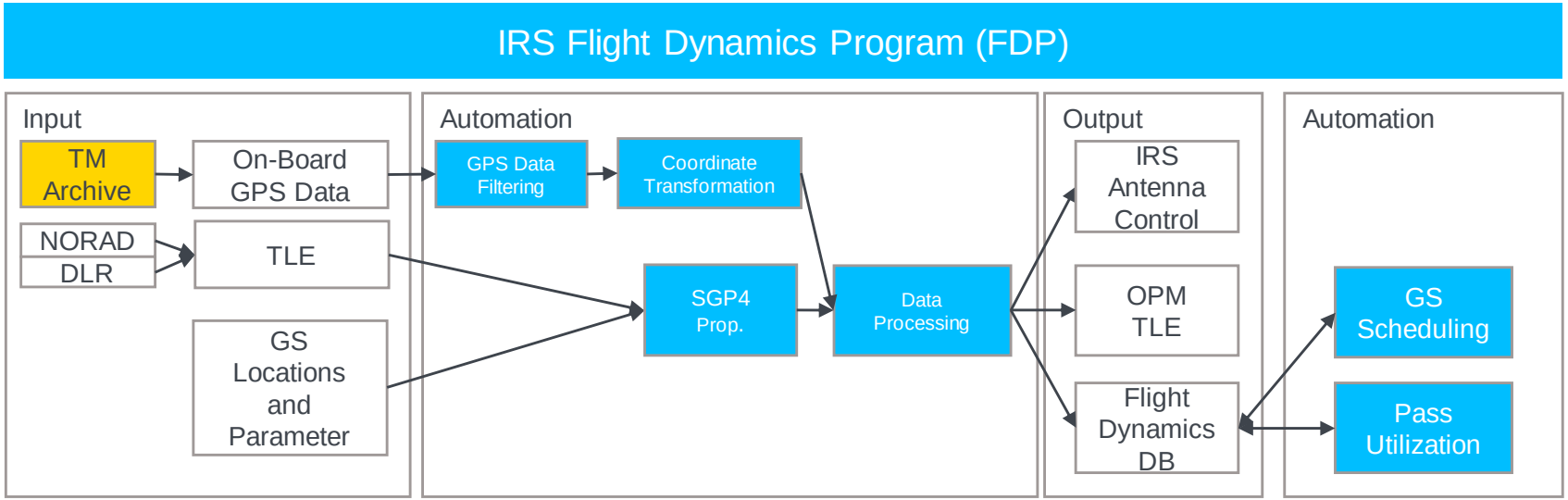


Overview: Ground Segment Automation Tools



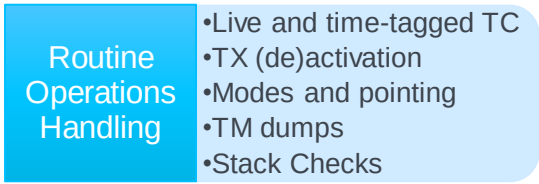
Mission Planning
Flight Dynamics Program

- 2x daily GPS data processing and OPM/TLE generation
- SGP4 and TLEs used for daily 4 week orbit propagation
- Weekly GS scheduling (including external GS) and pass utilization



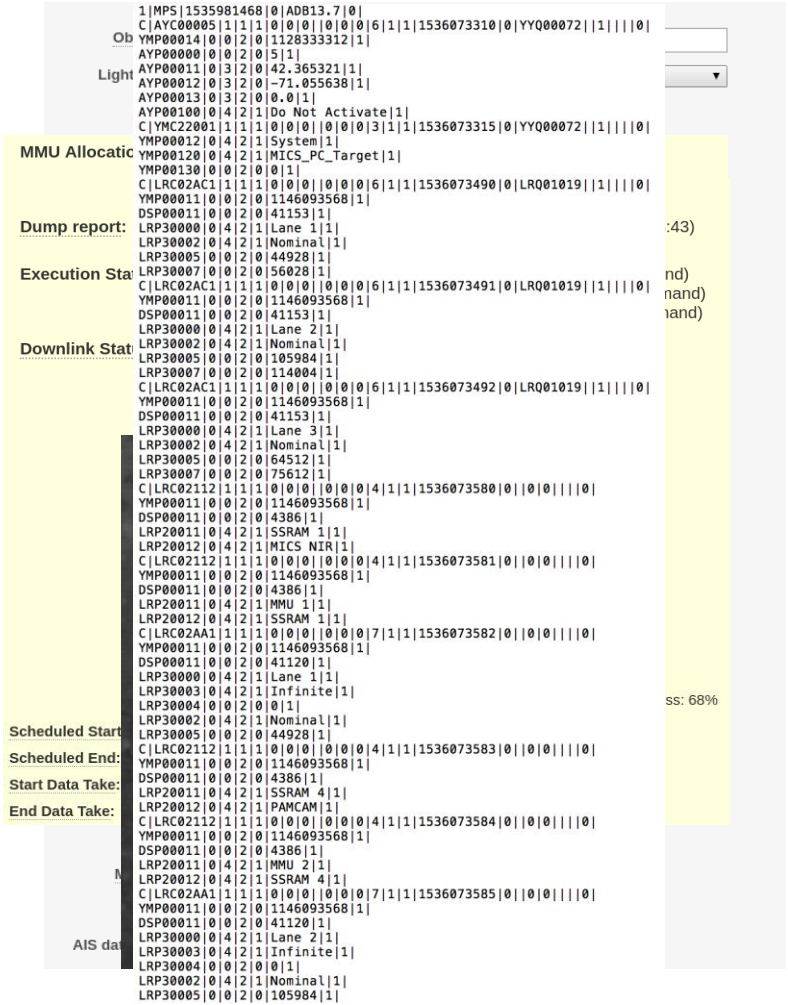
Mission Planning
Routine Operations Handling

- Handles all time-tagged activities between two uplink passes
  - Transmitter (de)activation
  - Mode changes and pointing manoeuvres
    - Handles overlapping passes
  - Telemetry dumps and deletion
  - All timings based on pass data in Flight Dynamics DB
- Live activities during the uplink pass
  - Spacecraft Green Check
  - Upload of TLE for on-board propagator
  - Communication Timer
- Command stack is automatically created before the pass



Mission Planning
Payload request handling

- User fills form for (non)-recurring data takes
- Starts observability calculation
  - Considering uplink passes, latest TLE and constraints
  - Observability Report
- Requests single data take or start campaign
  - On-board memory allocation
  - Conflict check with mission schedule
  - Payload dump pass allocation
  - Stack creation and uplink pass allocation
- Status tracking and email notifications
- Re-dumps are scheduled automatically

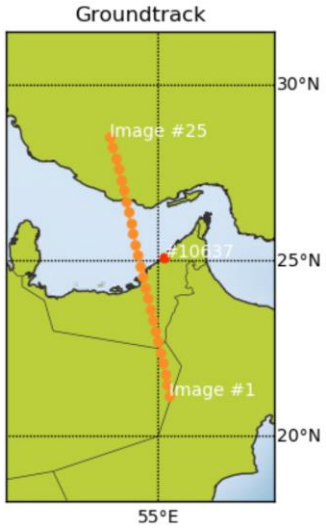


Payload Request Handling

Automatic
< 30 s

Manual
> 60 min

Visibility Start	2019-110T06:37:16
Max. elevation	83.0°
Sun angle at max. elev.	62.67°
Cloudinees	3%

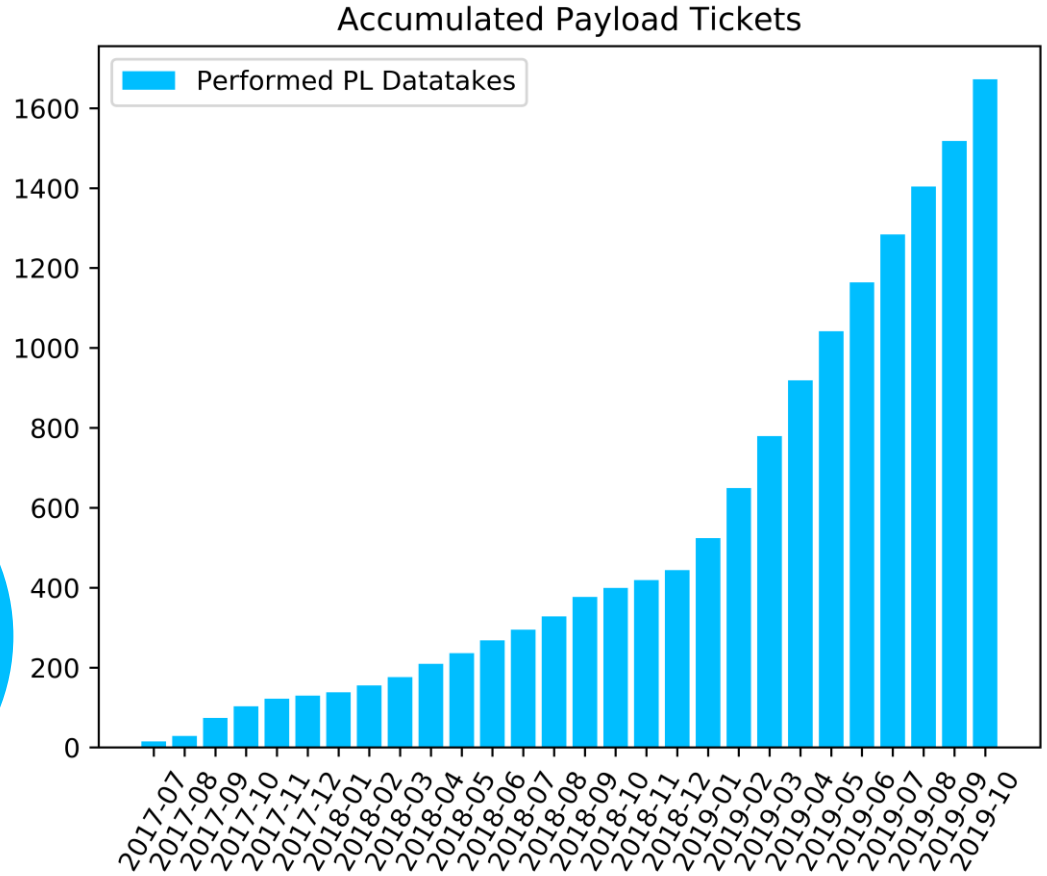


Payload Tickets

1672

Aktive parallele Kampagnen

24



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Thank you!

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FLP TM

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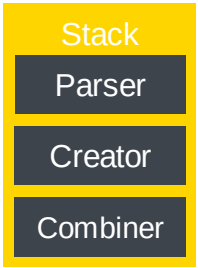
Workshop Ansätze

- Einschätzung/Vergleich Stand Missionsplanung und Satellitenbetrieb mit anderen Institutionen
- Was lief gut/schlecht bzw. würde sich besser machen lassen
- Relevanz für die Zukunft (weitere Missionen, Multimissionsfähigkeiten, neue Ansätze ...)

Mission Planning

Key Python Stack Module



- Stack Parser and Checker
  - Input: command stack file
  - Output: list of all TCs with calibrated parameters (MIB)
  - Check Report (critical commands, pointing, modes …)
- Stack Creator
  - Use Python syntax to create command stacks
  - Commands or sequences as objects with parameters as attributes
  - Render to different command stacks
  - Based on commands and procedures (seq.) from MIB
- Stack Combiner
  - Combines all stacks indented to be uplinked during a pass
  - Checks uplink duration with pass duration (flight dynamics db)

```
def setPamcamIntTime(stack, ex_time, int_pc):
    pcIntTime = S2Kstack.CMD('LPC000C5',mib)
    pcIntTime.setP('LPP00015',int_pc,0)
    pcIntTime.exTime.setRefTime(ex_time.timestamp())
    stack.addEle(pcIntTime)
    return stack
```