



**Universität Stuttgart**  
Institut für Raumfahrtssysteme



# Flying Laptop Abschlussworkshop

Missionsplanung und Satellitenbetrieb

Jonas Keim

# 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

The screenshot displays the Redmine interface for 'FLP Operations'. The top navigation bar includes 'Home', 'Projects', 'Help', and 'Sign in / Register'. A search bar is located on the right. The main navigation menu has tabs for 'Overview', 'Activity', 'Issues' (selected), 'Gantt', 'Calendar', 'Documents', 'Wiki', and 'Files'. The central content area shows an issue for 'Day #9720' from week #9705 (CW 8 2019) on 2019-02-20. The issue was added by 'Stack Bot' 10 months ago and updated 10 months ago. The issue details are as follows:

|                  |           |                    |            |
|------------------|-----------|--------------------|------------|
| <b>Status:</b>   | New       | <b>Start date:</b> | 2019-02-20 |
| <b>Priority:</b> | Normal    | <b>Due date:</b>   | 2019-02-21 |
| <b>Day:</b>      | Wednesday |                    |            |

**Description**  
Day generated from FDP

**Subtasks**

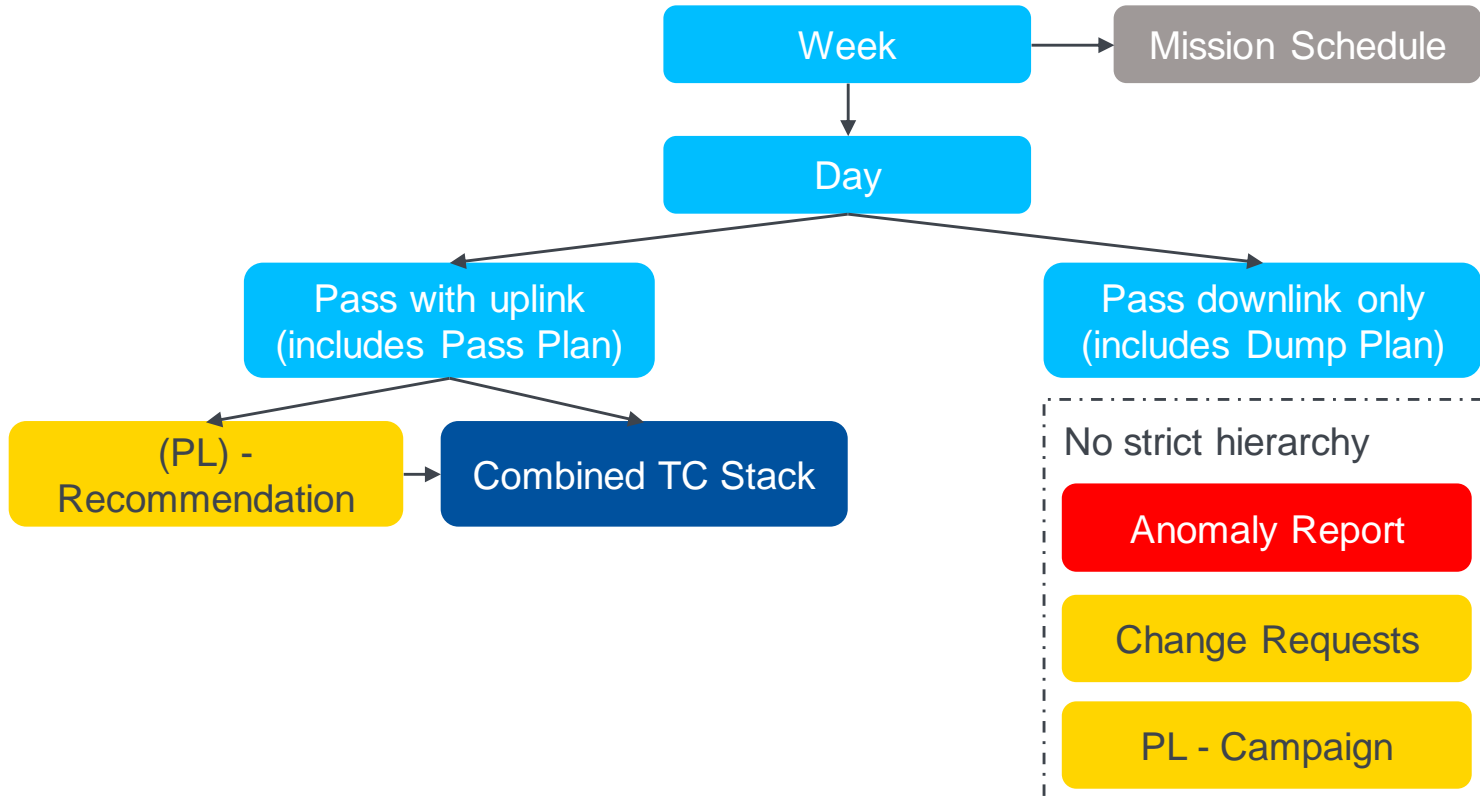
|  |                        |                  |
|--|------------------------|------------------|
| Pass downlink only #9721: NYA 2019-02-20T00:39:43.000Z | Planned                |                  |
| Pass downlink only #9722: NYA 2019-02-20T03:50:54.000Z | New                    |                  |
| Pass downlink only #9723: NYA 2019-02-20T07:01:54.000Z | New                    |                  |
| Pass with Uplink #9724: IRS 2019-02-20T08:28:48.771Z   | Planned                |                  |
| > PL Recommendation #9701: DTU Full Moon 20.2.         | Stack ready for Uplink | Jona Petri       |
| > PL Recommendation #9755: 5. Taiwan                   | Stack ready for Uplink | Sebastian Wenzel |
| > TC Stack #9777: TC Stack for Pass 9724               | New                    |                  |
| > PL Recommendation #9781: AIS Test Data Take          | Stack ready for Uplink |                  |
| > Recommendation #9787: Turn on Kalman TM for Tests    | Approved               | Steffen Gaisser  |
| Pass downlink only #9725: IRS 2019-02-20T10:04:15.211Z | New                    |                  |
| Pass downlink only #9726: IRS 2019-02-20T23:18:57.500Z | Planned                |                  |

**Issues**  
View all issues  
Summary  
Calendar  
Gantt

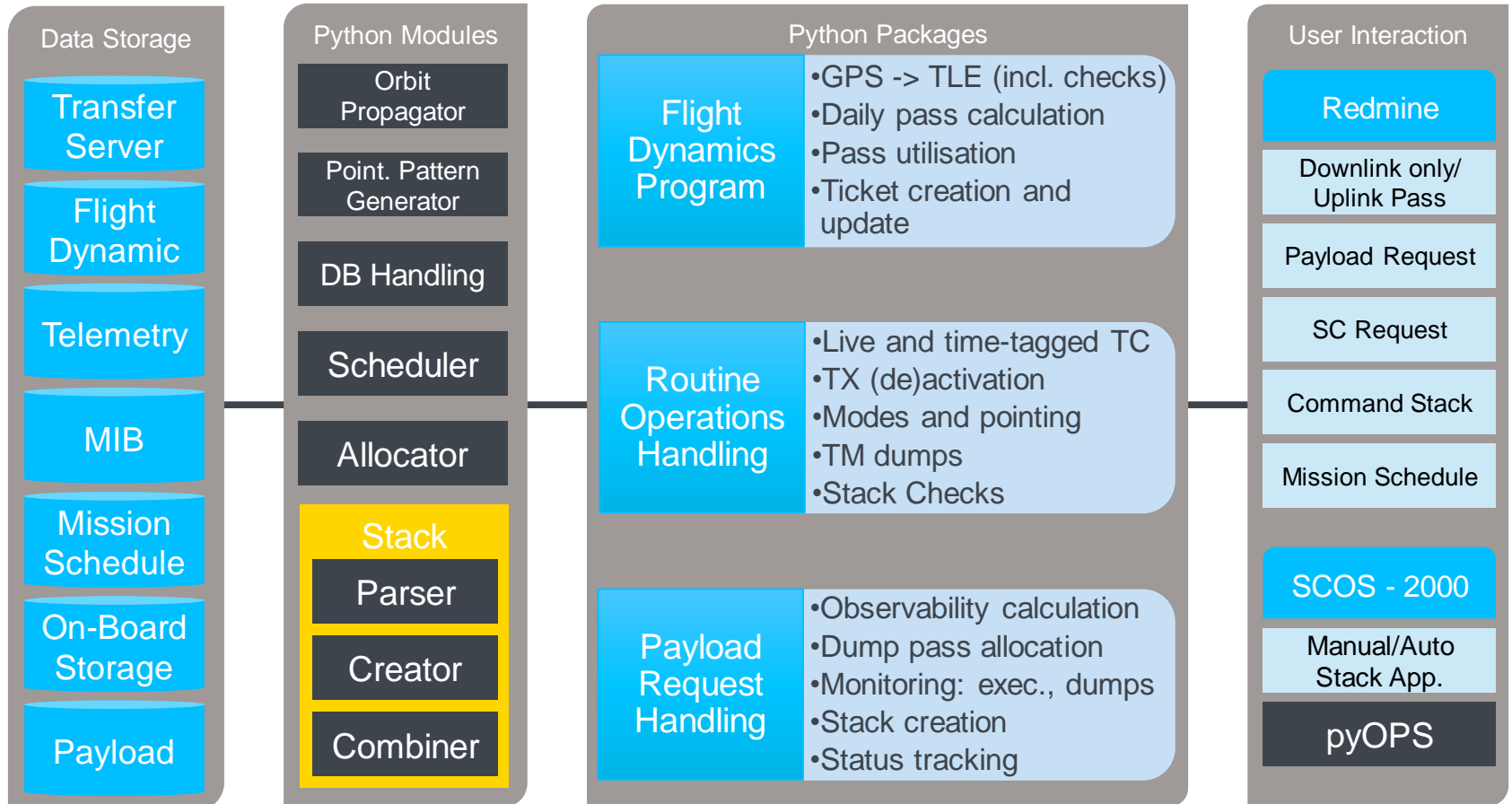
**Custom queries**  
Assigned to me  
Check Campaigns  
Executed PL Procedures to be downlinked  
Open REcommendations  
Ready for Uplink  
show passes with uplink  
Today's Activities

# Satellite Operations Documentation and Mission Planning

## Redmine Issues Overview and Hierarchy



# Overview: Ground Segment Automation Tools



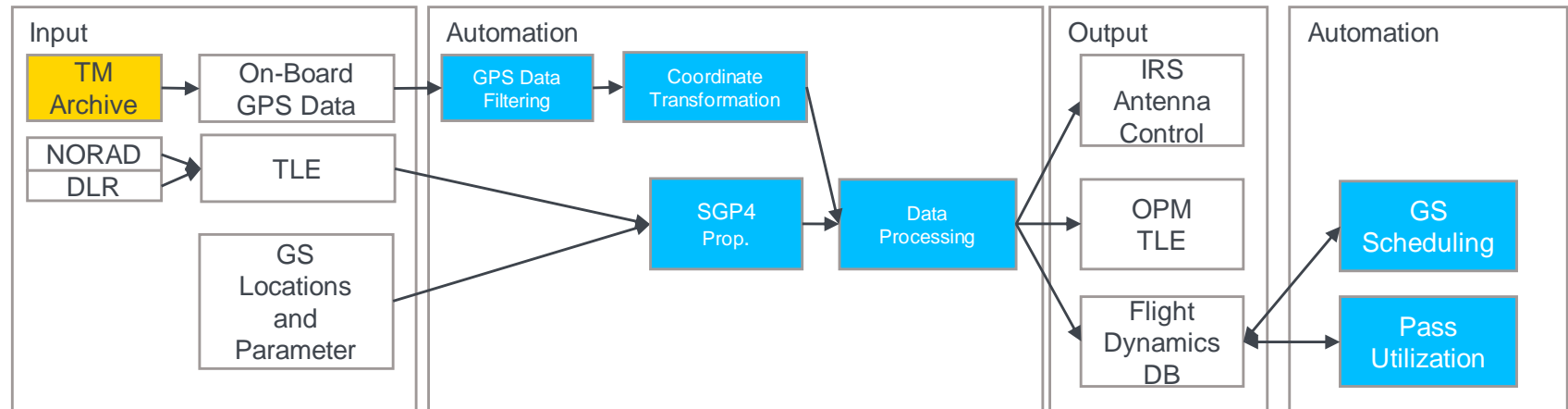


# Mission Planning

## 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

### IRS Flight Dynamics Program (FDP)



# 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

### Routine Operations Handling

- Live and time-tagged TC
- TX (de)activation
- Modes and pointing
- TM dumps
- Stack Checks

# 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

```

1MPS [1535981468 |0|ADB13.7|0|
C|AYC00005|1|1|1|0|0|0|0|6|1|1|1536073310|YY000072|1|1|1|0|
Ob   YMP00014|0|0|2|0|112833332|1|
   AYPO0000|0|0|2|0|5|1|
Ligh AYPO0011|0|3|2|0|42.365321|1|
   AYPO0012|0|3|2|0|-71.055638|1|
   AYPO0013|0|3|2|0|0.0|1|
   AYP00100|0|4|2|1|Do Not Activate|1|
   C|YMC22001|1|1|1|0|0|0|0|0|0|3|1|1|1536073315|YY000072|1|1|1|0|0|
   YMP00012|0|4|2|1|System|1|
MMU Allocat YMP00120|0|4|2|1|MICS_PC_Target|1|
   YMP00130|0|0|2|0|0|1|
   C|LR02AC1|1|1|1|0|0|0|0|6|1|1|1536073490|LR001019|1|1|1|0|0|
   YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|41153|1|
Dump report: LRP30000|0|4|2|1|Lane 1|1|
   LRP30002|0|4|2|1|Nominal|1|
   LRP30005|0|0|2|0|44928|1|
Execution Sta LRP30007|0|0|2|0|56028|1|
   C|LR02AC1|1|1|1|0|0|0|0|0|0|6|1|1|1536073491|LR001019|1|1|1|0|0|
   YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|41153|1|
   LRP30000|0|4|2|1|Lane 2|1|
Downlink Stat LRP30002|0|4|2|1|Nominal|1|
   LRP30005|0|0|2|0|105984|1|
   LRP30007|0|0|2|0|114004|1|
   C|LR02AC1|1|1|1|0|0|0|0|0|0|6|1|1|1536073492|LR001019|1|1|1|0|0|
   YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|41153|1|
   LRP30000|0|4|2|1|Lane 3|1|
   LRP30002|0|4|2|1|Nominal|1|
   LRP30005|0|0|2|0|64512|1|
   LRP30007|0|0|2|0|75612|1|
   C|LR02112|1|1|1|0|0|0|0|0|0|4|1|1|1536073580|0|0|0|0|0|0|0|
   YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|4386|1|
   LRP20011|0|4|2|1|SSRAM 1|1|
   LRP20012|0|4|2|1|MICS NIR|1|
   C|LR02112|1|1|1|0|0|0|0|0|0|4|1|1|1536073581|0|0|0|0|0|0|0|
   YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|4386|1|
   LRP20011|0|4|2|1|MMU 1|1|
   LRP20012|0|4|2|1|SSRAM 1|1|
   C|LR02AA1|1|1|1|0|0|0|0|0|0|7|1|1|1536073582|0|0|0|0|0|0|0|
   YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|41120|1|
   LRP30000|0|4|2|1|Lane 1|1|
   LRP30003|0|4|2|1|Infinite|1|
   LRP30004|0|0|2|0|0|1|
   LRP30002|0|4|2|1|Nominal|1|
Scheduled Start LRP30005|0|0|2|0|44928|1|
   C|LR02112|1|1|1|0|0|0|0|0|0|4|1|1|1536073583|0|0|0|0|0|0|0|
Scheduled End: YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|4386|1|
Start Data Take: LRP20011|0|4|2|1|SSRAM 4|1|
   LRP20012|0|4|2|1|PAMCAM|1|
   C|LR02112|1|1|1|0|0|0|0|0|0|4|1|1|1536073584|0|0|0|0|0|0|0|
End Data Take: YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|4386|1|
   LRP20011|0|4|2|1|MMU 2|1|
   LRP20012|0|4|2|1|SSRAM 4|1|
   C|LR02AA1|1|1|1|0|0|0|0|0|0|7|1|1|1536073585|0|0|0|0|0|0|0|
   YMP00011|0|0|2|0|1146093568|1|
   DSP00011|0|0|2|0|41120|1|
AIS data LRP30000|0|4|2|1|Lane 2|1|
   LRP30003|0|4|2|1|Infinite|1|
   LRP30004|0|0|2|0|0|1|
   LRP30002|0|4|2|1|Nominal|1|
   LRP30005|0|0|2|0|105984|1|

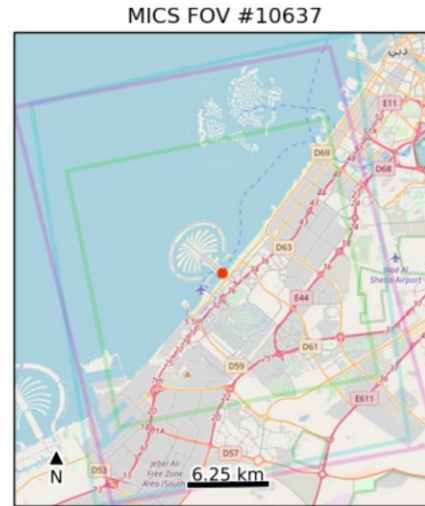
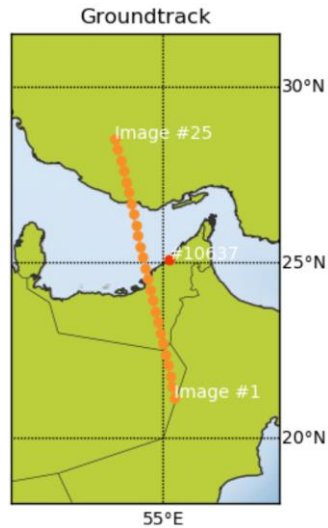
```

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°            |
| Cloudiness              | 3%                |

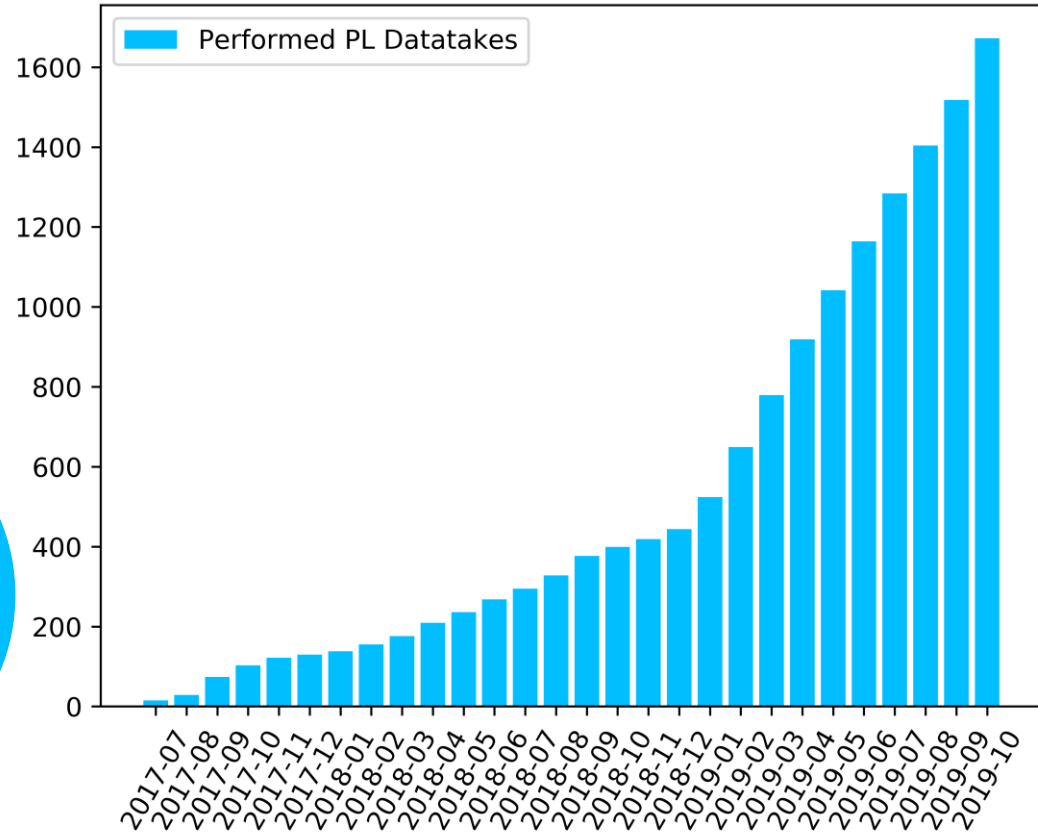


Payload  
Tickets  
1672

Aktive  
parallele  
Kampagnen

24

Accumulated Payload Tickets





University of Stuttgart  
Institute of Space Systems

Thank you!



**Jonas Keim, M.Sc.**

e-mail [keim@irs.uni-stuttgart.de](mailto:keim@irs.uni-stuttgart.de)

phone +49 (0) 711 685- 69606

University of Stuttgart  
Institute of Space Systems  
Pfaffenwaldring 29, 70569 Stuttgart

FLP TM



[doi.org/10.18419/darus-451](https://doi.org/10.18419/darus-451)

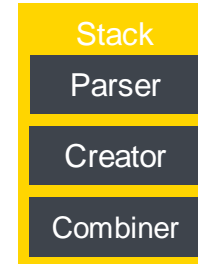
# Workshop Ansätze

- 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.COMD('LPC000C5', mib)  
    pcIntTime.setP('LPP00015', int_pc, 0)  
    pcIntTime.exTime.setRefTime(ex_time.timestamp())  
    stack.addEle(pcIntTime)  
    return stack
```