# A Historical Review of Logistics Mass and Crew Time Demands for ISS Operations

**Chase Lynch, Andrew C. Owens, Nicole Piontek, and William Cirillo (Retired)**
*Systems Analysis and Concepts Directorate (SACD), NASA Langley Research Center, Hampton, VA, 23681*

**Chel Stromgren, Jon M. Vega, Jacob D. Kulikowski, and Ari Drake**
*Binera, Inc., Rockville, MD, 20852*

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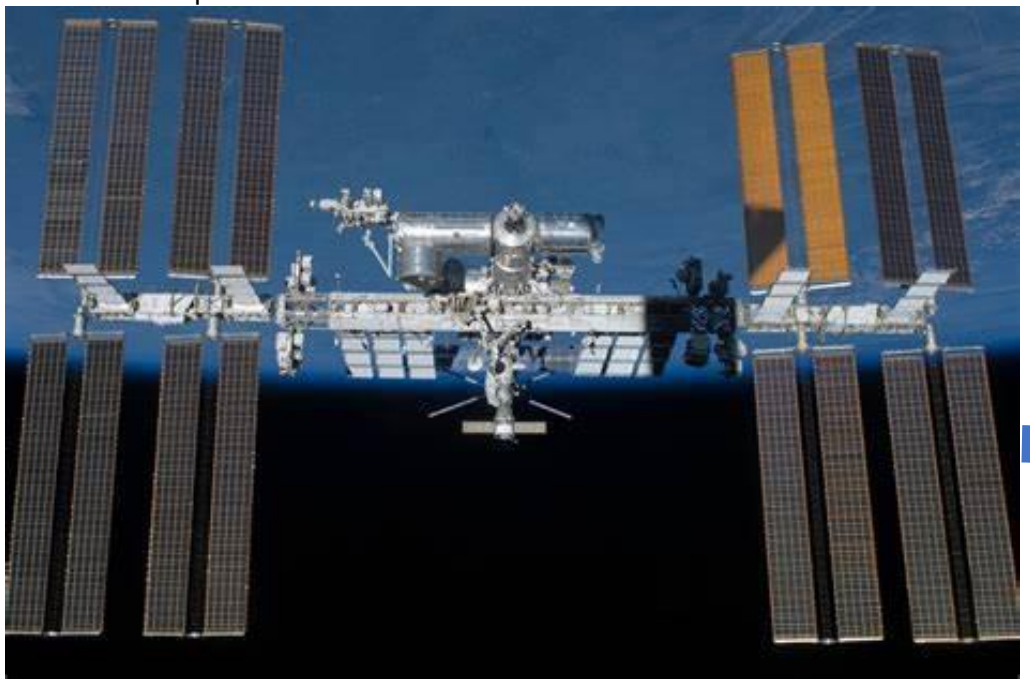
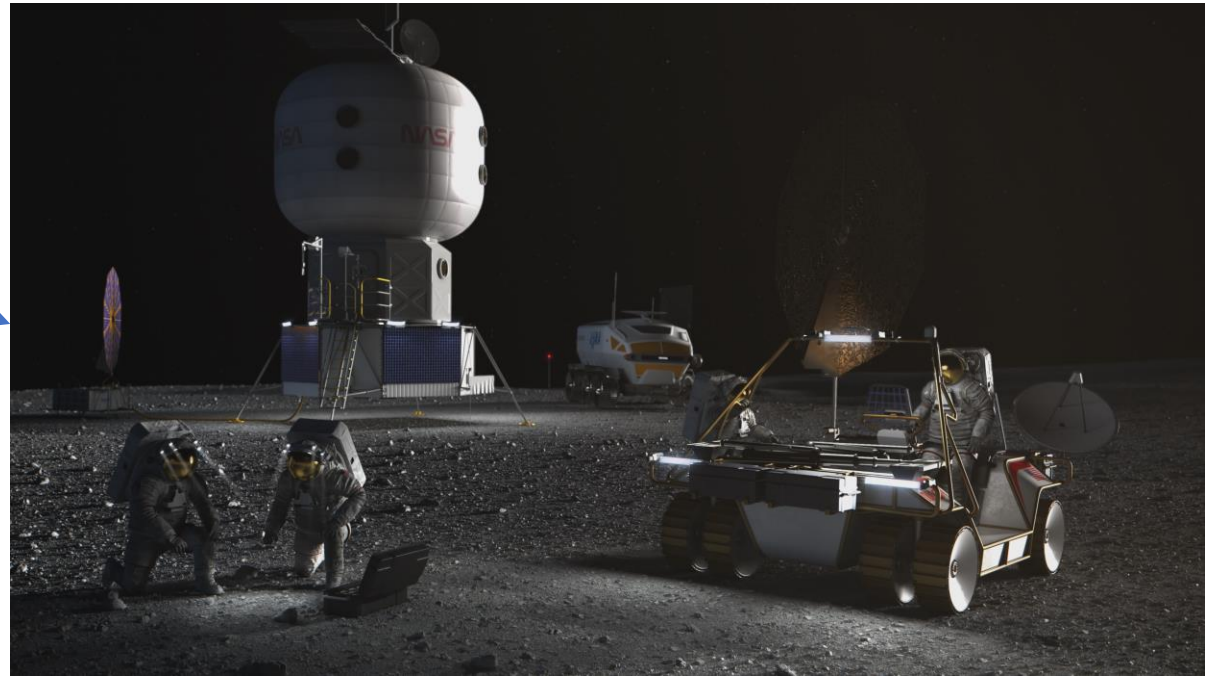
# Introduction

International Space Station - NASA



Over 20 years of continuous crewed missions
System knowledge and data
Wide variety of missions and operations

Beyond Low Earth Orbit (LEO)
Some known systems, some in development
Decreased capability of quick resupply



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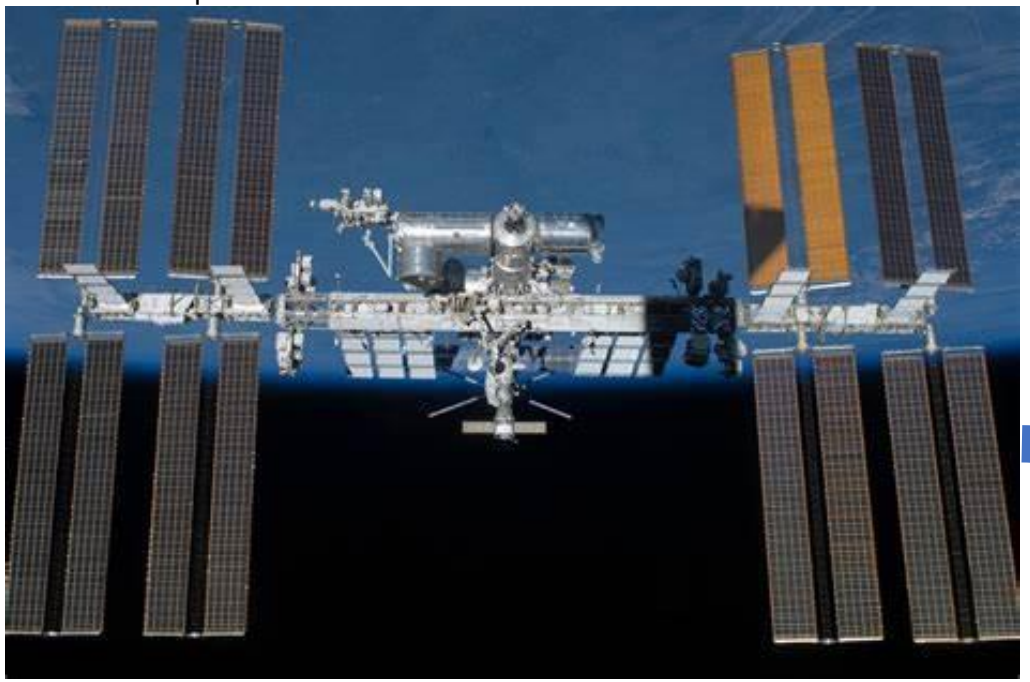

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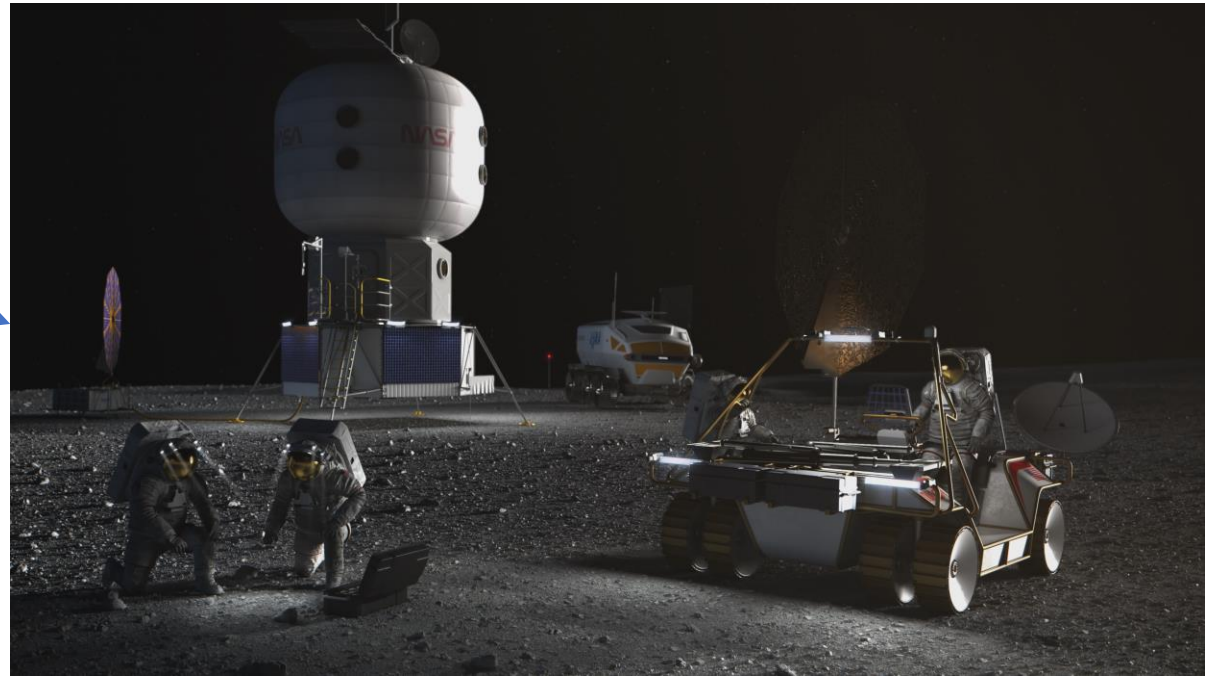

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***As we venture further into the cosmos, margin of error decreases. To best plan for lunar and Mars missions, it is necessary to examine and fully understand what has been required for historical human spaceflight missions.***

# Sources and Categorization

Operations Planning Timeline Integration System (OPTimIS)

Mission Integration Database Application System (MIDAS)

*Raw Data*

***Text Processor***

*Categorized Data*

| Category | Sub-Category | Major Activity |
|---|---|---|
| ***Work*** | ***Scheduled Operations*** | Vehicle Ops |
| | | Upkeep Ops |
| | | Outfitting |
| | | Medical |
| | | Extravehicular Activities (EVAs) |
| | | Logistics |
| | | Training |
| | | Exercise |
| | | Utilization |
| | ***Ops Prep and Conferences*** | Work Prep |
| | | Public Relations |
| | | Conferences |
| | | Tag-Ups |
| ***Non-Work*** | | Personal |
| | | Sleep |
| | | Meal |

| Category | Item |
|---|---|
| ***Consumables*** | Food |
| | Wipes and Gloves |
| | Health Care Consumables |
| | Waste Collection |
| | Operational Supplies |
| | Recreation and Personal Items |
| | Hygiene |
| | Clothing |
| | Towels |
| | EVA Consumables |
| ***Maintenance*** | Scheduled Maintenance |
| | Tools |
| ***Spares*** | |
| ***Utilization*** | |
| ***Outfitting*** | |
| ***Packaging*** | Individual Packaging |
| | Tanks |
| | Cargo Transfer Bags (CTBs) |

# Data Processing Format

***OPTimIS processor works in similar format***

## Logistics Data Processor

**Step 1:**
Organization "VehicleHardware" contains 4 potential logistics categories in the organization library.

| MIDAS Organization Entry: |
|---|
| VehicleHardware |
| **Potential Logistics Cats:** |
| Consumables |
| Maintenance |
| Spares |
| Outfitting |

**Step 2&3:**
Subcategory "Support" does not list Outfitting as a potential category, and Subsystem "USA IVA TOOLS" does not list Spares as a potential option, reducing the potential categories from 4 to 2.

| MIDAS Subcategory Entry: |
|---|
| Support |
| **Potential Logistics Cats:** |
| Consumables |
| Maintenance |
| Spares |
| ~~Outfitting~~ |

| MIDAS Subsystem Entry: |
|---|
| USA IVA TOOLS |
| **Potential Logistics Cats:** |
| Consumables |
| Maintenance |
| ~~Spares~~ |
| ~~Outfitting~~ |

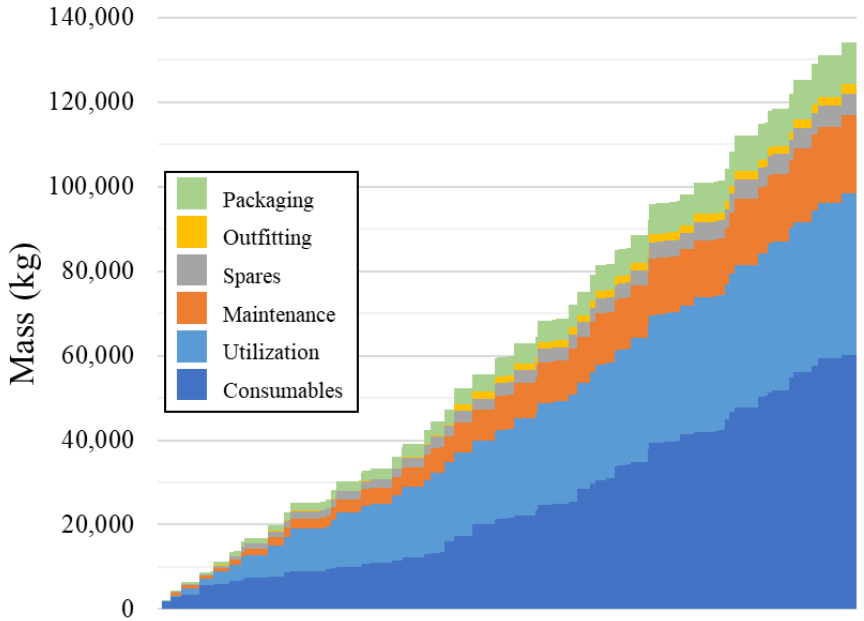
| Keyword Identified: |
|---|
| Ratchet |
| **Potential Logistics Cats:** |
| ~~Consumables~~ |
| **Maintenance** |
| ~~Spares~~ |
| ~~Outfitting~~ |

**Step 4:**
The word "Ratchet" in the item name is listed in the keyword library associated with the Maintenance logistics category.

## MIDAS Starting Data

| Data Type: | Data Entry: |
|---|---|
| **Item Name** | RATCHET, SEALED, 1/4" DRIVE, 4-1/2" LONG |
| **Item Organization** | VehicleHardware |
| **Item Subcategory** | Support |
| **Item Subsystem** | USA IVA TOOLS |

# ISS Mass and Crew Time Needs




Maintenance: ~18,000 kg

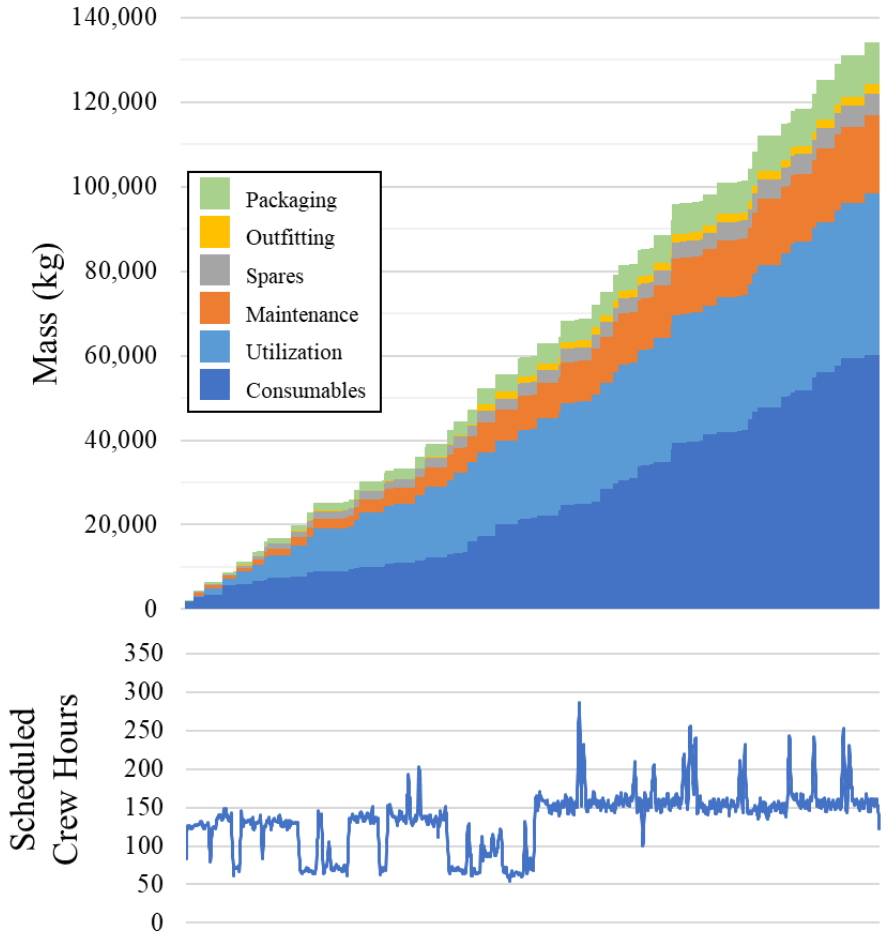
Utilization: ~38,000 kg

Consumables: ~60,000 kg

Packaging: ~10,000 kg
Outfitting: ~2,200 kg
Spares: ~5,000 kg

*Results are shown from October 1, 2017, to December 31, 2023*

# ISS Mass and Crew Time Needs

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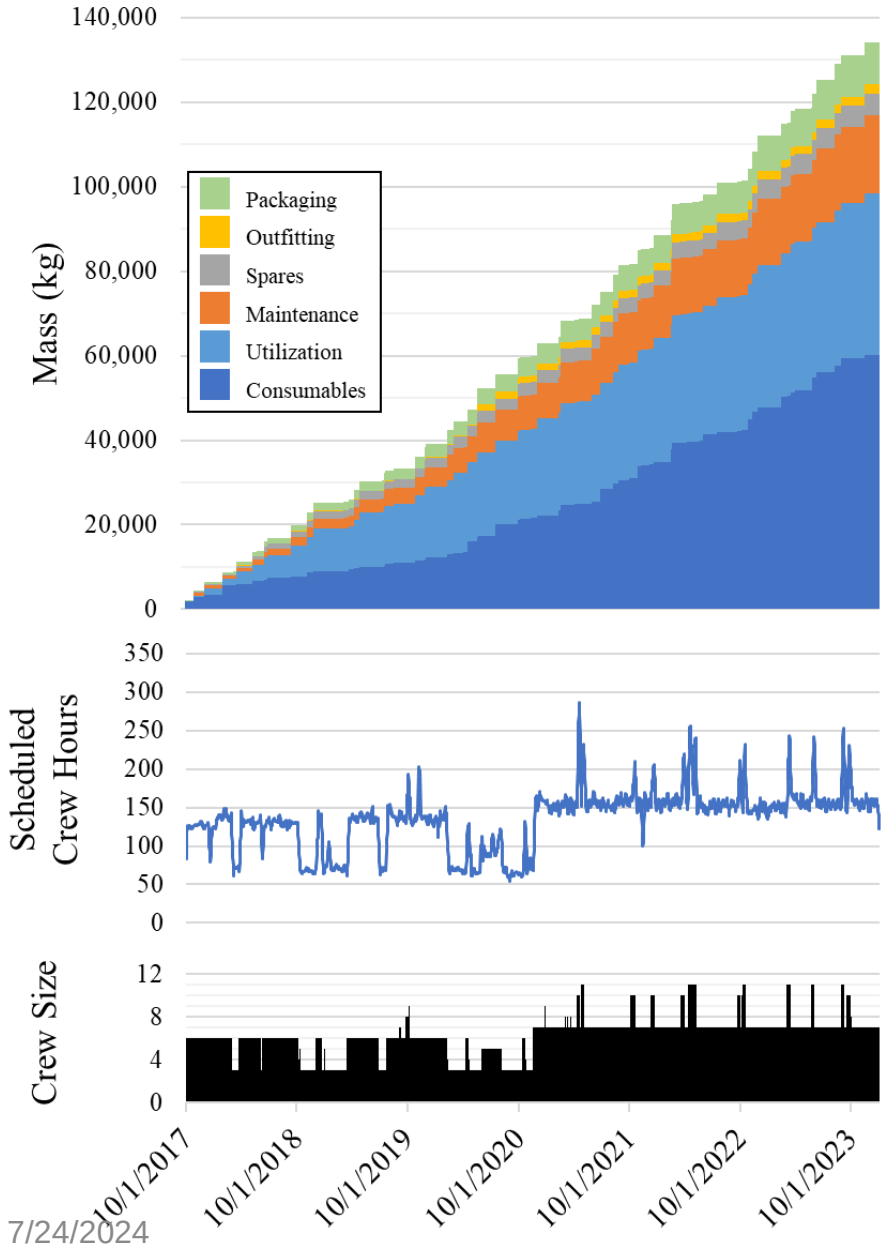


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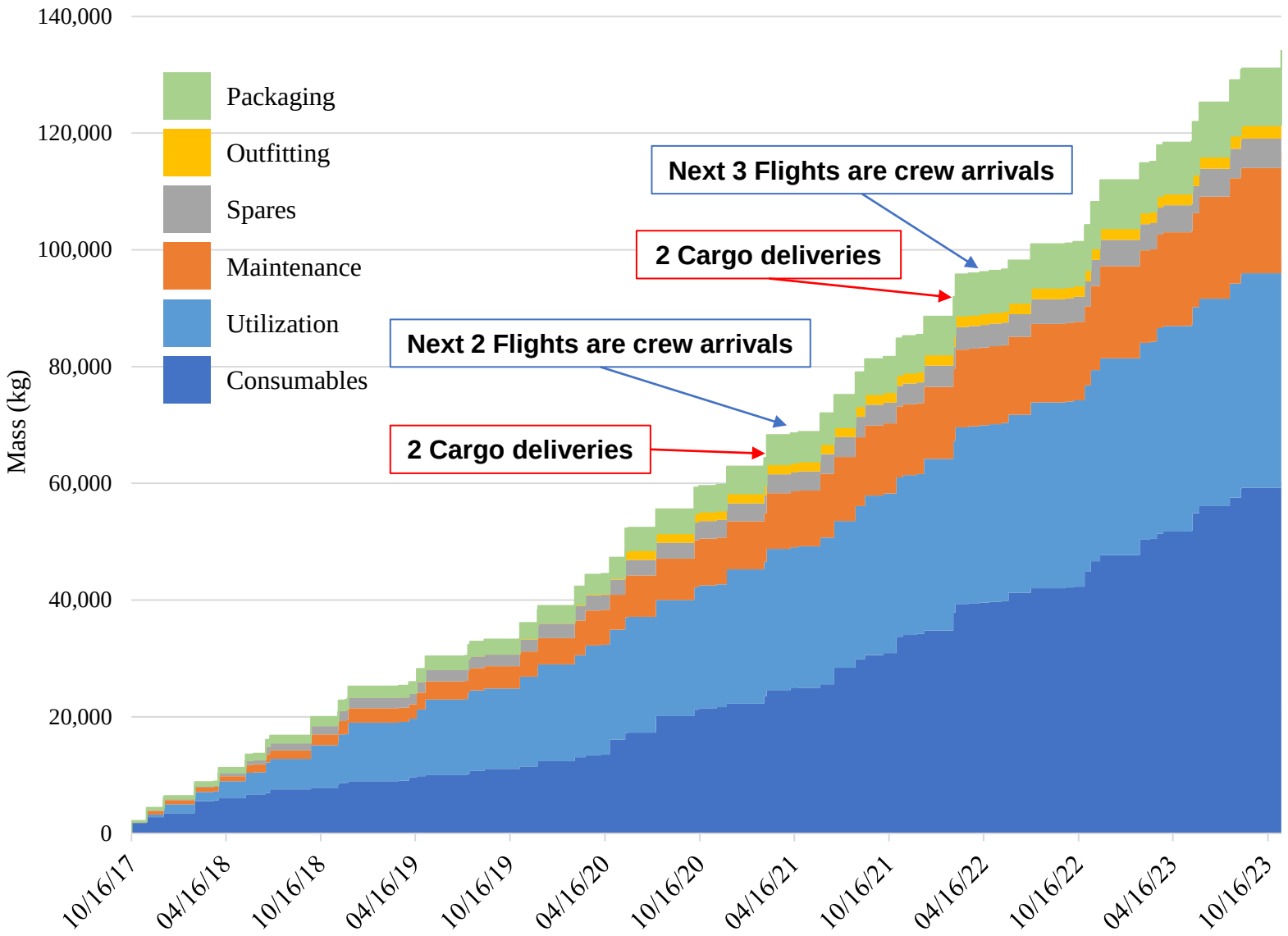
Total Scheduled Crew Hours : ~309,000 hrs

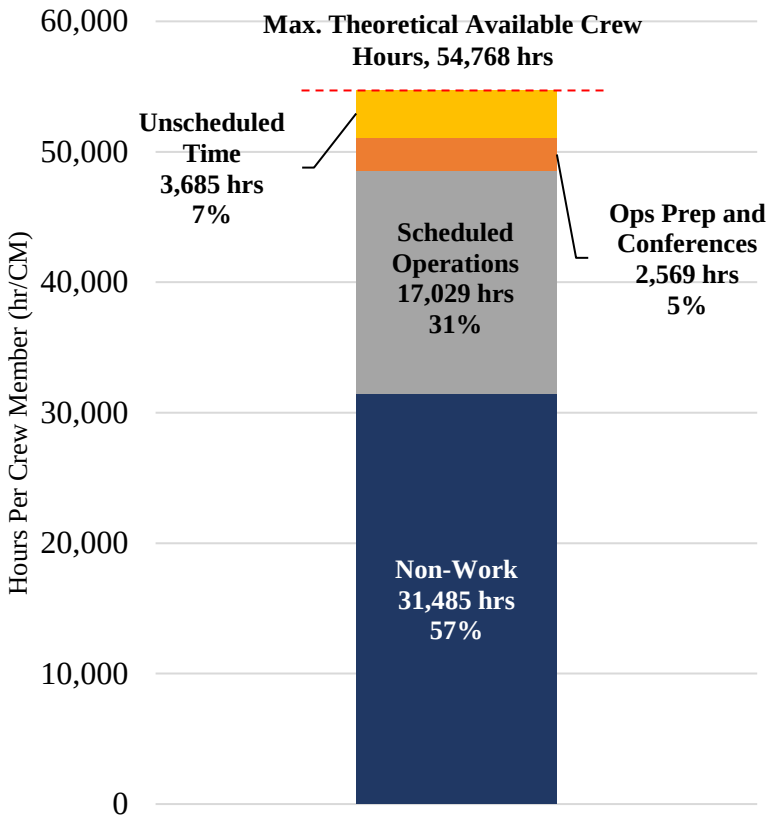
Min. of 3 Crew
Max. of 11 Crew
Median of 7 Crew

# Logistics Overview




- Endurance is one of the largest driver of logistics supply needs
- New crew will need additional personal items, adding to logistics delivery mass
- Many large cargo deliveries are in preparation of subsequent new crew arrivals

# Crew Time Overview



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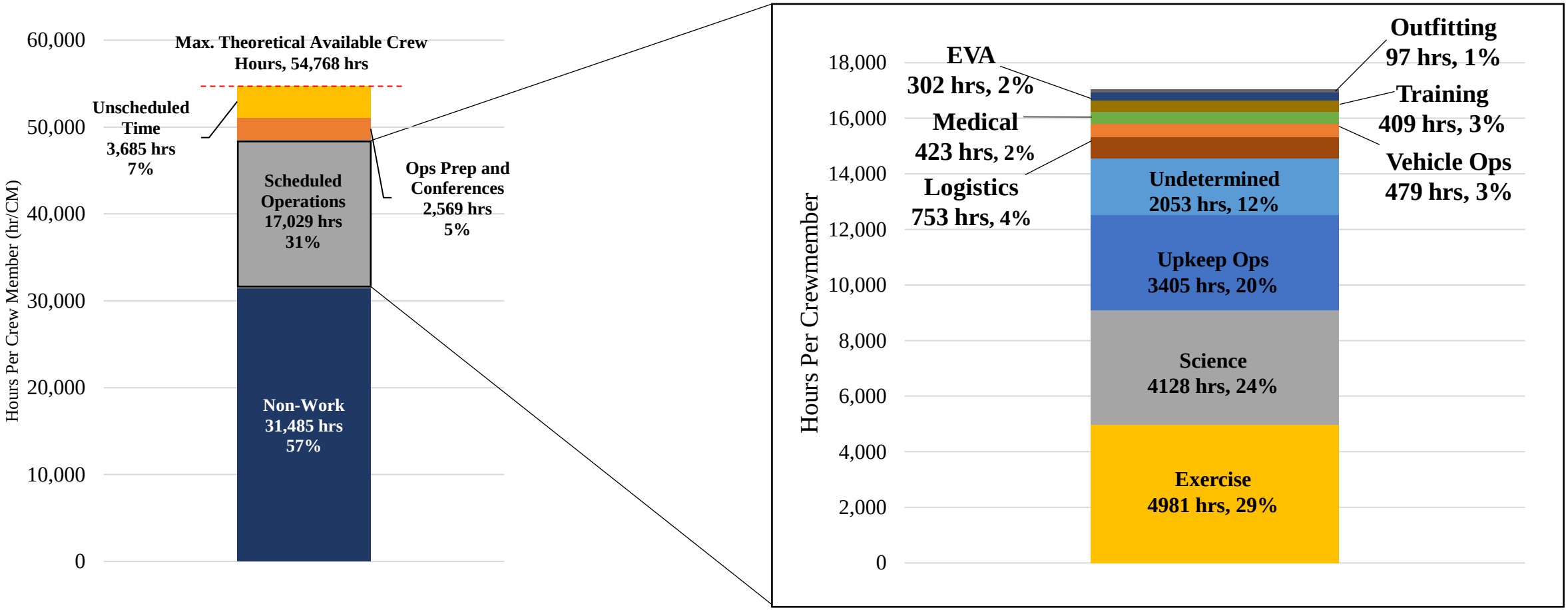
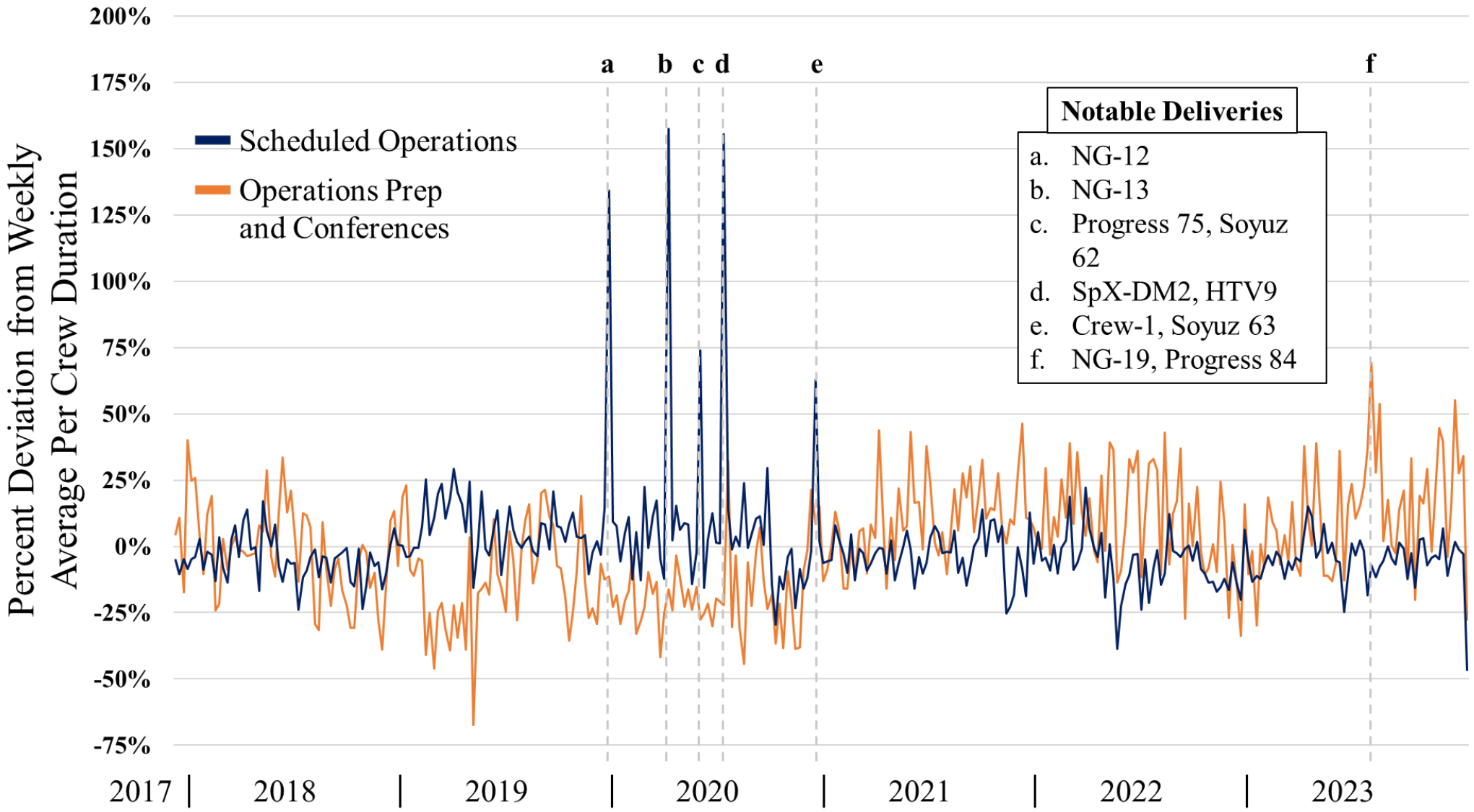
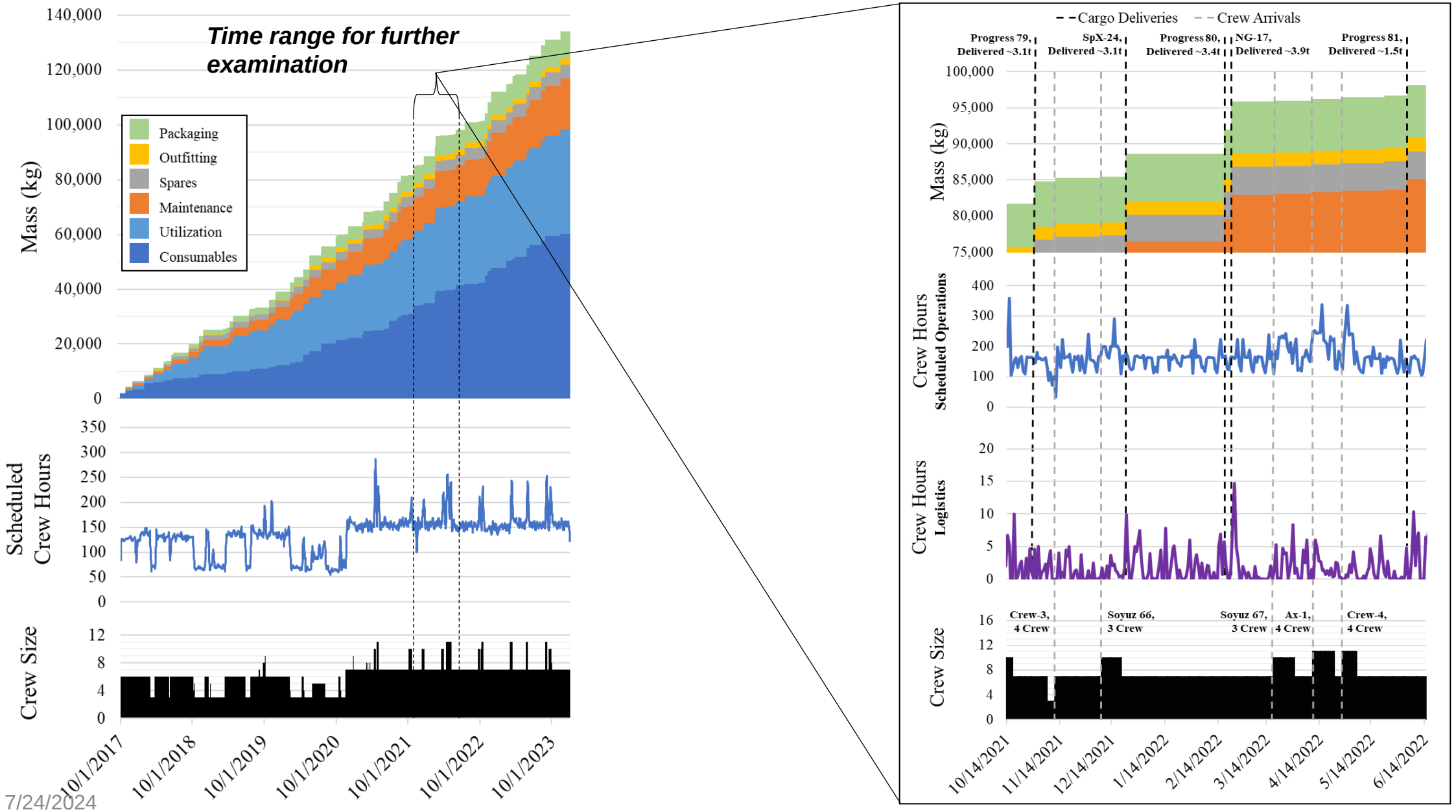


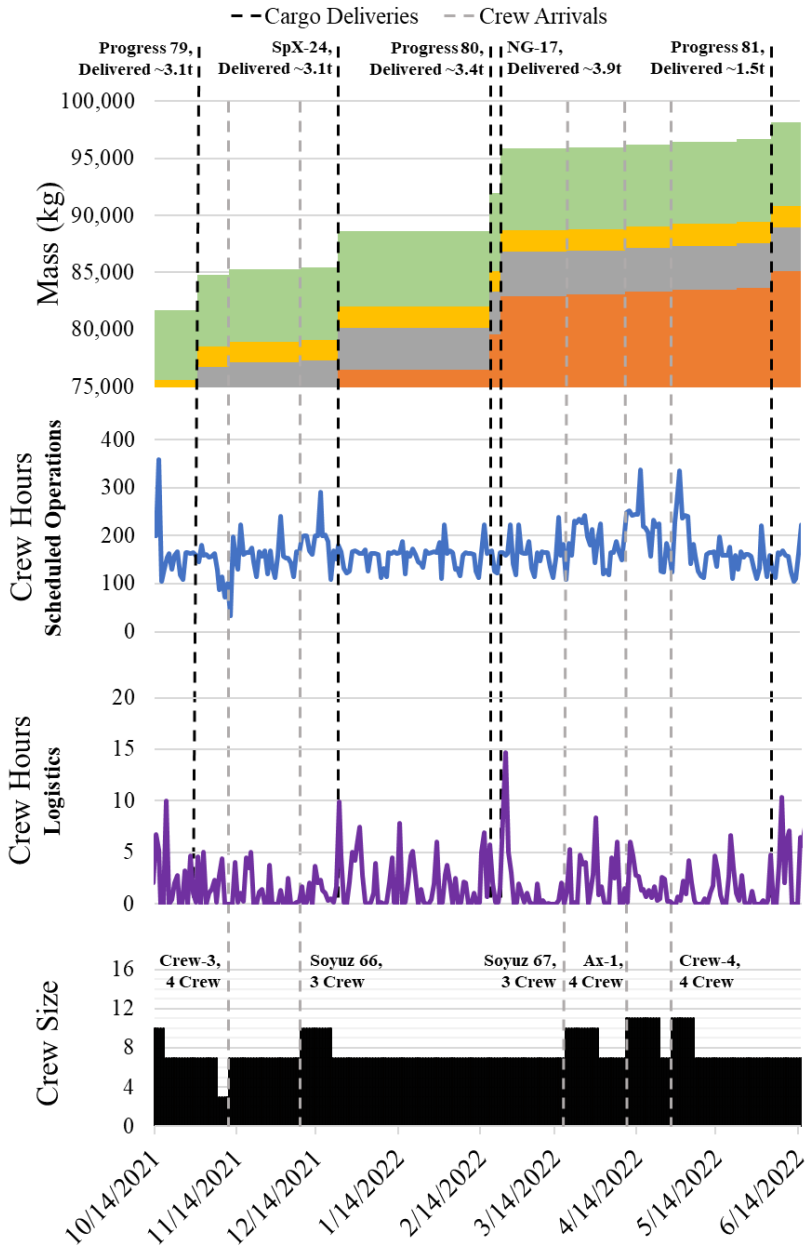
# Crew Operations and Time



# Closer Look


Time range for further examination
Mass (kg)
Packaging
Outfitting
Spares
Maintenance
Utilization
Consumables
Scheduled Crew Hours
Crew Size
10/1/2017
10/1/2018
10/1/2019
10/1/2020
10/1/2021
10/1/2022
10/1/2023
Cargo Deliveries
Crew Arrivals
Progress 79, Delivered ~3.1t
SpX-24, Delivered ~3.1t
Progress 80, Delivered ~3.4t
NG-17, Delivered ~3.9t
Progress 81, Delivered ~1.5t
Crew Hours Scheduled Operations
Crew Hours Logistics
Crew-3, 4 Crew
Soyuz 66, 3 Crew
Soyuz 67, 3 Crew
Ax-1, 4 Crew
Crew-4, 4 Crew
10/14/2021
11/14/2021
12/14/2021
1/14/2022
2/14/2022
3/14/2022
4/14/2022
5/14/2022
6/14/2022

# Integrated Results of Highlighted Region




- Large logistics deliveries in preparation for crew arrivals
- Scheduled crew hours peak with changes in crew size
- Highest peaks occur following new crew arrivals
- Increases in crew time on logistics following cargo deliveries

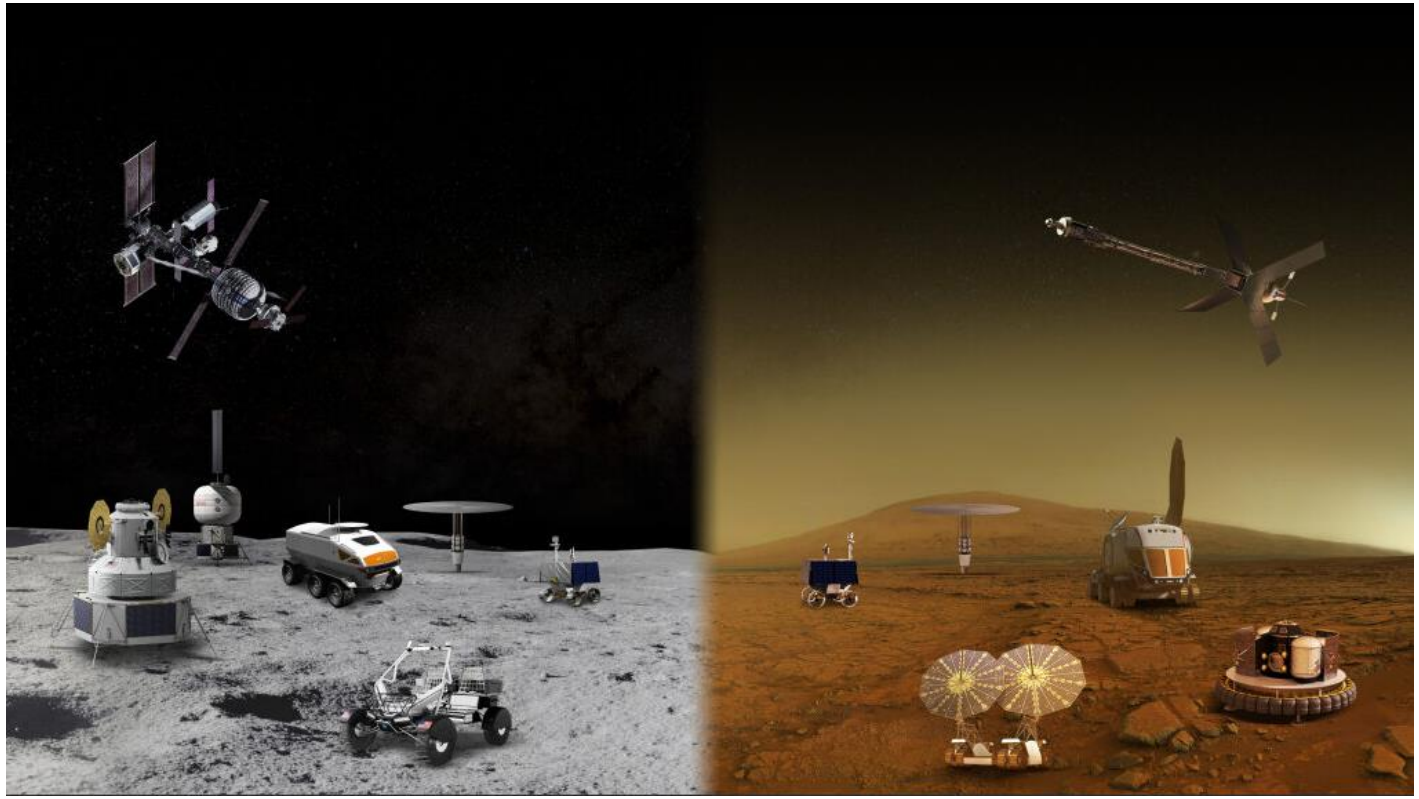
# Connections to Beyond LEO

**Lunar Surface Considerations**

- Short crewed mission durations
- High cost
- Gravity environment
- Dust

**Mars Transit Considerations**

- Long crewed mission duration
- No planned resupply
- Inability to quickly abort



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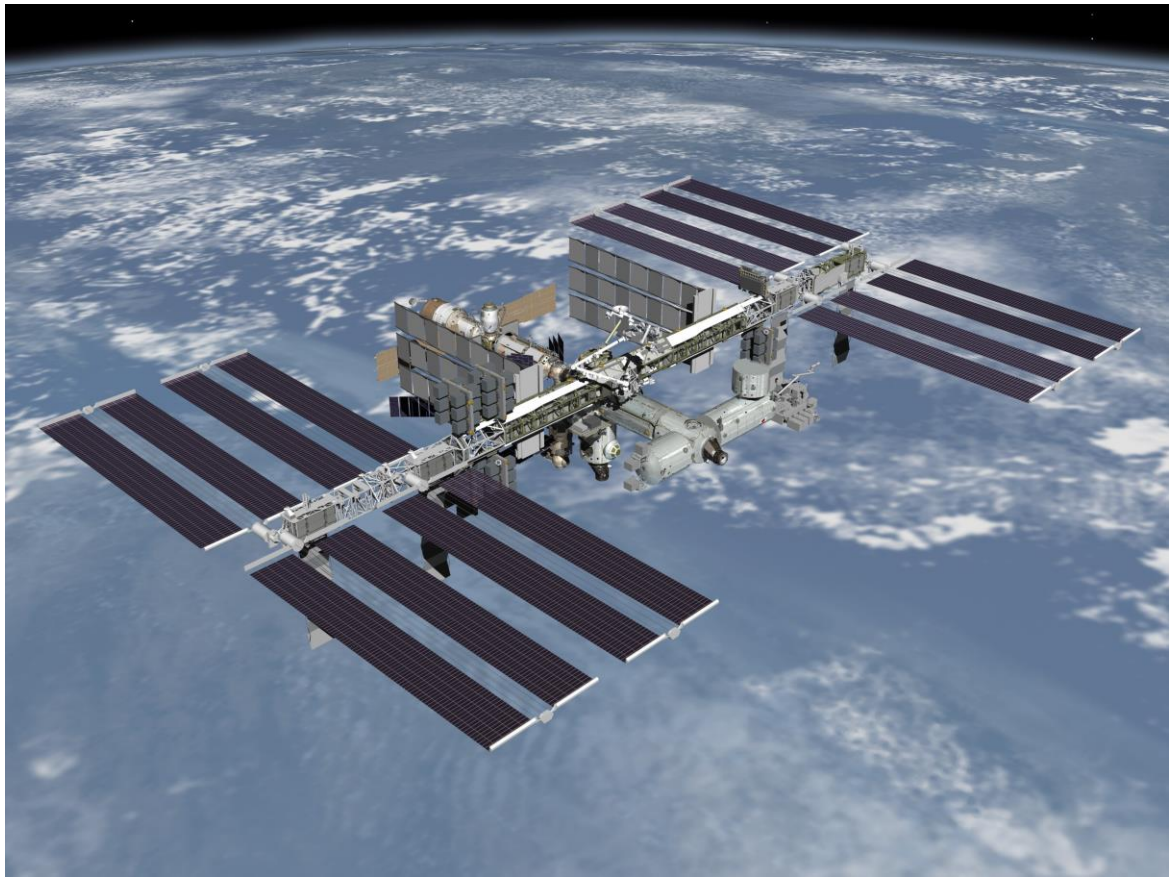
# Conclusion

- **Historical ISS logistics mass and crew time allocations provide a baseline to inform future mission design.**
- **Over 6.25 years of ISS operations between October 2017 and December 2023:**
  - >134,000kg logistics delivered
  - >17,000 hours of crew work activities per crew member
- **Future Work:**
  - Analyze specific logistics item deliveries and their role in mission objective
  - Map specific item and activity differences between ISS, surface missions, and Mars transit missions



International Space Station - NASA

# QUESTIONS

# Appendix

| Launch ID | Launch Name | Launch Date | Docking Date | Launch ID | Launch Name | Launch Date | Docking Date |
|---|---|---|---|---|---|---|---|
| 197 | Progress 68 | 10/14/2017 | 10/16/2017 | 237 | Progress 77 | 2/15/2021 | 2/17/2021 |
| 198 | OA-8 | 11/17/2017 | 11/14/2017 | 238 | NG-15 | 2/20/2021 | 2/22/2021 |
| 199 | SpX-13 | 12/15/2017 | 12/17/2017 | 239 | **Soyuz 64** | **4/9/2021** | **4/9/2021** |
| 200 | **Soyuz 53** | **12/17/2017** | **12/19/2017** | 240 | **Crew-2** | **4/23/2021** | **4/24/2021** |
| 201 | Progress 69 | 2/13/2018 | 2/15/2018 | 241 | SpX-22 | 6/3/2021 | 6/5/2021 |
| 202 | Soyuz 54 | 3/21/2018 | 3/23/2018 | 242 | Progress 78 | 6/29/2021 | 7/2/2021 |
| 203 | SpX-14 | 4/2/2018 | 4/2/2018 | 243 | Nauka | 7/21/2021 | 7/29/2021 |
| 204 | OA-9 | 5/21/2018 | 5/24/2018 | 244 | NG-16 | 8/10/2021 | 8/12/2021 |
| 205 | **Soyuz 55** | **6/6/2018** | **6/8/2018** | 245 | SpX-23 | 8/29/2021 | 8/30/2021 |
| 206 | SpX-15 | 6/29/2018 | 7/2/2018 | 246 | **Soyuz 65** | **10/5/2021** | **10/5/2021** |
| 207 | Progress 70 | 7/9/2018 | 7/10/2018 | 247 | Progress 79 | 10/28/2021 | 10/30/2021 |
| 208 | HTV7 | 9/22/2018 | 9/27/2018 | 248 | **Crew-3** | **11/11/2021** | **11/11/2021** |
| 209 | Progress 71 | 11/16/2018 | 11/18/2018 | 249 | Progress M-UM* | 11/24/2021 | 11/26/2021 |
| 210 | NG-10 | 11/17/2018 | 11/19/2018 | 250 | **Soyuz 66** | **12/8/2021** | **12/8/2021** |
| 211 | **Soyuz 57** | **12/3/2018** | **12/3/2018** | 251 | SpX-24 | 12/21/2021 | 12/22/2021 |
| 212 | SpX-16 | 12/5/2018 | 12/8/2018 | 252 | Progress 80 | 2/15/2022 | 2/17/2022 |
| 213 | SpX-DM1 | 3/2/2019 | 3/3/2019 | 253 | NG-17 | 2/19/2022 | 2/21/2022 |
| 214 | **Soyuz 58** | **3/14/2019** | **3/15/2019** | 254 | **Soyuz 67** | **3/18/2022** | **3/18/2022** |
| 215 | Progress 72 | 4/4/2019 | 4/4/2019 | 255 | Ax-1 | 4/8/2022 | 4/9/2022 |
| 216 | NG-11 | 4/17/2019 | 4/19/2019 | 256 | **Crew-4** | **4/27/2022** | **4/27/2022** |
| 217 | SpX-17 | 5/4/2019 | 5/6/2019 | 257 | Boe-OFT2 | 5/19/2022 | 5/21/2022 |
| 218 | **Soyuz 59** | **7/20/2019** | **7/20/2019** | 258 | Progress 81 | 6/3/2022 | 6/3/2022 |
| 219 | SpX-18 | 7/25/2019 | 7/27/2019 | 259 | SpX-25 | 7/15/2022 | 7/16/2022 |
| 220 | Progress 73 | 7/31/2019 | 7/31/2019 | 260 | **Soyuz 68** | **9/21/2022** | **9/21/2022** |
| 221 | **Soyuz 60** | **8/22/2019** | **8/27/2019** | 261 | **Crew-5** | **10/5/2022** | **10/6/2022** |
| 222 | HTV8 | 9/24/2019 | 9/28/2019 | 262 | Progress 82 | 10/26/2022 | 10/28/2022 |
| 223 | NG-12 | 11/2/2019 | 11/4/2019 | 263 | NG-18 | 11/7/2022 | 11/9/2022 |
| 224 | SpX-19 | 12/5/2019 | 12/8/2019 | 264 | SpX-26 | 11/26/2022 | 11/27/2022 |
| 225 | Progress 74 | 12/6/2019 | 12/9/2019 | 265 | Progress 83 | 2/9/2023 | 2/11/2023 |
| 226 | NG-13 | 2/15/2020 | 2/18/2020 | 266 | **Crew-6** | **3/2/2023** | **3/3/2023** |
| 227 | SpX-20 | 3/7/2020 | 3/9/2020 | 267 | SpX-27 | 3/15/2023 | 3/16/2023 |
| 228 | **Soyuz 62** | **4/9/2020** | **4/9/2020** | 268 | **Soyuz 69** | **3/28/2023** | **3/28/2023** |
| 229 | Progress 75 | 4/25/2020 | 4/25/2020 | 269 | Ax-2 | 5/21/2023 | 5/22/2023 |
| 230 | HTV9 | 5/20/2020 | 5/25/2020 | 270 | Progress 84 | 5/24/2023 | 5/24/2023 |
| 231 | SpX-Demo2 | 5/30/2020 | 5/31/2020 | 271 | SpX-28 | 6/5/2023 | 6/6/2023 |
| 232 | Progress 76 | 7/23/2020 | 7/23/2020 | 272 | NG-19 | 8/2/2023 | 8/4/2023 |
| 233 | NG-14 | 10/3/2020 | 10/5/2020 | 273 | Progress 85 | 8/23/2023 | 8/25/2023 |
| 234 | **Soyuz 63** | **10/14/2020** | **10/14/2020** | 274 | **Crew-7** | **8/26/2023** | **8/27/2023** |
| 235 | **Crew-1** | **11/16/2020** | **11/17/2020** | 275 | SpX-29 | 11/10/2023 | 11/11/2023 |
| 236 | SpX-21 | 12/6/2020 | 12/7/2020 | | | | |

**Crew flights in bold**

*** Progress M-UM delivered 0 kg logistics mass**