Launch Windows

How is Matthias Maurer going to join Thomas Pesquet's Halloween party?

Adrien CHARDON

2021-11-03

PTS.space - *Lunch & Learn*

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1. Introduction

Any Germans here? What's happening on this date?

Sun Nov 07, 2021 03:36 UTC

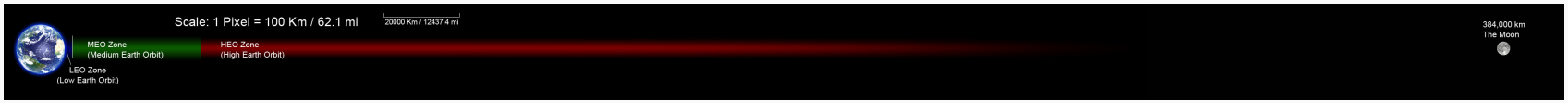
NASA's Crew-3 Mission

Source: [**?**]

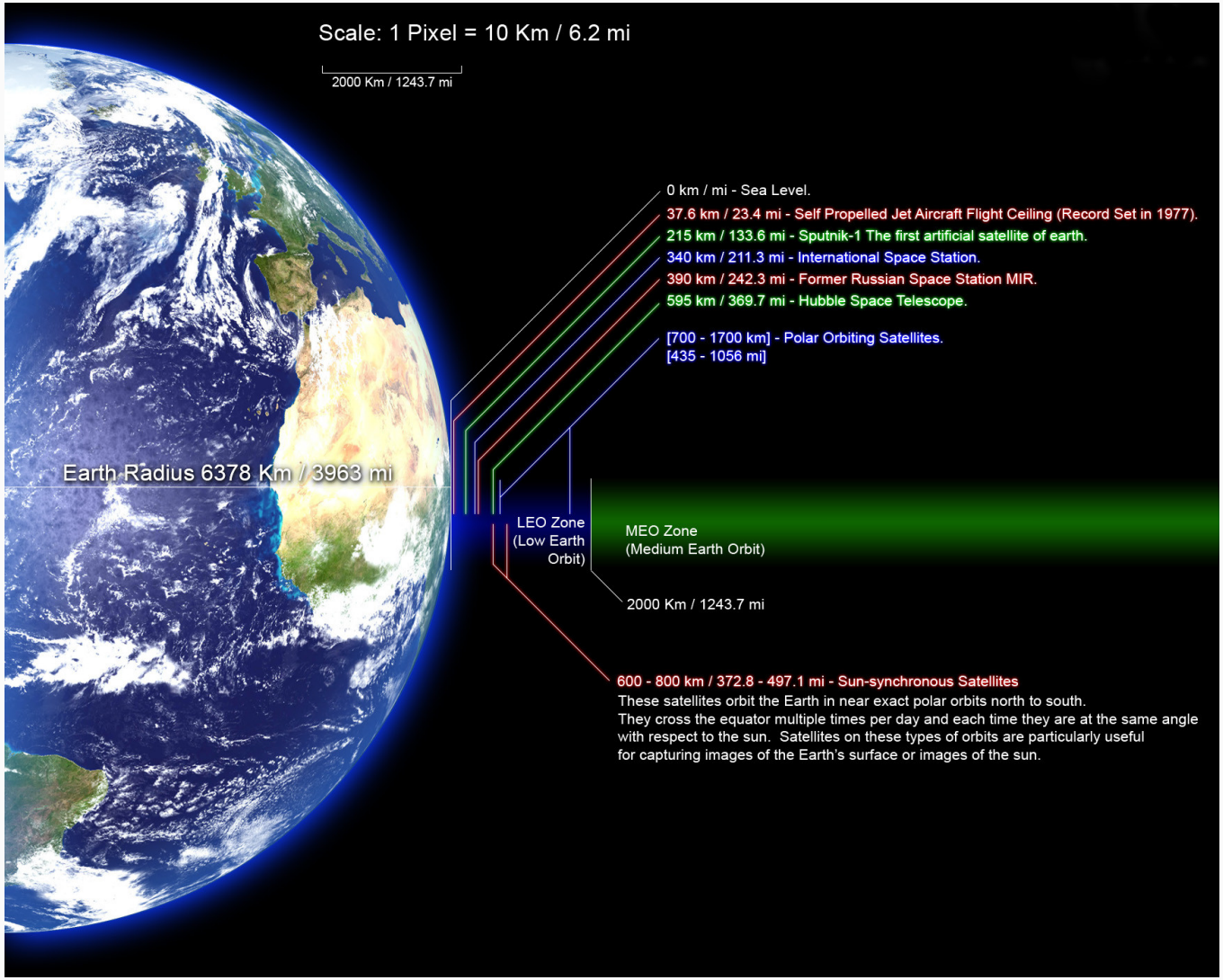
- German astronaut!
- I'm not (too much) interested in science, but rather the engineering supporting the science

2. Where is the ISS?

Orbits


Scale: 1 Pixel = 100 Km / 62.1 mi
20000 Km / 12437.4 mi
MEO Zone
(Medium Earth Orbit)
HEO Zone
(High Earth Orbit)
LEO Zone
(Low Earth Orbit)
384,000 km
The Moon

Orbits



Source: [10]

- ISS: 370-460 km -> 93 minutes per orbit

Orbital Decay

- Atmospheric drag: ~2 km/month

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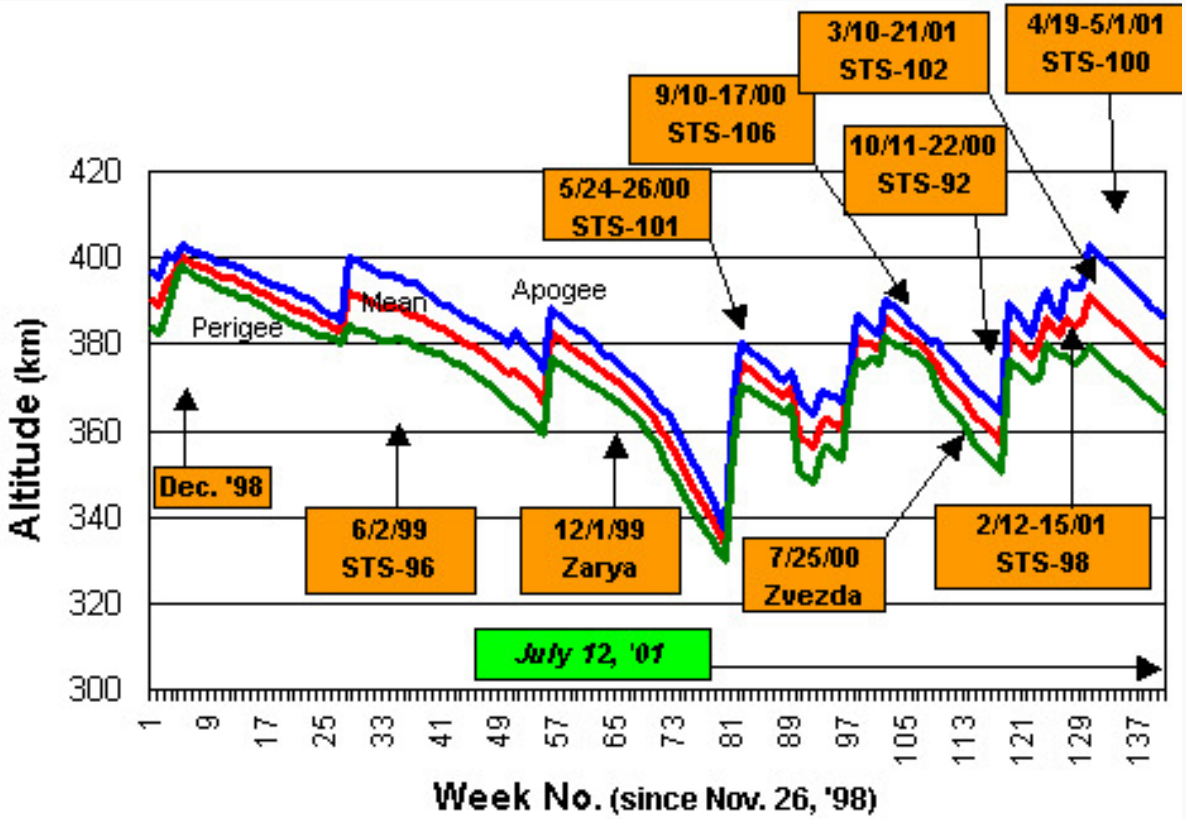
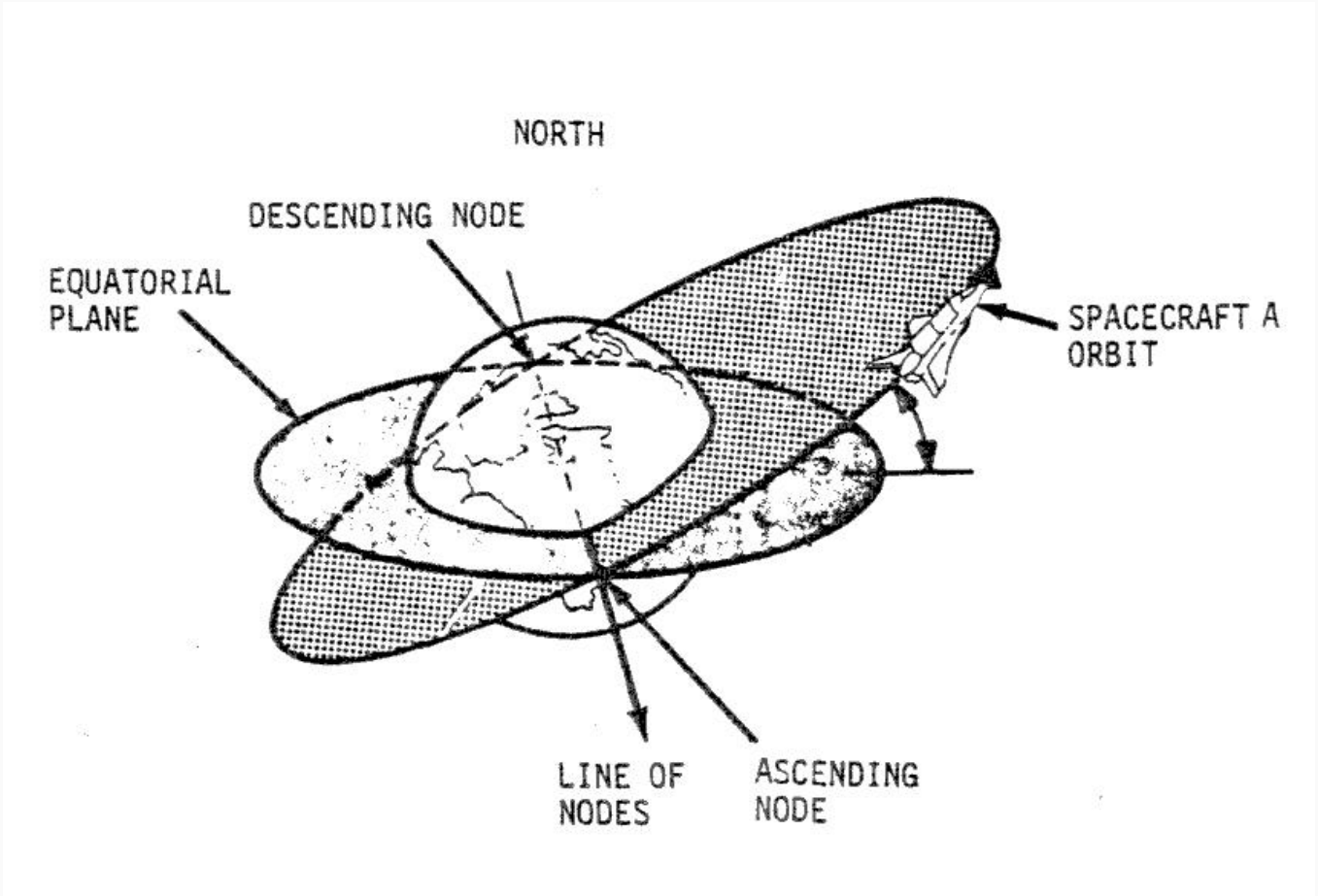
- Altitude boost



Source: [8]

Inclination - Theory

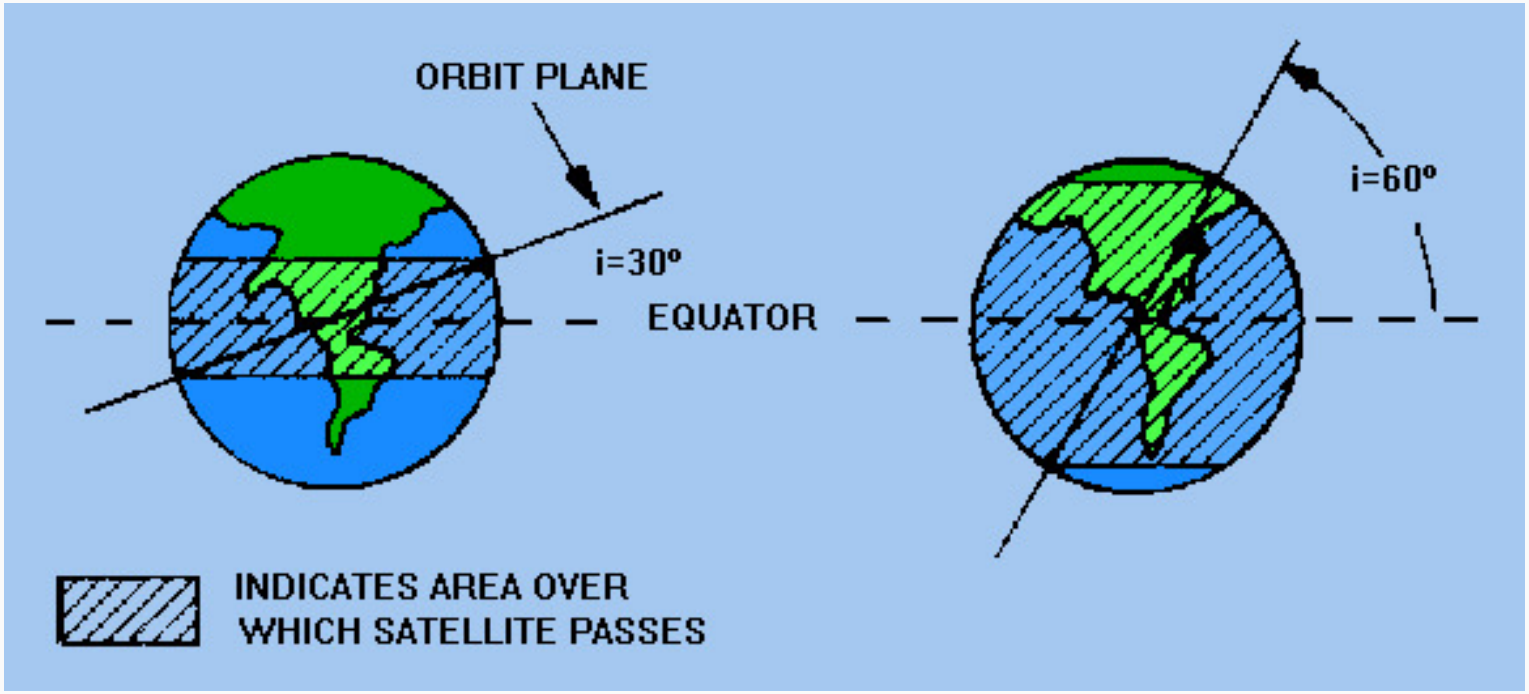


Source: [2]

Inclination - ISS

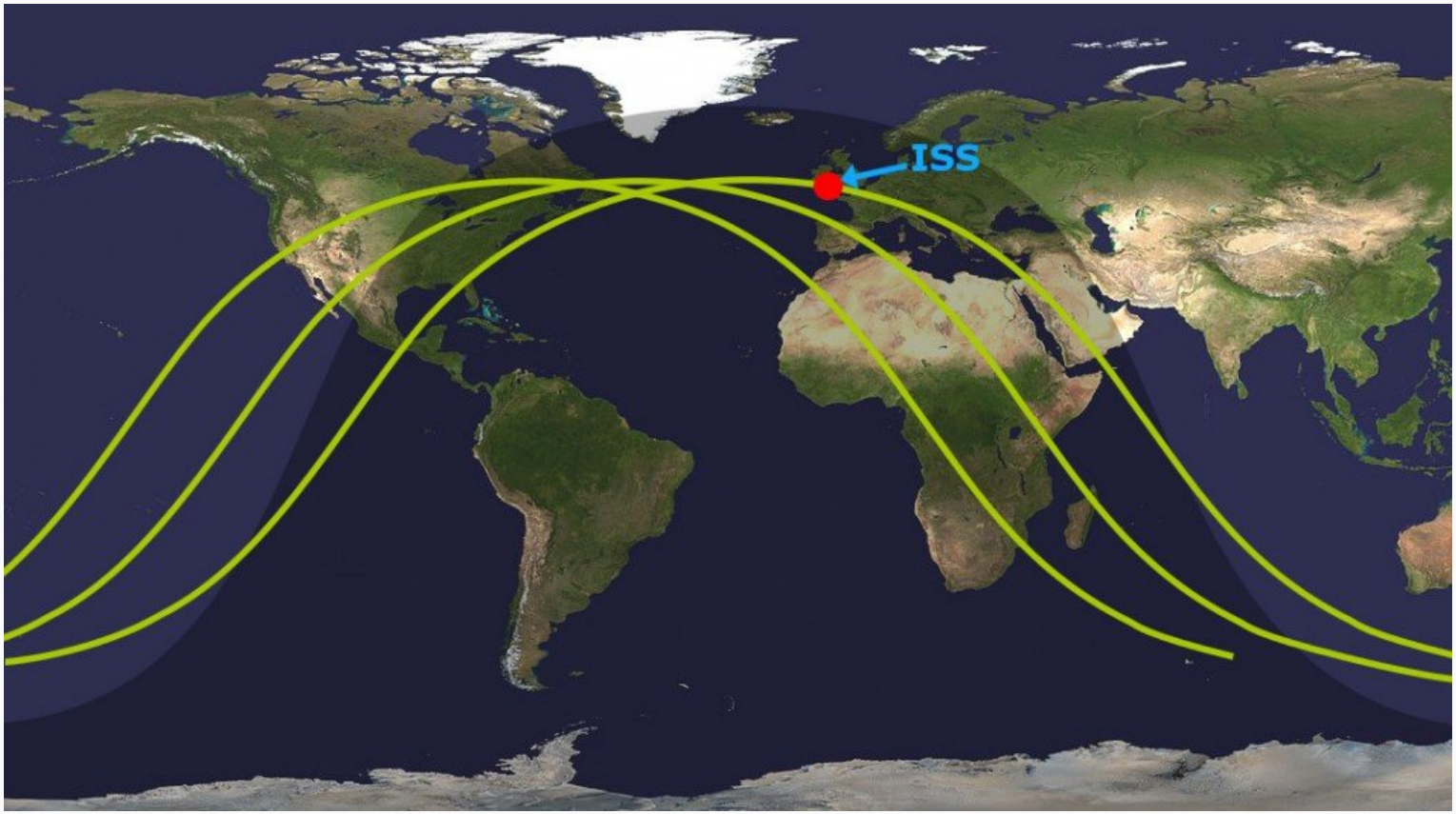
- Launch sites:
  - USA: Kennedy Space Center: 28.5° N
  - USSR/Russia: Baikonur Cosmodrome: 46.0° N
- Adjusting the inclination in flight:
  - Going higher: (relatively) easy
  - Going lower: very expensive
- -> ISS is the lowest inclination without overflying China or dropping spent rocket stages in inhabited areas => 51.6° N

Ground track



Source: [2]

Ground track



Source: [6]

- Can see the inclination -> ISS: 51.6°
- Track shifts west -> because of the Earth rotation

3. Going to the ISS: Launch Window Constraints

Launch Date and Time

Successive Launch Date And Time

- Sun Oct 31 06:21 UTC (02:21 local)
- Wed Nov 03 05:10 UTC (01:10 local)
- Sun Nov 07 03:36 UTC (23:36 local)

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Oddly specific date and time:

- During the night
- During the weekend
- Precision down to the minute

The Question

=> Which factors drives a launch date and time?

Constraint 1: Inclination

- A given launch site crosses the plane twice a day (instantaneous window)

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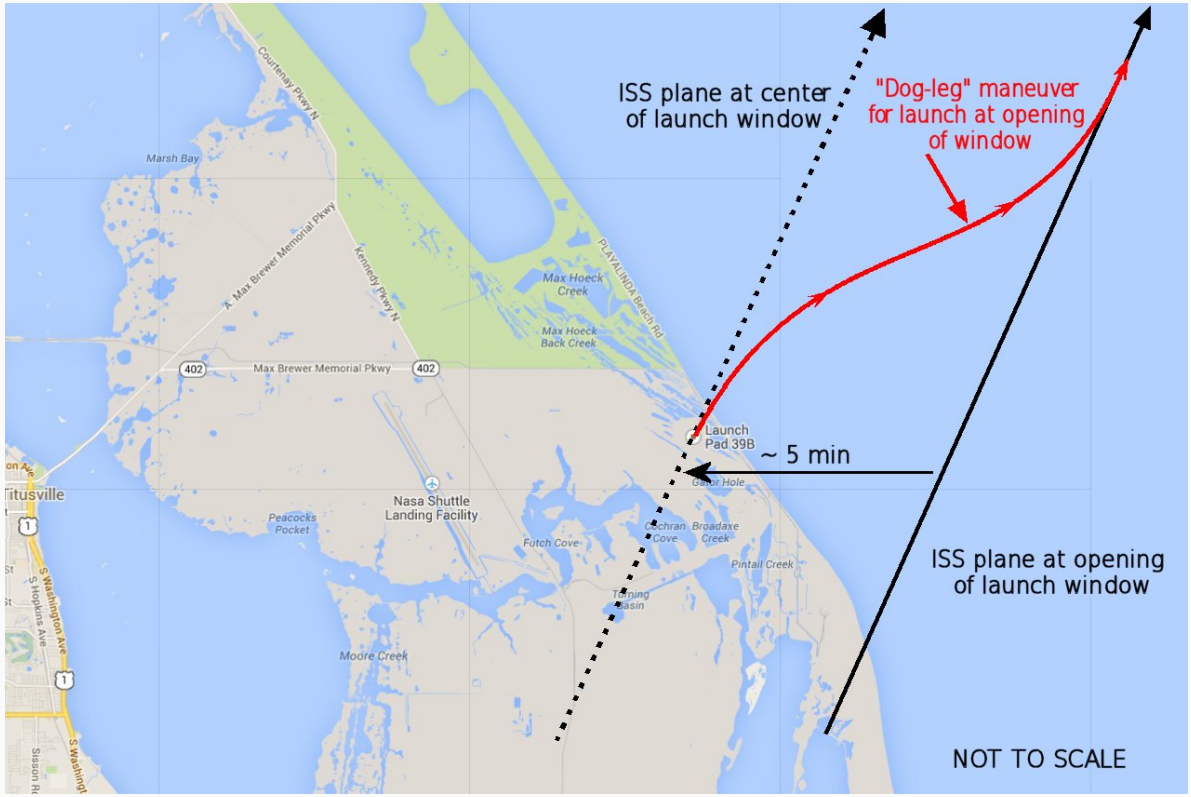
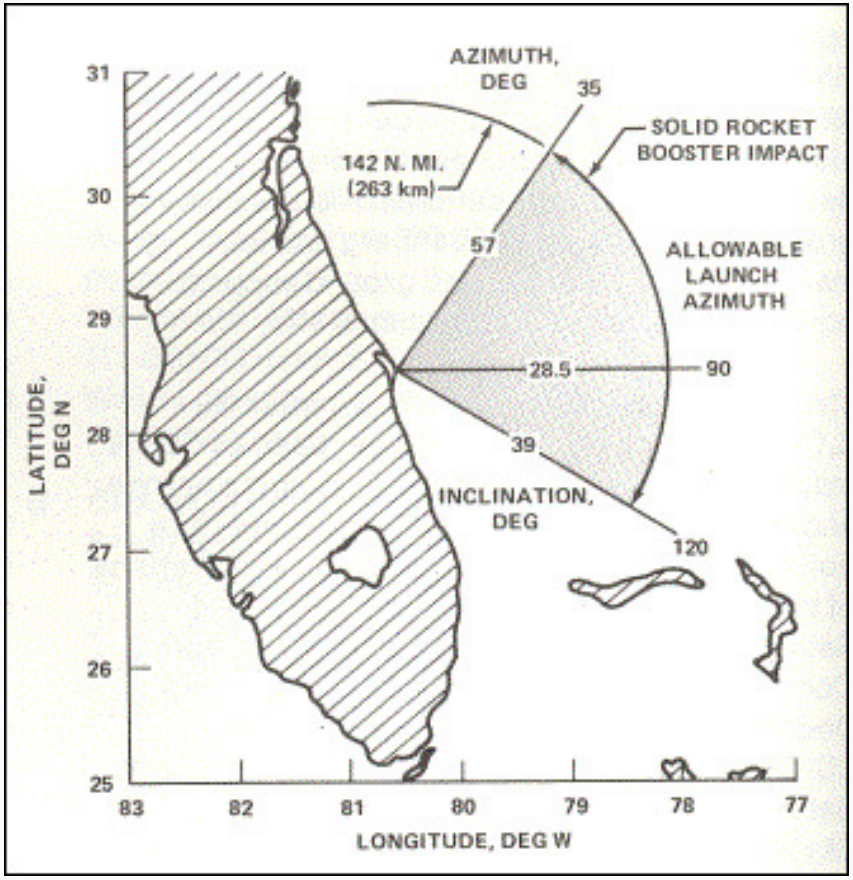
- Can afford some misalignment: dogleg maneuver



Source: [1]

Constraint 2: Launch Azimuth (Range Safety)



Source: [5]

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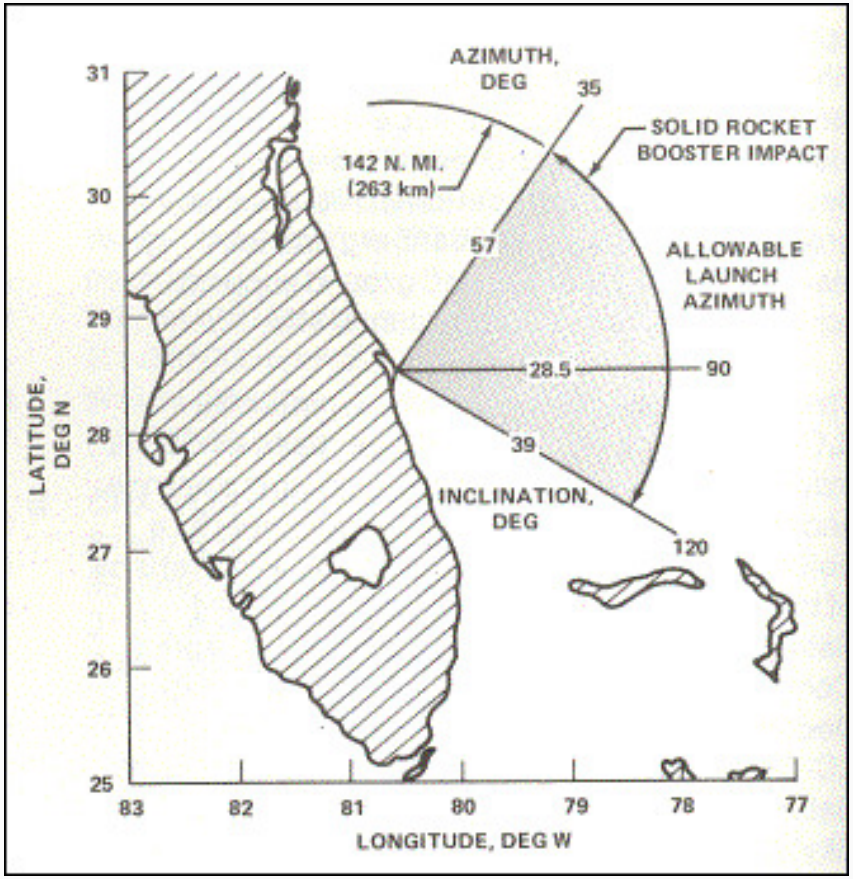
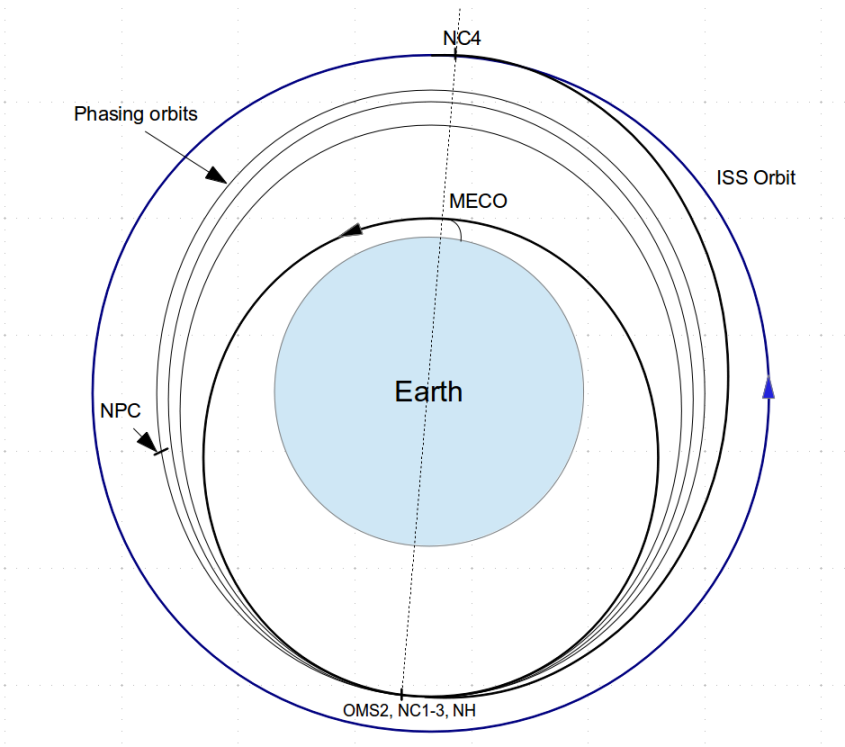


Source: [5]

- Don’t want to fly over Cuba
- ISS is at 51.6° N
- Fun fact: Israel launches toward west

Constraint 3: Orbit Phasing

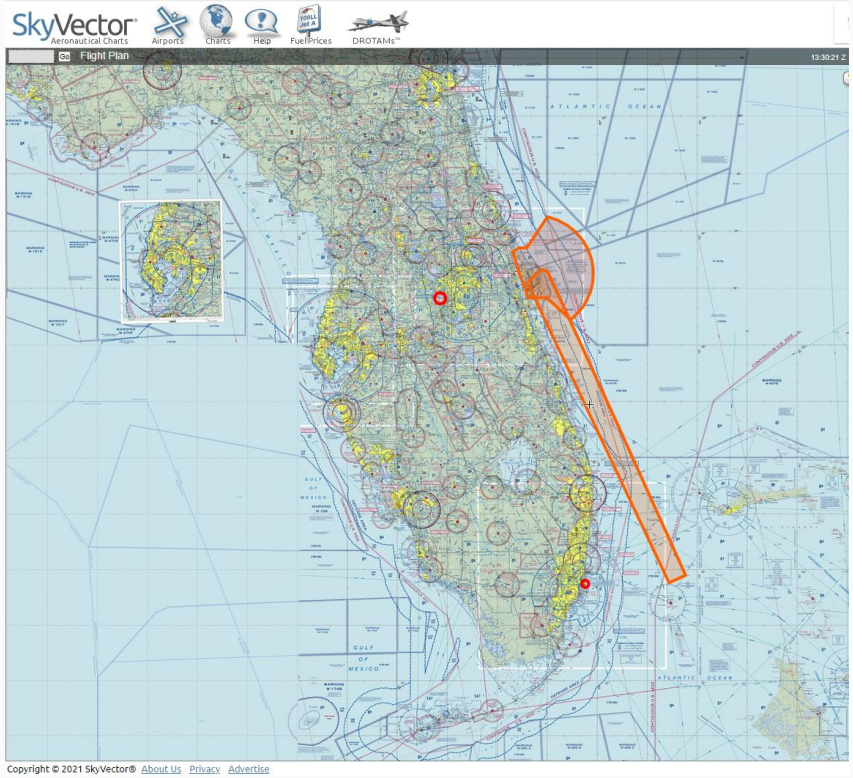
- Launch when ISS is (approximately) overhead, to reduce phasing time as much as possible
- Inclination is still more important
- Soyuz's fast rendezvous: from 24-48h to 6h to 3h



Source: [3]

Constraint 4: Range Safety (Exclusion Zones)

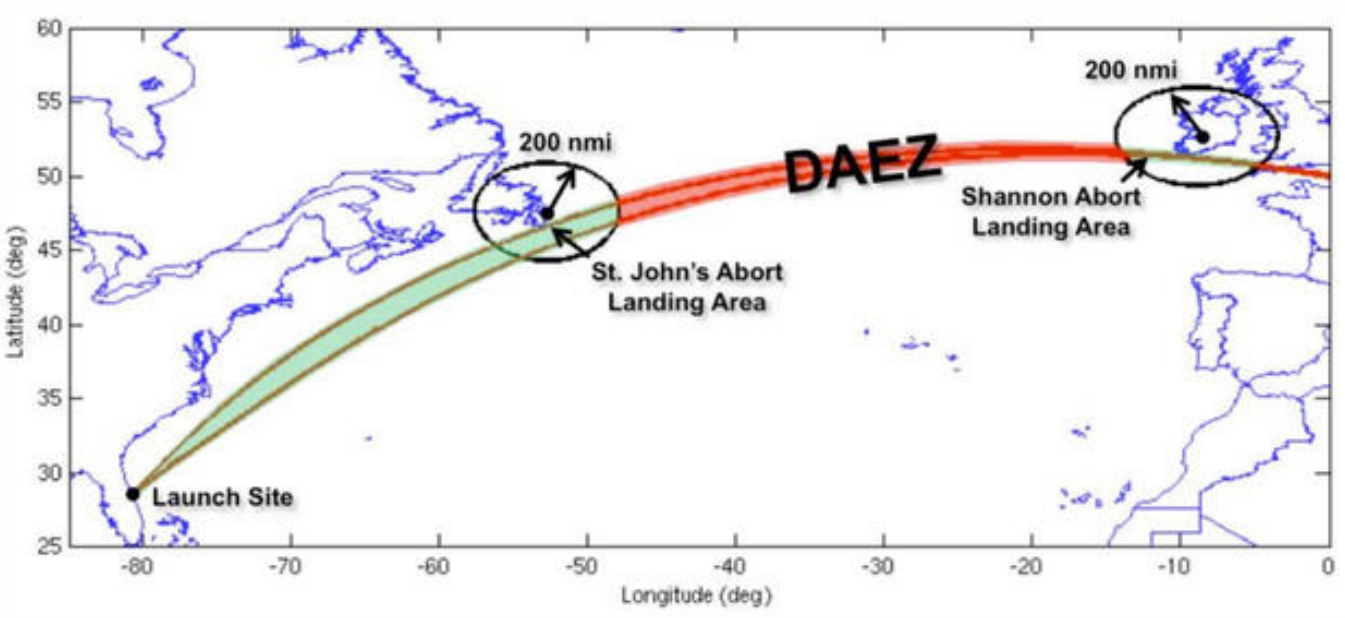
NOTAM/NOTMAR:



Source: [7]

- There could be constraints (visit of the president, a 10 billions $ telescope traveling, ...)

Constraint 5: Abort Scenarios



Source: [4]

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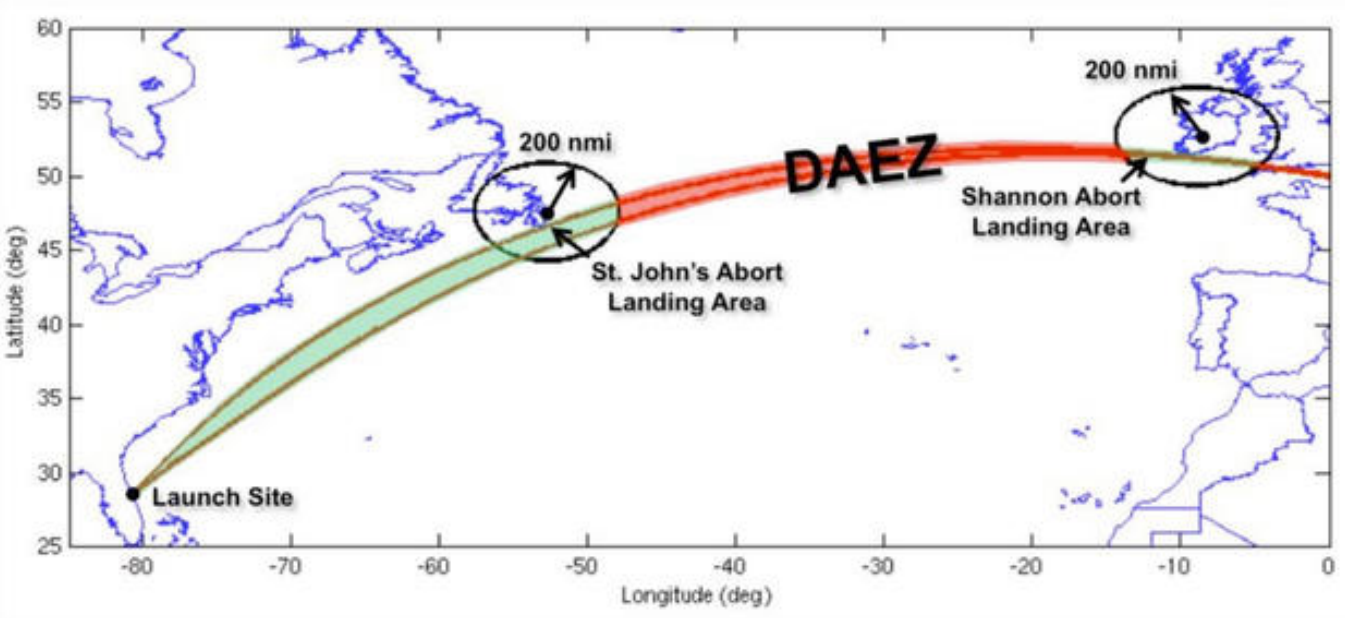

Source: [4]

- Constraints in the abort zones
  - Weather
  - Support available - ex: Space Shuttle's TAL abort mode
  - ...

Constraint 6: Flight Path and Target Conditions

- Sun: power, temperature
  - Apollo: visibility required the Sun to be very low on the horizon
  - Space Shuttle: thermal control required specific Sun conditions (beta angle)

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  - Space Shuttle: thermal control required specific Sun conditions (beta angle)
- Communication: visibility, antenna handover

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  - Fuel loading/unloading

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  - Falcon 9 Crew Dragon Launch Weather Criteria: link

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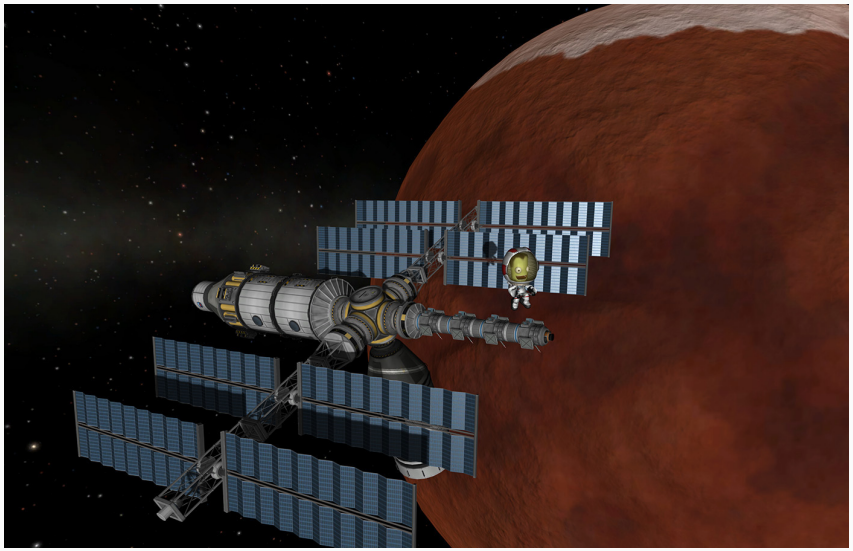
4. Conclusion

Conclusion

- Launch notifications: https://nextspaceflight.com/
  - Don't forget to watch Crew-3's launch next Saturday evening
- Try to dock to the ISS: https://iss-sim.spacex.com/
- Learn orbital mechanics: Kerbal Space Program (KSP)



Source: [9]

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Questions?