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

NASA’s Crew-3 Mission

Source: [7]

Launch Date and Time

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

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Crew-3 Successive Launch Date And Time

- Sun Oct 31 06:21 UTC (02:21 local)
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Crew-3 Successive Launch Date And Time

- Sun Oct 31 06:21 UTC (02:21 local)
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Oddly specific date and time:

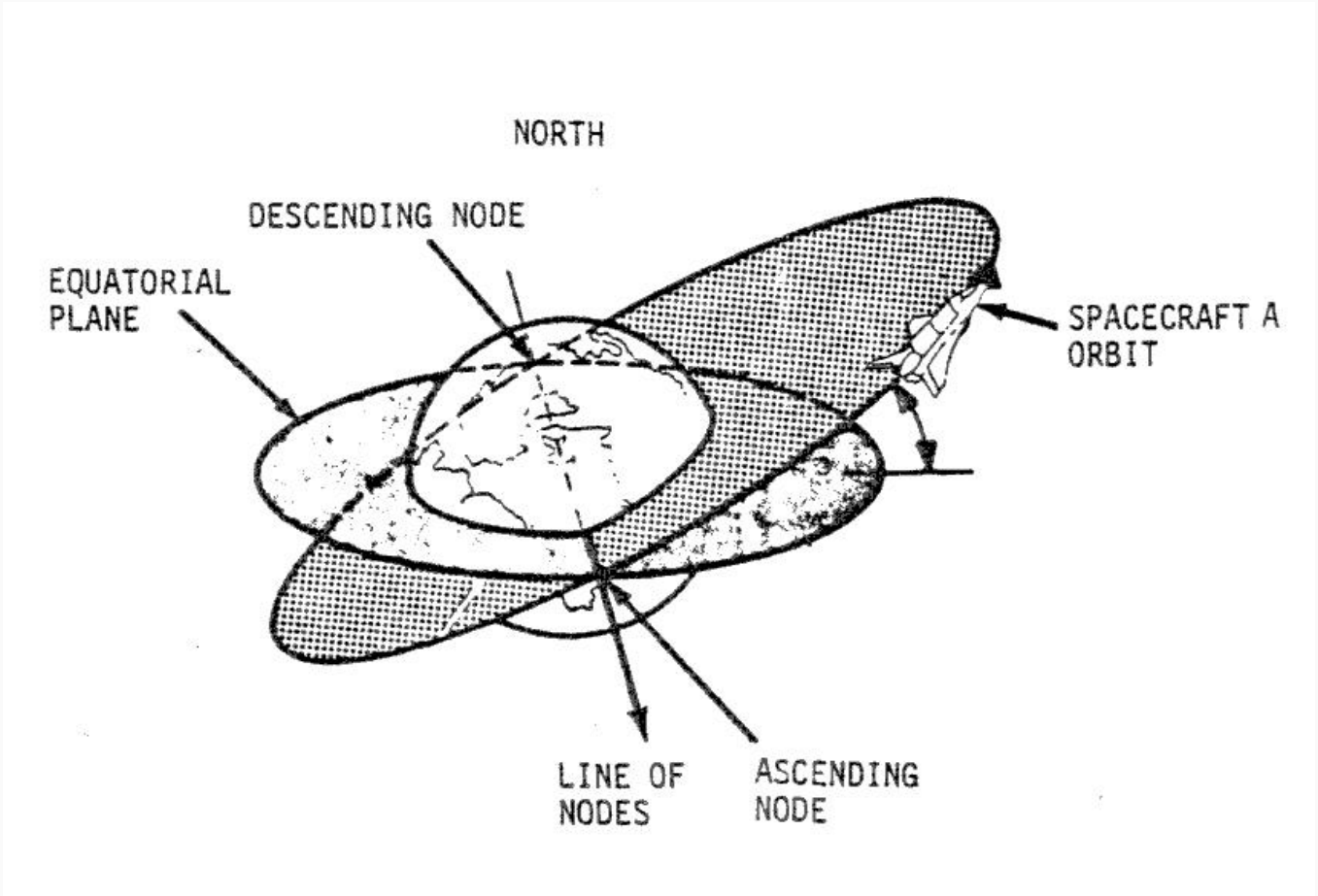
- During the night
- During the weekend
- Precision down to the minute

The Question

=> What factors drive a launch date and time?

2. Going to the ISS: Launch Window Constraints

Constraint 1: Inclination - Theory



Source: [2]

Constraint 1: Inclination - Summary

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

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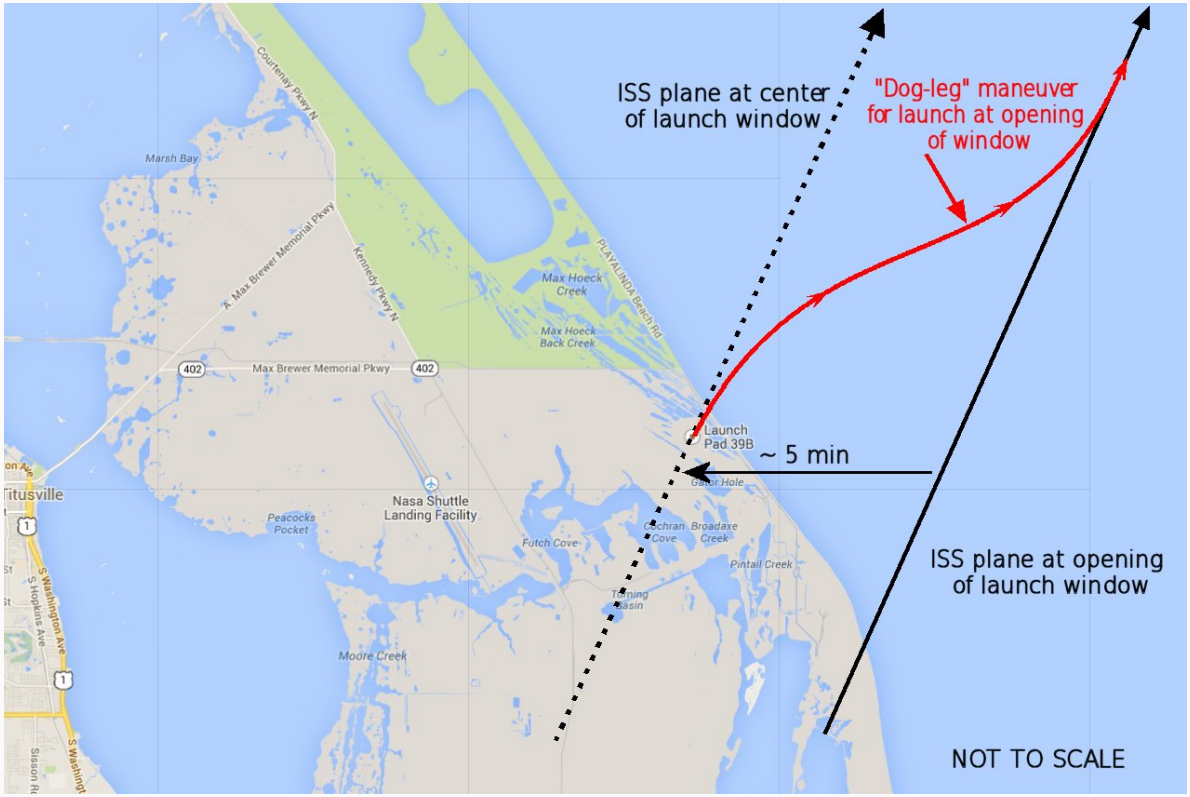
- Can afford some misalignment: dogleg maneuver



Source: [1]

Constraint 2: Launch Azimuth - Launch Site

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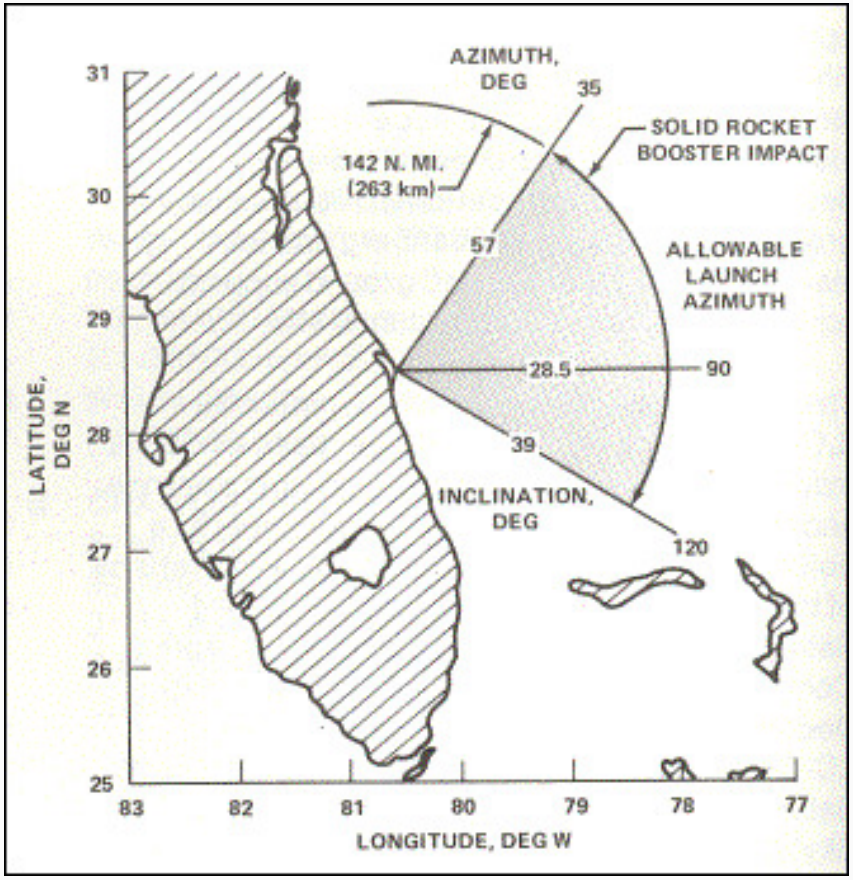
- -> ISS is the lowest inclination without overflying China or dropping spent rocket stages in inhabited areas => 51.6° N

Constraint 2: Launch Azimuth - ISS



Source: [5]

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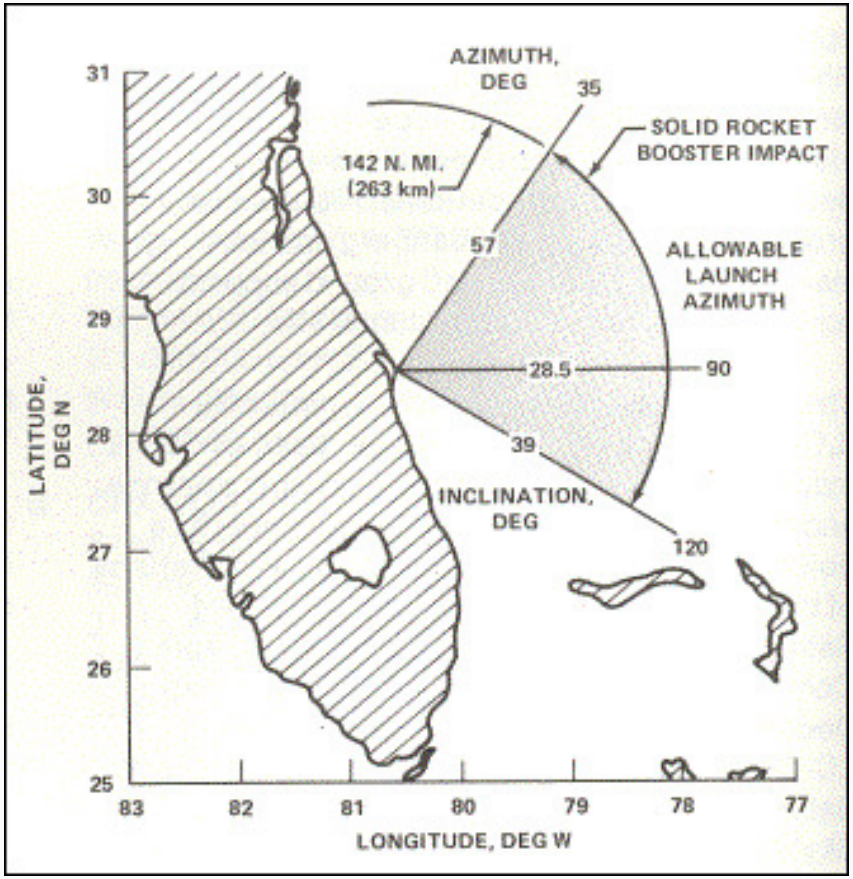
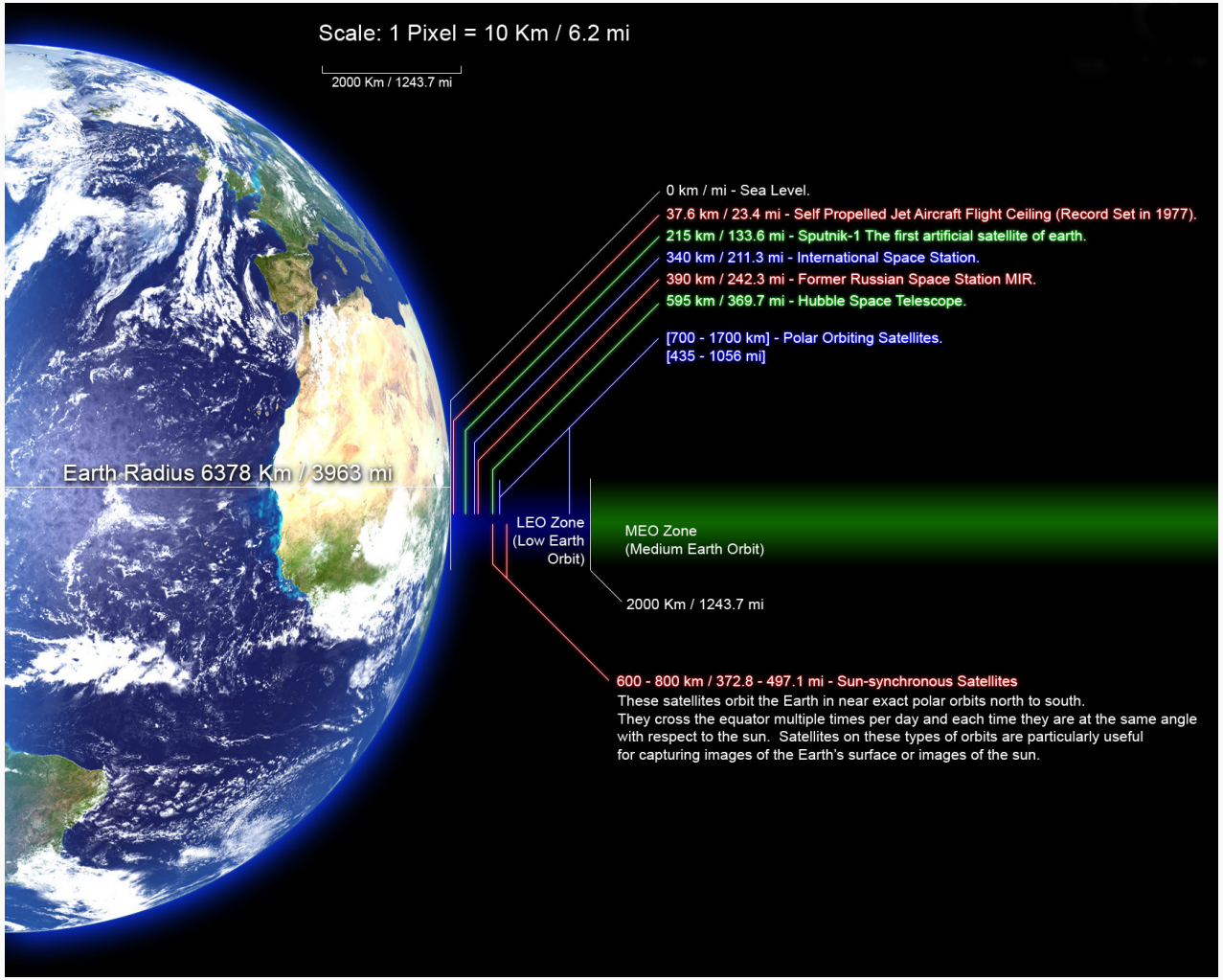


Source: [5]

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

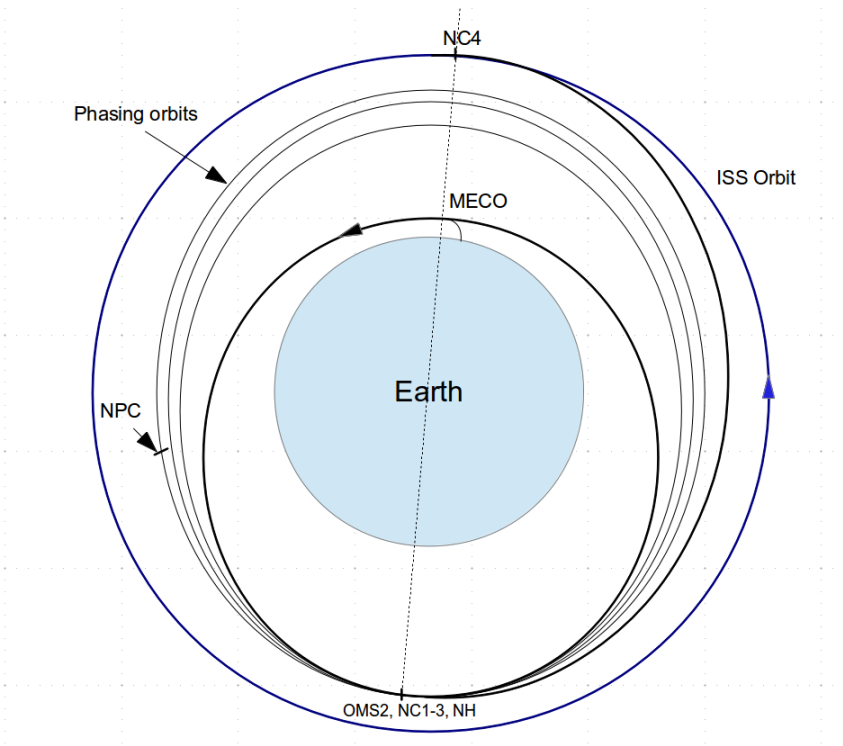
Constraint 3: Orbit Phasing - Altitude



Source: [9]

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

Constraint 3: Orbit Phasing - ISS



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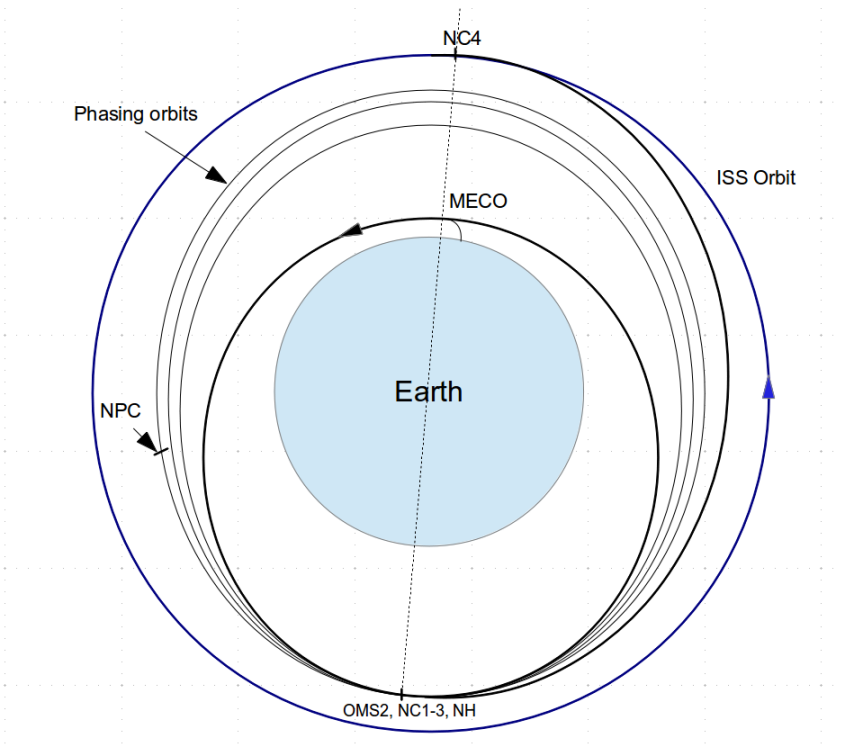
Constraint 3: Orbit Phasing - ISS

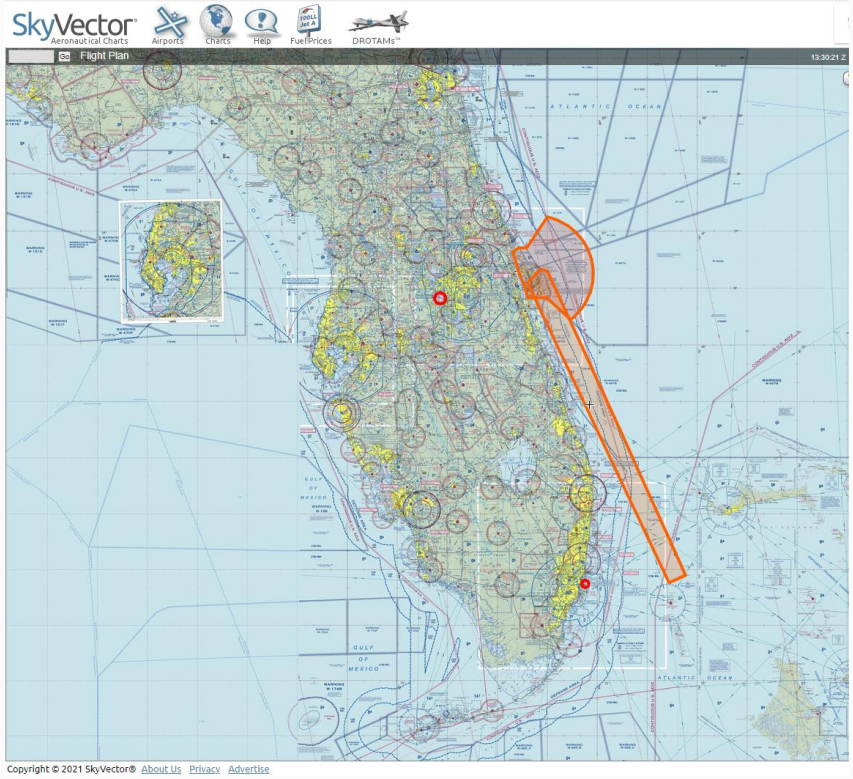


Source: [3]

- 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

Constraint 4: Range Safety (Exclusion Zones)

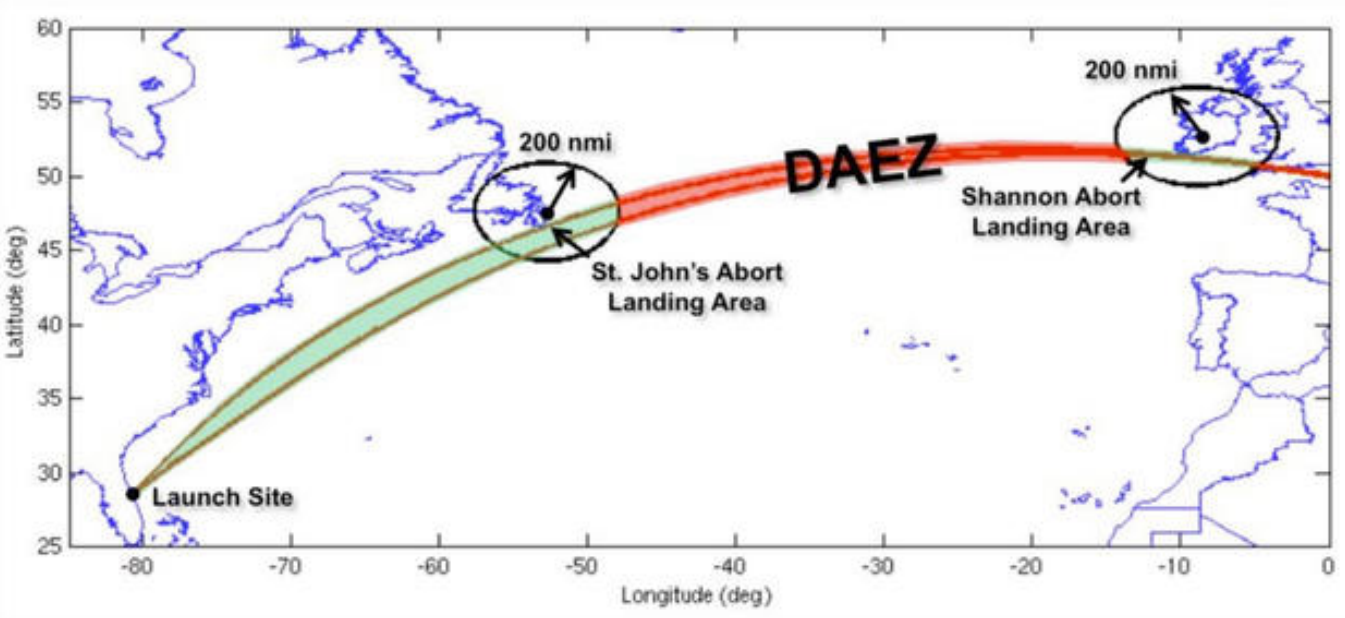
NOTAM/NOTMAR:



Source: [6]

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

Constraint 5: Abort Scenarios



Source: [4]

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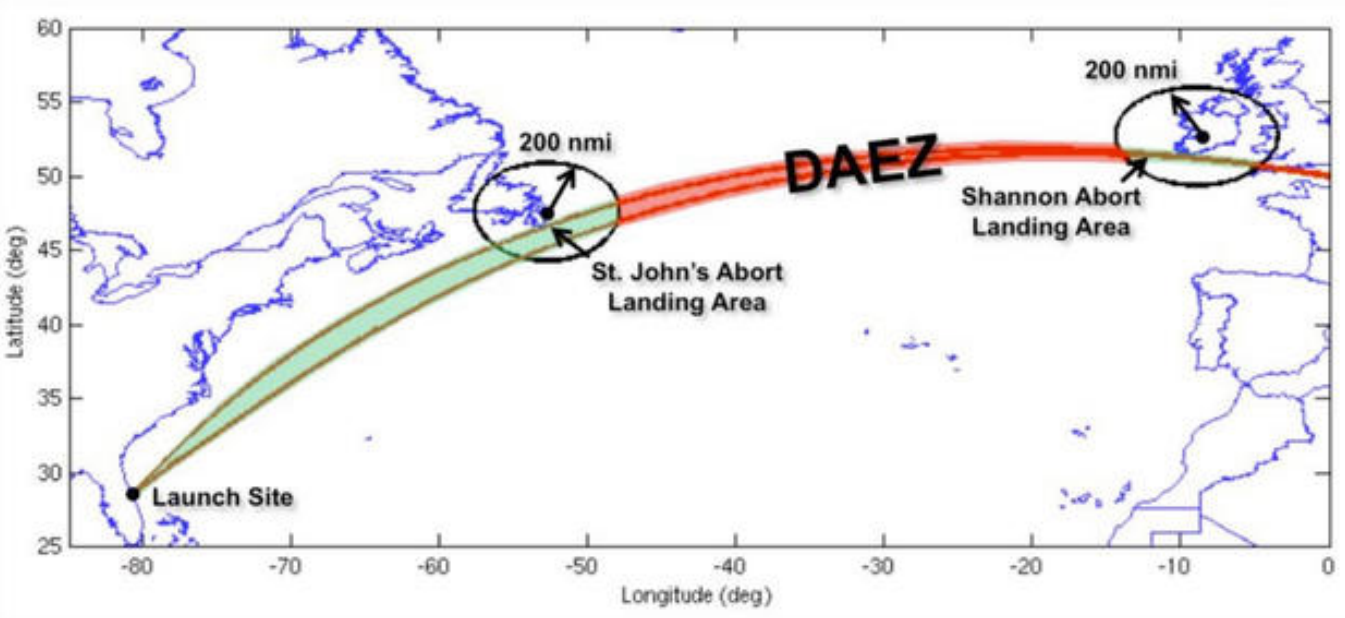

Source: [4]

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

Constraint 6: Flight Path and Target Conditions

- Sun: visibility, temperature, power
  - Apollo: visibility required the Sun to be very low on the horizon
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- Communication: visibility, antenna handover

More Constraints

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  - Falcon 9 Crew Dragon Launch Weather Criteria: link

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3. Conclusion

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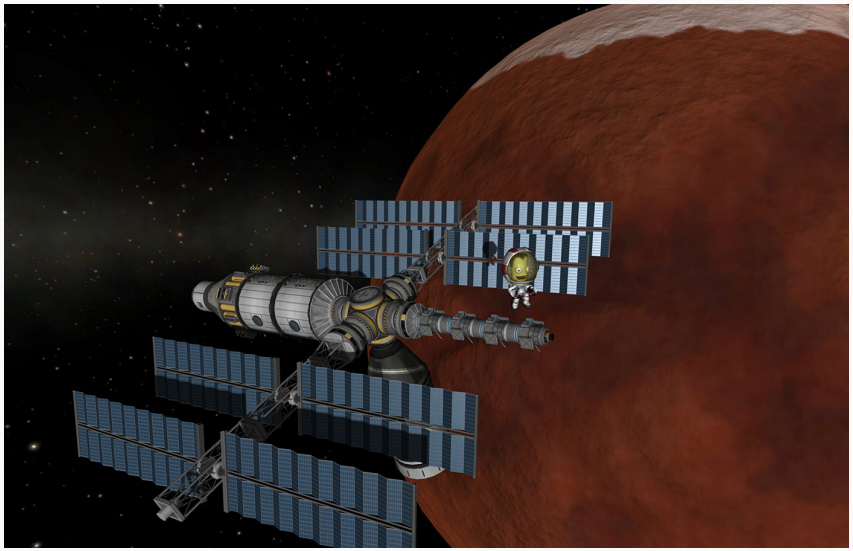
- Launch notifications: https://nextspaceflight.com/
  - Don't forget to watch Crew-3's launch next Saturday evening
- Try to dock to the ISS: https://iss-sim.spacex.com/
- Learn orbital mechanics: Kerbal Space Program (KSP)



Source: [8]

References i

[1] Baen, *Dog-leg*.

https://www.baen.com/rendezvous, accessed 2021-10-27.

[2] ———, *Orbital plane*.

https://www.baen.com/rendezvous, accessed 2021-10-27.

[3] ———, *Phasing orbit*.

https://www.baen.com/rendezvous, accessed 2021-10-27.

[4] CBSNews, *Abort Exclusion Zones*.

https://www.cbsnews.com/news/spacex-launch-preview-nasa-astronauts-historic-mission-piloted-spacecraft/, accessed 2021-10-27.

[5] NasaSpaceFlight, *Cape Canaveral launch azimuth*.

https://forum.nasaspaceflight.com/index.php?topic=37558.0, accessed 2021-10-27.

References ii

[6] S. . SkyVector, *Exclusion Zones*.

https://space.stackexchange.com/questions/53927/just-how-unreasonably-gigantic-was-the-exclusion-zone-for-the-scrubbed-spacex, accessed 2021-10-27.

[7] N. . SpaceX, *Crew-3*.

https://blogs.nasa.gov/crew-3/2021/11/01/nasas-spacex-crew-3-launch-delayed-from-nov-3/, accessed 2021-11-03.

[8] Squad, *KSP screenshot*.

https://www.kerbalspaceprogram.com/media/, accessed 2019-09-01.

[9] Wikipedia, *Orbital altitudes*.

https://commons.wikimedia.org/wiki/File:Orbitalaltitudes.jpg, accessed 2021-10-27.

[10] ———, *Orbital altitudes*.

https://commons.wikimedia.org/wiki/File:Orbitalaltitudes.jpg, accessed 2021-10-27.

Questions?