CSI's *Lunar Express*^{SM} System: A low-cost manned trip around the Moon in 3 years or less

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These charts are a visual aid meant to supplement, and not replace, an oral presentation.

Why Haven't We Returned to the Moon?

Constellation Services International

- The only funded lunar missions since 1972:
  - Clementine: ~ $25 million
  - Lunar Prospector: ~ $80 million (including LV)
- Funding is the key to a return to the Moon
  - If it were free to go to the Moon, we would be there
  - If it will cost $1 trillion, there will be no lunar missions
- Therefore, Cheaper is Better
- ***So don't ask for <u>MORE</u> money, ask for <u>CHEAPER</u> missions!***

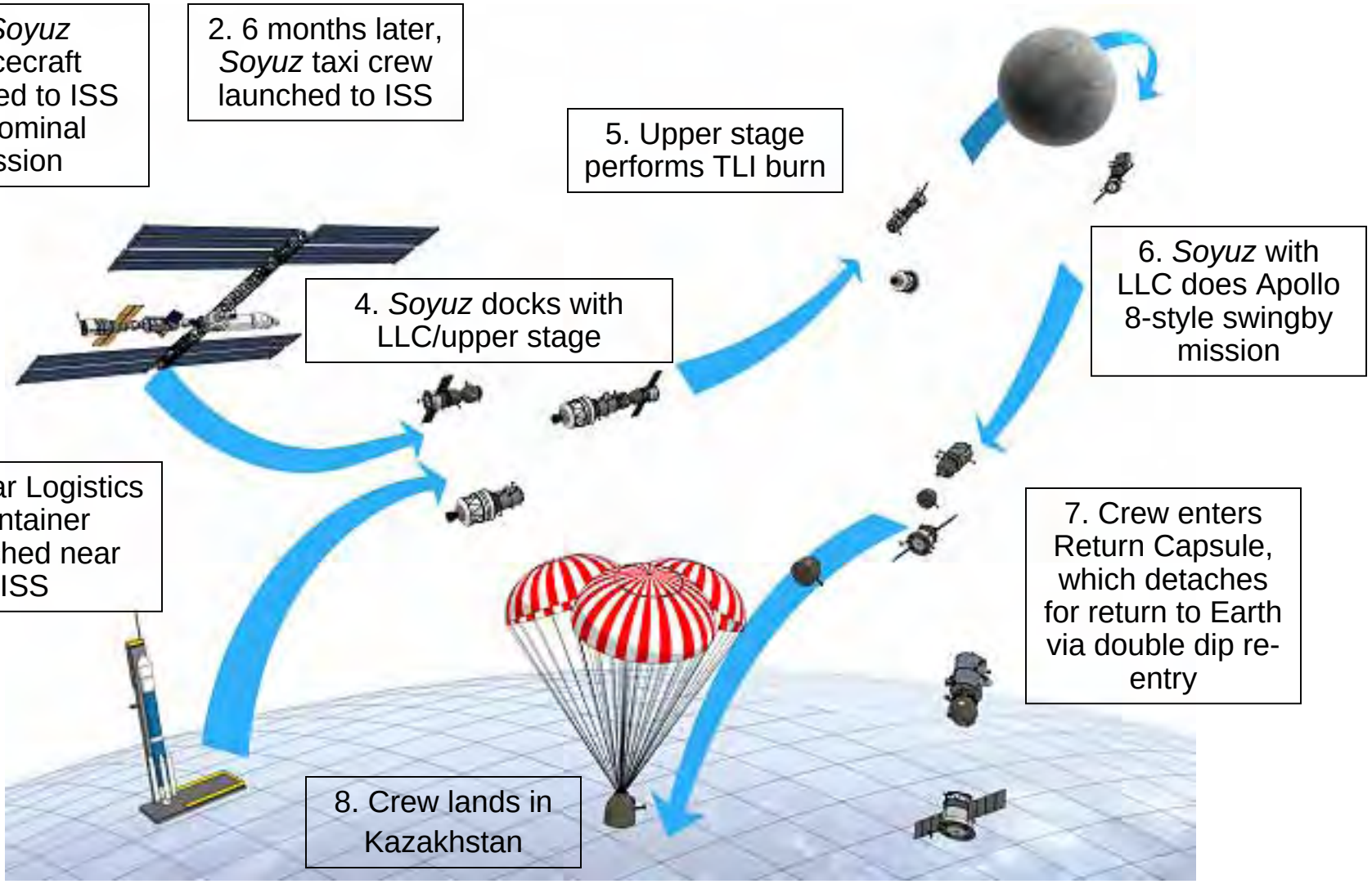
Keys to Early Return to the Moon

Constellation Services International

- One way to get ***cheap*** missions
  - Re-use existing hardware
    - That is already designed for lunar missions
  - Leverage hardware *already* in space
    - Pay “incremental” cost for mission
      - Like “piggyback” launch of many smallsats
- International or commercial partners
  - Involved where possible
  - “Commercial” doesn’t mean “contractors”
    - Means companies with private capital at risk
- One commercial passenger may be sufficient
  - ***If*** costs are low enough

CSI Lunar Mission Architecture (Patent Pending)

Constellation Services International



Features of *Lunar Express*^{SM} Mission

Constellation Services International

- Can be done in < 3 years
- Low cost, using off-the-shelf flight hardware
  - Already-paid-for Soyuz spacecraft
  - Existing launch vehicles
- Avoids major modifications to Soyuz spacecraft
  - Most Lunar-specific hardware and logistics
    - Carried in the Lunar Logistics Container
- LLC launch from US is possible
  - Other launch vehicles may be cheaper

Benefits of *Lunar Express*^{SM} Mission

Constellation Services International

- Could be done as 100% commercial mission
- Lower risk than similar alternatives
  - Avoids major modifications to Soyuz spacecraft
- Piggyback opportunity for other missions/customers
  - IMAX and or HD video imagery from the lunar vicinity

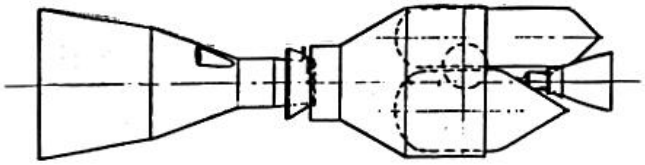
- Re-establishes human lunar operations quickly
  - Early results may be critical to “sustainability of VSE
- Supports IP “functional redundancy” for VSE
- Pathfinder for Crew Exploration Vehicle
  - As Gemini was to Apollo
- Testbed for exploration technologies & mission issues
  - Radiation shielding, etc.
  - Human interplanetary return after 6-month spaceflight

Optional Features

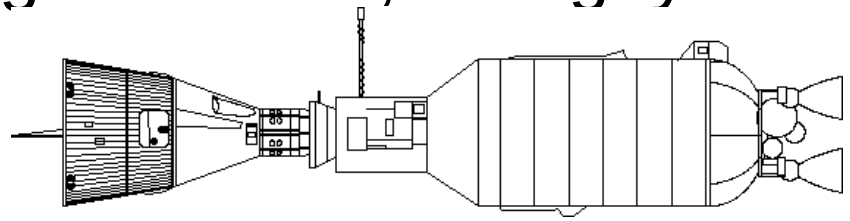
- Lunar Polar flyby: 1st visit by humans
- Allows first EVA beyond LEO since 1972
- Tether (between spacecraft and upper stage)
  - Creates partial-g environment
  - Pathfinder for long duration Mars missions
  - Find “sweet spot” for minimum safe partial-G
    - Via multiple missions
- Opportunities for unique science

“Great artists steal” (Picasso, et al)

- Creative combination of 4 earlier ideas
- 1965 - 1967 McDonnell-Douglas Gemini proposals
  - (I) Dock with Titan III upper stage in LEO
  - Use upper stage engine for TLI, swingby orbit

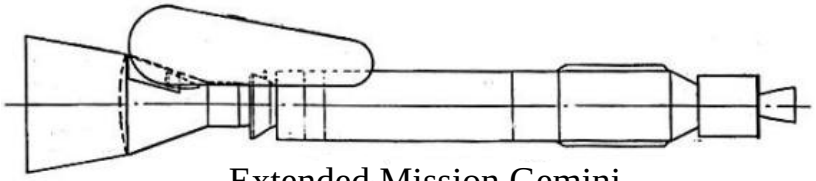


Translunar Gemini with Transtage
(Credit: McDonnell Douglas)



Translunar Gemini with Centaur
(Credit: © Mark Wade)

  - (II) Dock with orbital shelter on Agena
    - Extend LEO mission duration to several weeks



Extended Mission Gemini
(Credit: McDonnell Douglas)

Can Soyuzes Really Fly to the Moon?

- (III) Soyuzes have flown to the Moon 4 times
  - Zond 5, 6, 7, 8 missions (1968-70)
  - Capsules were stripped down (for 2 vs. 3 crew)
    - Mods for current Soyuz: Zond heat shield + TBD

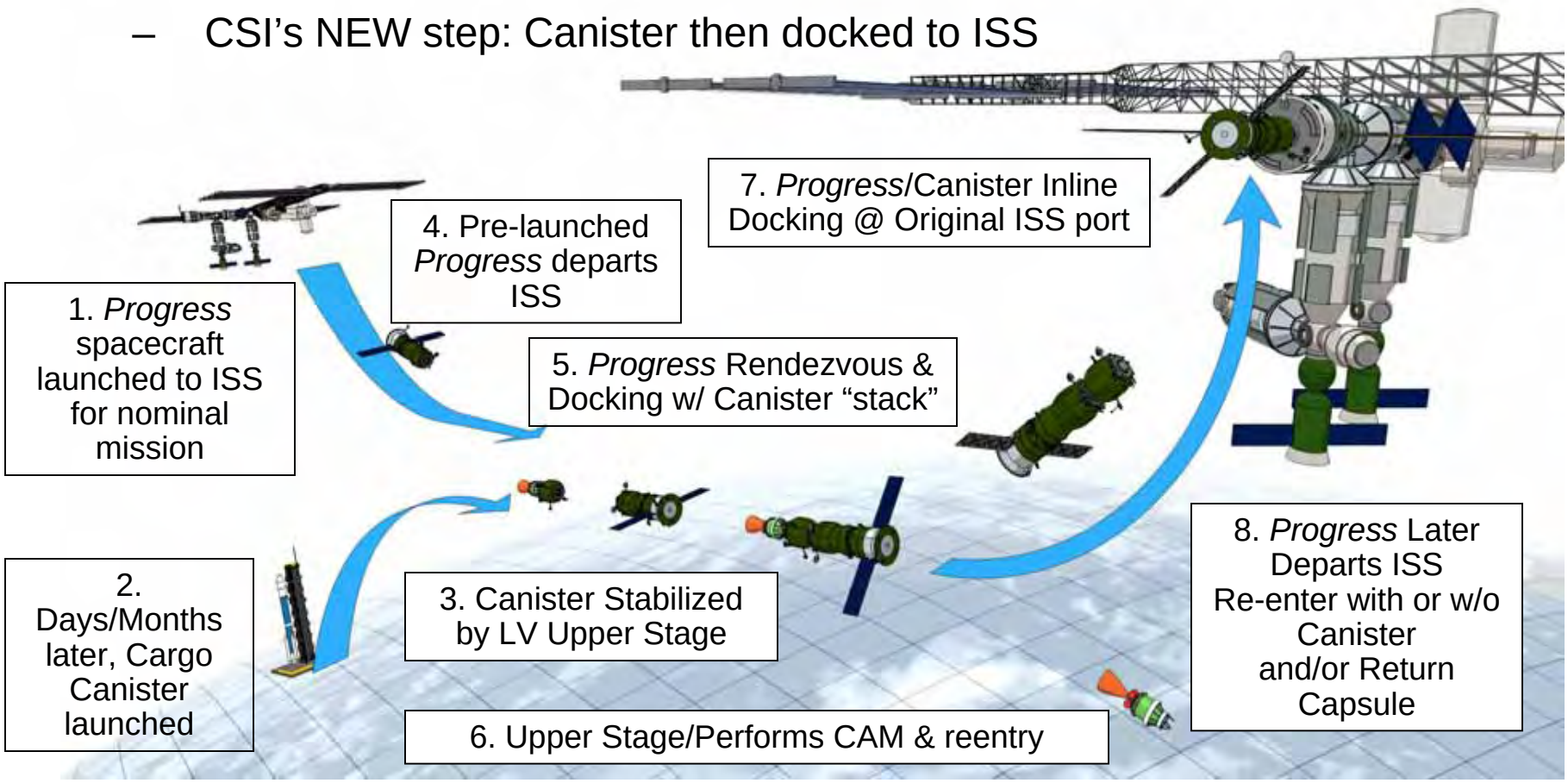
Zond 6 capsule

Lunar Swing-by, November 1968

(Soyuz 3 capsule in background)

Lunar Logistics Container Inspiration

- (IV) CSI's patented *LEO Express*^{SM} Architecture for ISS cargo delivery
  - Extension of Apollo-Soyuz Test Project concept (1975)
  - "Cargo Canister" launched w/ Upper Stage
  - Docked to "Soyuz-class" s/c
  - CSI's NEW step: Canister then docked to ISS



Lunar Logistics Container Functions

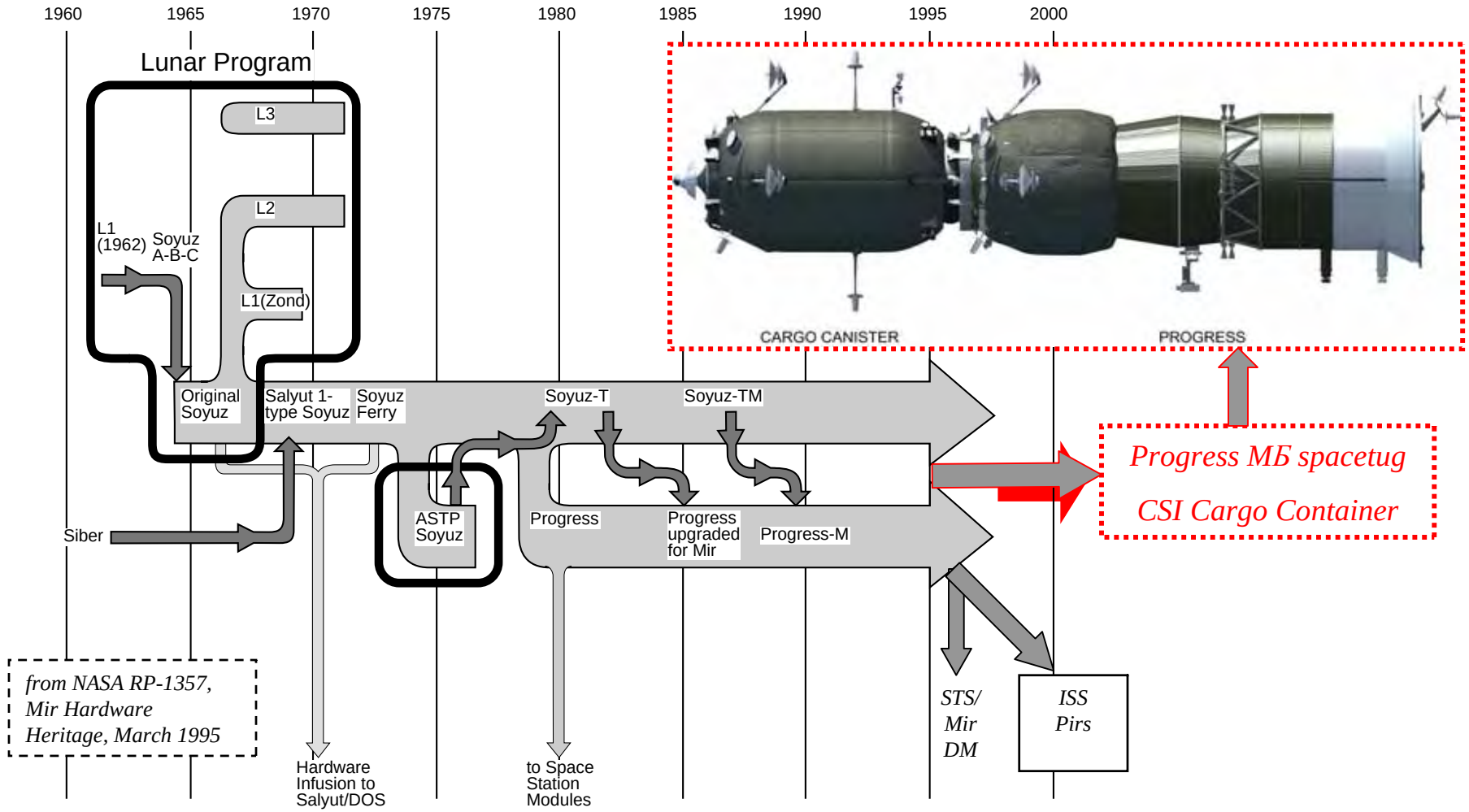
- Increase safety for Soyuz crew
  - Backup for critical Soyuz functions
  - Similar to Apollo 13 LM
- Provides lunar mission logistics
  - Food, water, oxygen, hygiene
- Lunar communications system
- Additional crew habitation volume
- Enables Soyuz to dock to upper stage
  - Kurs radar, docking system
- **Does all this cheaply**

Lunar Logistics Container
derived from CSI LEO Express
Cargo Container

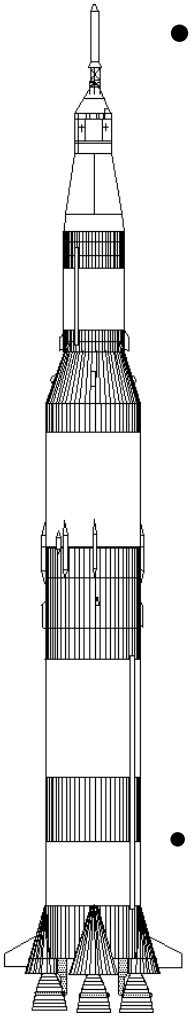
Shuttle/Mir Docking Module
Launched 12 Nov 1995 on STS-74

Next step in 35+ year Soyuz evolution

- ISS CC (hence LLC) can be built & launched in 18-24 months
  - RSC-E Feasibility Study & NASA Systems Design Review completed

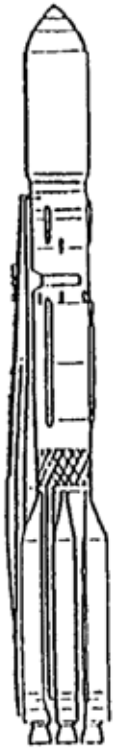


“Incremental” Cost



- “Full-up” vs. “Piggyback” Lunar launchers
  - Soyuz spacecraft & LV $ via “barter” w/ ISS Program
  - Lunar mission pays for LLC launch & ops

Saturn V	Launcher	Proton/Breeze M
102 m	LV Length	57.2 m
3,038,500 kg	LV liftoff mass	691,270 kg
~$43.3 billion	Lunar Program New Development Cost (FY04)	$ 0 to ? (mods to existing h/w) (e.g. Mir DM ~$0.02 billion)
$2.4 billion	Launch Price (FY04)	$0.125 to ? billion



- No detailed mission analysis yet, but
  - Proton M/Breeze M meets 1st cut mission delta-V requirements
  - Likely compatible with Delta IV, Atlas V, Ariane V
  - Possible Angara, Aurora, GSLV, LM 3B, Sea Launch, etc.?

Some Technical Issues

- Thickened Soyuz heat shield from Zond program
  - Re-certification required?
  - Mass penalty ~ 300 kg (per public data)
- Docking conditions for Soyuz – ELV docking
  - Only ~ 3 TLI opportunities per month from ISS
  - Safety for Soyuz crew in case of mission abort
    - Prior & post-docking with Logistics Carrier
  - Lighting conditions, communications to ground
    - ISS requirements applied to non-ISS dockings: TBD
  - Scenarios for contingency docking
    - In case of initial docking failure
- 200 day qualified (210 design) on-orbit lifetime for Soyuz
  - 180 day typical ISS mission, 6 extra days needed

System Analysis Needed

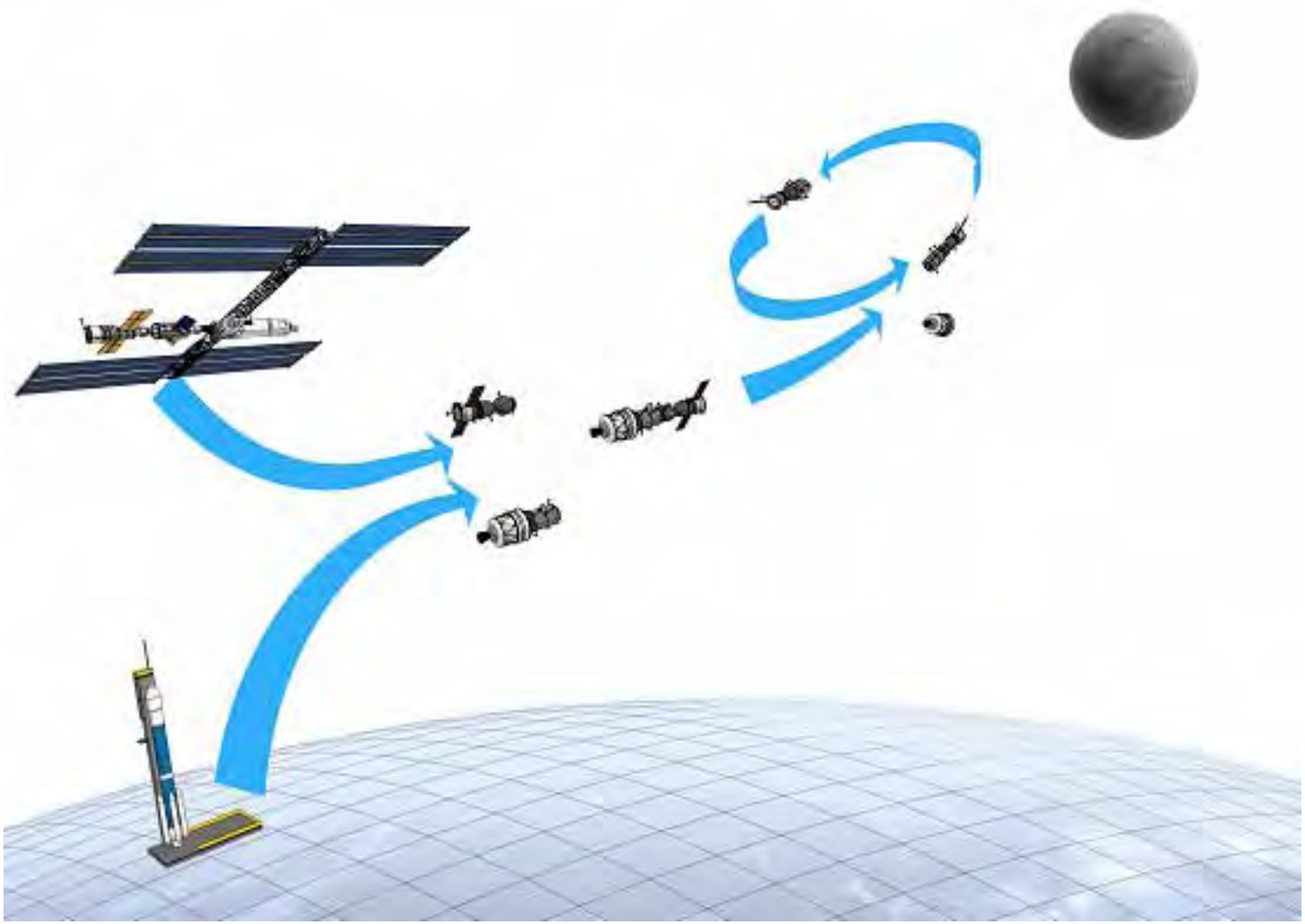
Soyuz toilet holding tank
(in Orbital Module)
note hand prints to provide scale

- Just one example of a small problem that can grow: crew toilet
- Original Soyuz could support multi-week missions
- Current “Ferry” Soyuz uses small 40 Watt toilet, designed for ~3 days
- Lunar Express^{SM} system provides toilet in Logistics Carrier
  - Current ISS class 100 Watt toilet could be used
    - Added Power ➔ Added Mass ➔ etc.
    - System analysis must be performed

A Cargo Variant

- Use Progress cargo vehicle instead of Soyuz
  - Supply depot at a L-1 could be developed
    - Allow early human controlled robotic missions
      - With minimal time delays
    - Create a staging point for lunar landings
    - Possible spaceport for Mars missions

L1 Mission Architecture



Other Applications

- Once human translunar capability is on hand
  - Missions beyond the Moon are possible
- Mars requires multiyear missions
- NEOs are infrequent
  - And often launch intervals are years apart
- What is needed is a place where:
  - Launch windows are frequent
  - Travel times are not much more than for the Moon
  - A reason to go

Sun-Earth L2: A Place to Go

- L2: Often cited as a possible location,
  - There has never been a reason to send humans there
- But things have changed!
- Starting in 2007, a series of big expensive satellites
  - Will be flown to Sun-Earth L2

Mission	Sponsor	Year of Launch
Herschel	ESA	2007
Planck	ESA	2007
Eddington	ESA	2007
JWST	NASA	2011
Constellation-X	NASA	2012
GAIA	ESA	2012
DARWIN	ESA	2014
TPF	NASA	2015
XEUS2	ESA	2015

Travel to Sun Earth L2

- L2 is 1.5 million kilometers from Earth
  - 3 - 4 times as far as the Moon
- Travel time depends on available rocket power
  - As low as 30 days via direct injection
    - Satellites can use fuzzy orbits over months
- L2 is not a stable Lagrange point
  - So all objects there must station-keep
  - Although the propellant requirement is very small

Thought Experiments

- What if Soyuz or COTS spacecraft
  - Could not only reach the Moon but travel beyond?
- What if humans could repair satellites at L2?
  - What if the James Webb Space Telescope
    - Could be repaired as is Hubble, by astronauts?
  - Could the L2 point be next satellite servicing orbit?
- If we can go to the Moon and Mars:
  - Why is the L2 point too far - or too dangerous?

What's Next?

- Commercial company could put deal together
- Russian pilot, ESA astronaut, 1 passenger
  - Russia brings 1 Proton launch (at discount)
    - Plus use of Soyuz after ISS mission
  - ESA astronaut & passenger each pay $X
  - Or ESA could provide Ariane V launch of LC
    - With A5 ESV, lunar ***orbit*** mission may be possible
- Space Adventures & CSI have signed MOU
  - Assess Lunar & ISS cargo opportunities

For More Information

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