



## **Russian Vehicles for ISS Cargo**

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## Purpose and Overview

- Purpose of Presentation – response to action from March 2003 SSUAS Winter Workshop:

“The SSUAS also requests a briefing on the... capabilities of the... Progress vehicles at the next SSUAS meeting.”

- Presentation Overview:
  - History of the Soyuz and Progress Vehicles
    - Launch Vehicle
    - Soyuz
    - Progress
  - Soyuz Vehicle Capability and Accommodations
  - Progress Capability and Accommodations
  - Typical Progress Stowage and Launch Preparation Flow



## History of the Soyuz and Progress

### □ Launch Vehicle

- Soyuz launch vehicles are part of the R-7 booster family
  - First R-7 (2-stage ICBM) was launched in May 1957
  - R-7 family includes Sputnik, Vostok, Luna, Voskhod, Molniya, and Soyuz Boosters
  - 1,605 successful launches out of 1,680 attempts since 1957 (95.5% success rate)
- Notable launches for the R-7 family:
  - Sputnik-1 (10/4/57), Sputnik-2 (11/3/57), Sputnik-3 (5/5/58)
  - Luna Probes (1959 - 1966)
  - Vostok (Successful launch & recovery of dogs Belka and Strelka – 8/19/60)
  - Vostok (Yuri Gagarin – first man in space – 4/12//61)
  - Venera Probes (1961 – 1965)
  - Mars Probes (1962 – 1965)
  - Voskhod-2 (Alexei Leonov – first spacewalk – 3/18/65)
  - Soyuz-1 (Vladimir Komarov – first fatality in space 4/23/67)
  - Progress-1 (1/20/1978)
  - Soyuz TM-31 (ISS Expedition 1 Crew launched – 10/31/2000)



## History of the Soyuz and Progress (cont.)

### □ Soyuz Vehicle

- Soyuz is the longest-serving manned spacecraft in history (1966-present)
- 106 flight articles have flown
- Originally designed by S.P. Korolev's OKB-1 design bureau for the Soviet lunar program
- Soyuz was analogous in the Soviet program to the U.S. Apollo capsule
- Though the basic structure and layout have changed little since 1966, 7 Soyuz versions have evolved, plus the L1 ("Zond") and L2 lunar vehicles

### □ Progress Vehicle

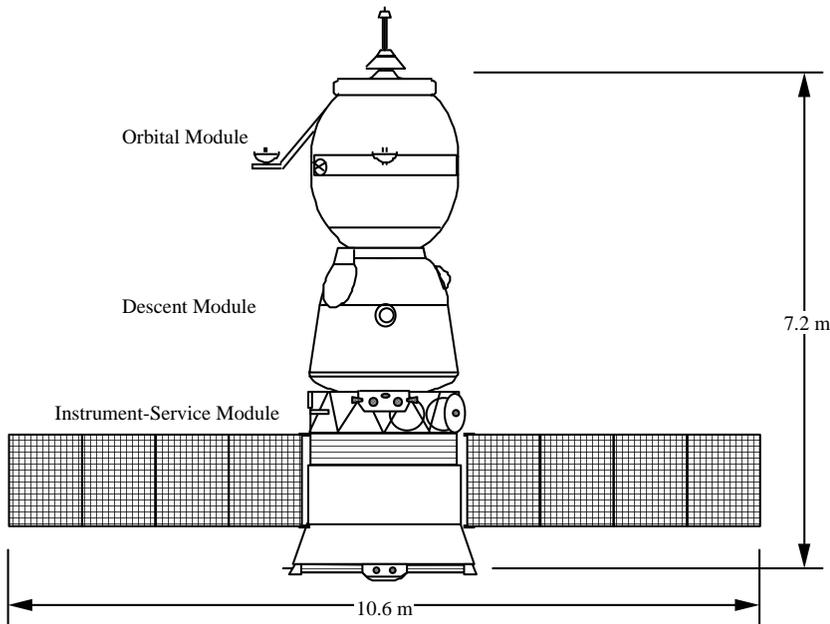
- Developed from the Soyuz vehicle, and shares many common systems
  - Proof of concept for Progress was the unmanned Soyuz 20 (11/17/75 – 2/16/76)
  - Docked with Salyut 4; carried biological experiments in descent module
- 100 flight articles have flown since Progress 1 (1/20-2/8/78)
- Progress has gone through 3 major upgrades to incorporate improvements made to Soyuz vehicles



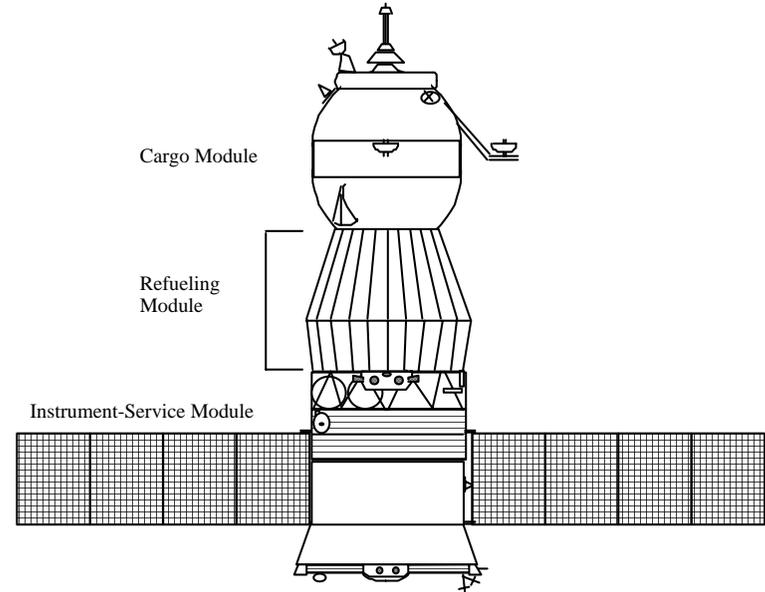
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## Soyuz and Progress Vehicle Comparison



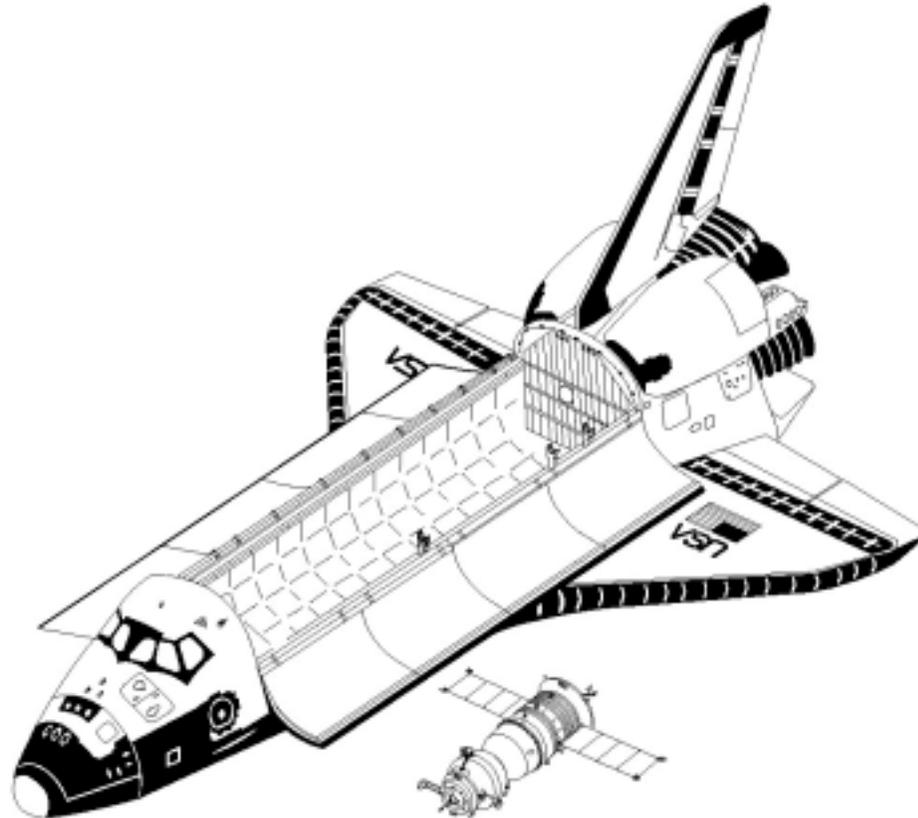
**Soyuz TMA Vehicle**



**Progress M1 Vehicle**



## Shuttle and Soyuz Vehicle Comparison



Space Shuttle and Soyuz TMA Vehicles Drawn to Scale

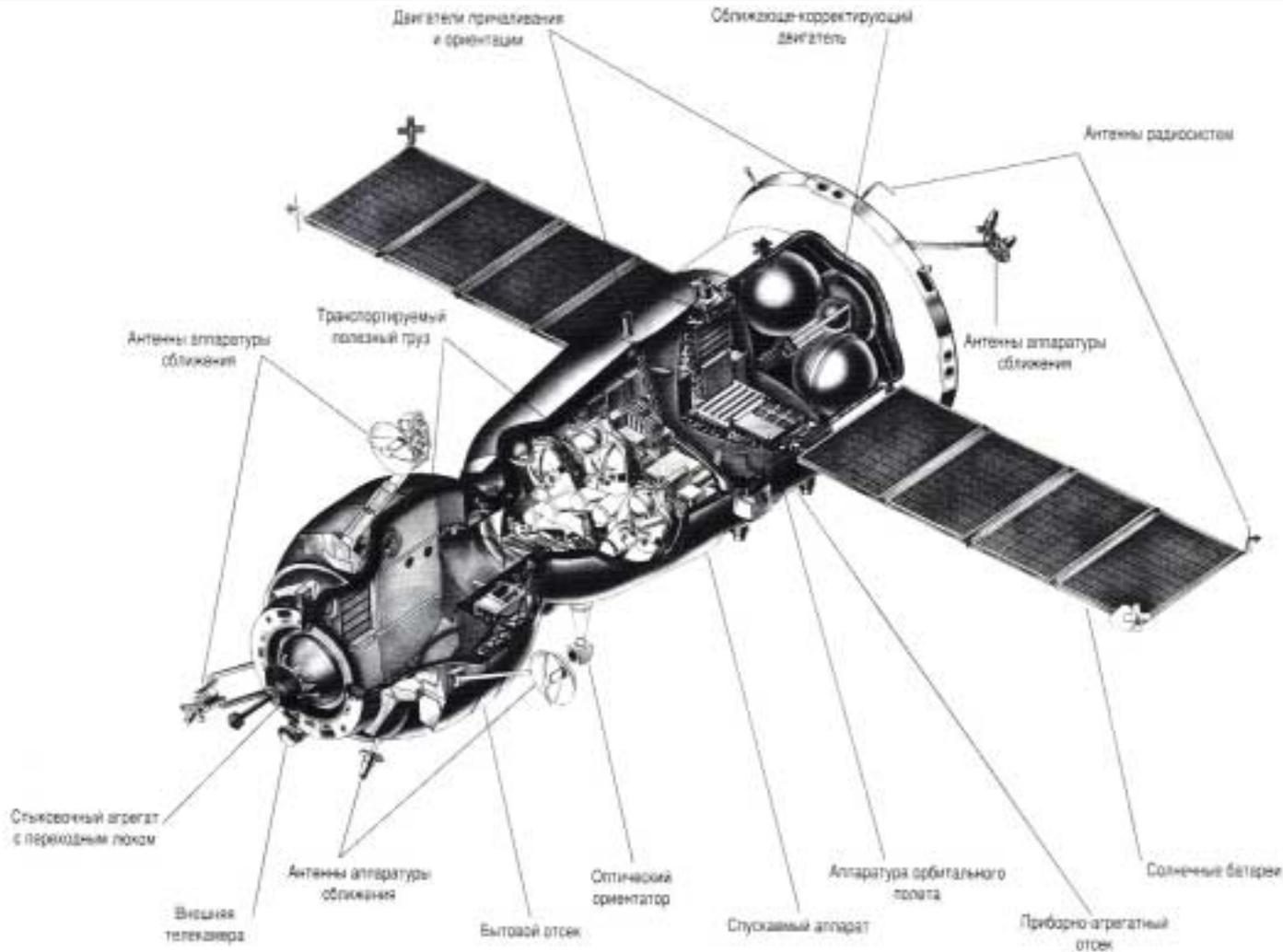


## Soyuz TMA Vehicle Capability and Accommodations

- Crewmembers: 2-3
- Total mass at launch: 7,190 kg (15,849 lbs)
- Total habitable volume: 10.5 m<sup>3</sup> (371 ft<sup>3</sup>)
  - Orbital Module: 6.5 m<sup>3</sup> (230 ft<sup>3</sup>)
  - Descent Module: 4 m<sup>3</sup> (141 ft<sup>3</sup>)
- Ascent Payload Capacity: 30-350 kg (66-772 lbs)
- Descent Payload Capacity: 50-150 kg (110-331 lbs)
- Crewmember weight: 50-95 kg (110-209 lbs)
- Crewmember height: 150-190 cm (4'11" – 6'3")
- Max stay time on orbit: 200 days
- Nominal descent g-loads: 3-4 g
- Nominal landing accuracy: 30 km (18.6 mi)
- Items ≤ 5 kg (11 lbs) are generally stowed in vehicle stowage containers
- Items > 5 kg must be hard-mounted on special structure



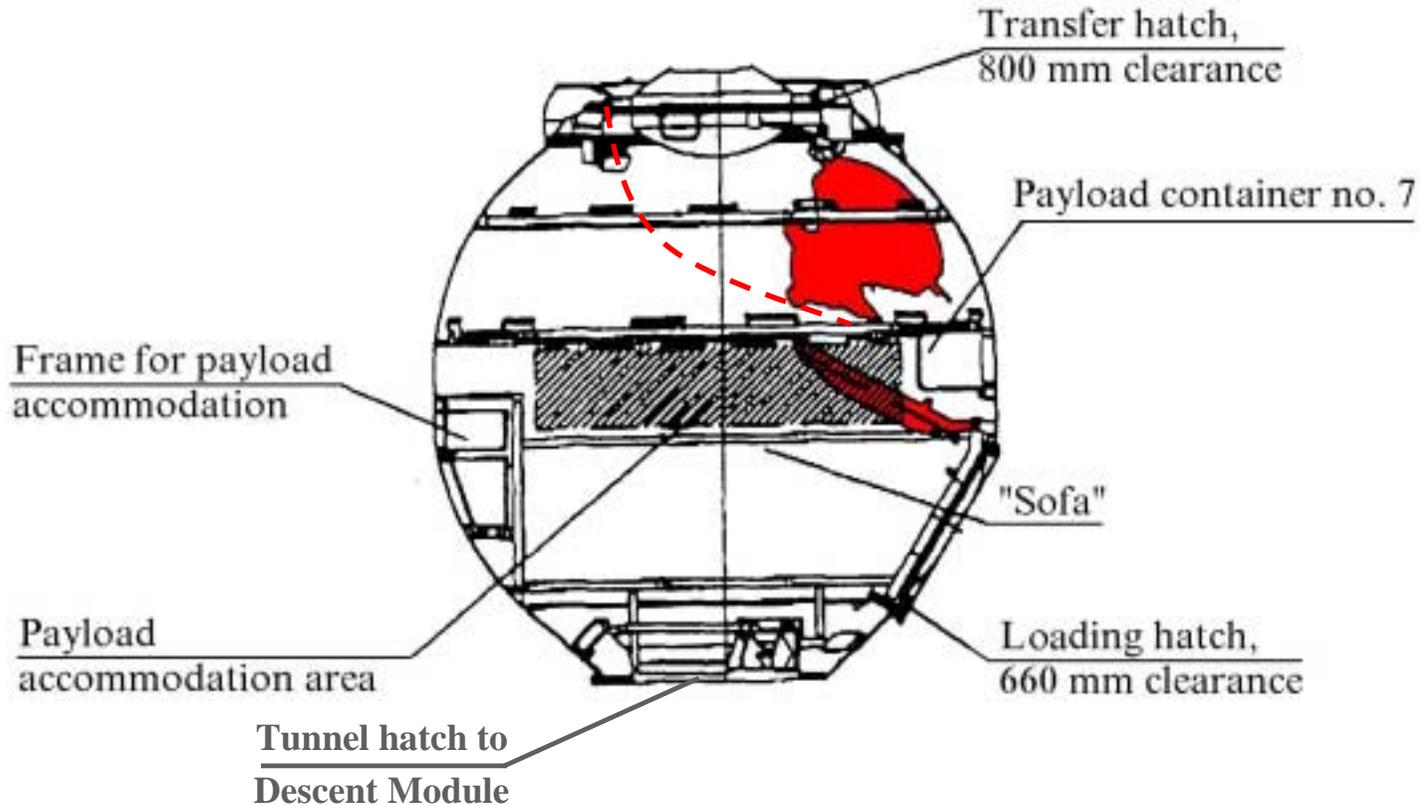
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## Soyuz TM / TMA



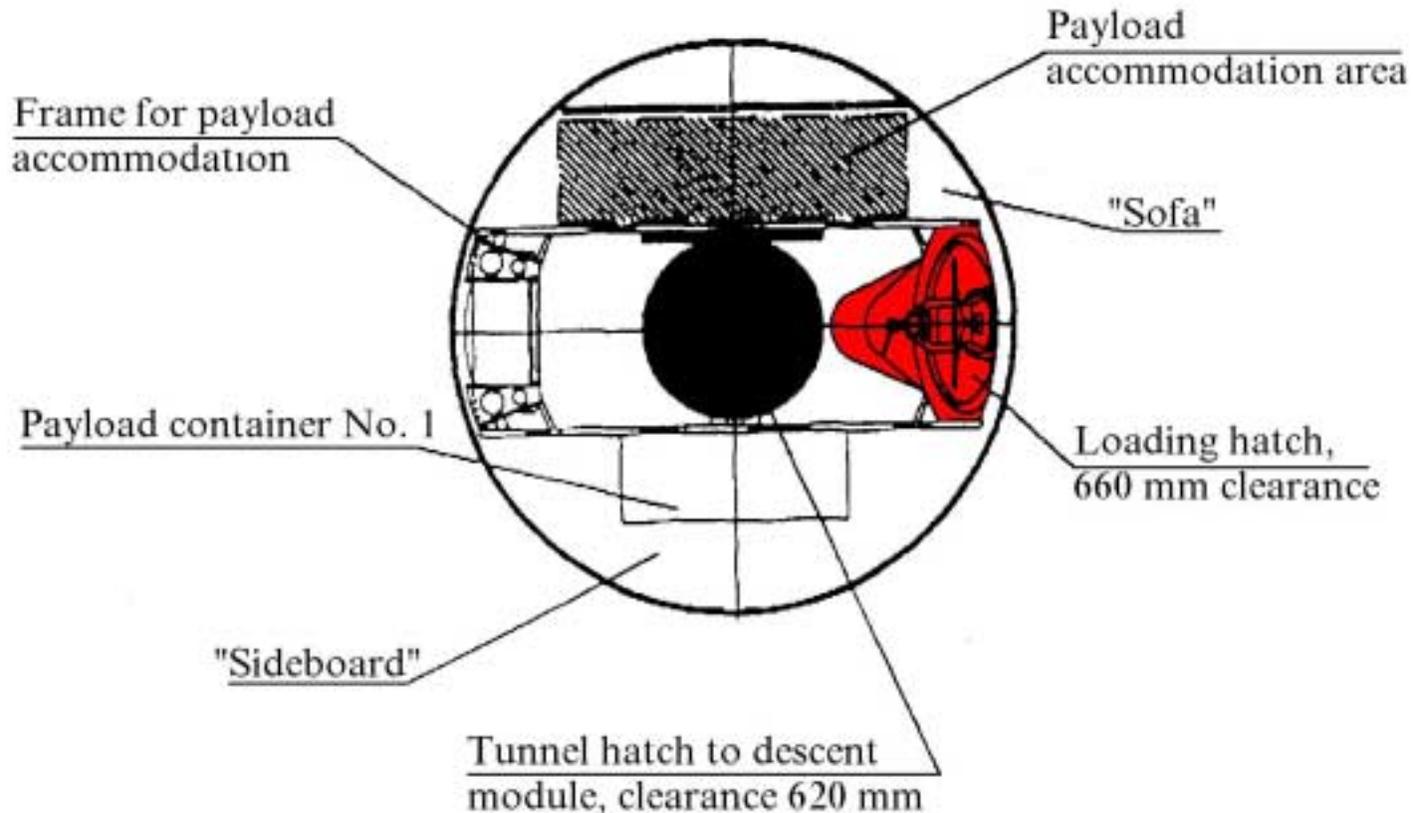
## Soyuz Vehicle Capability and Accommodations



**Soyuz Orbital Module (Vertical Cross Section)**



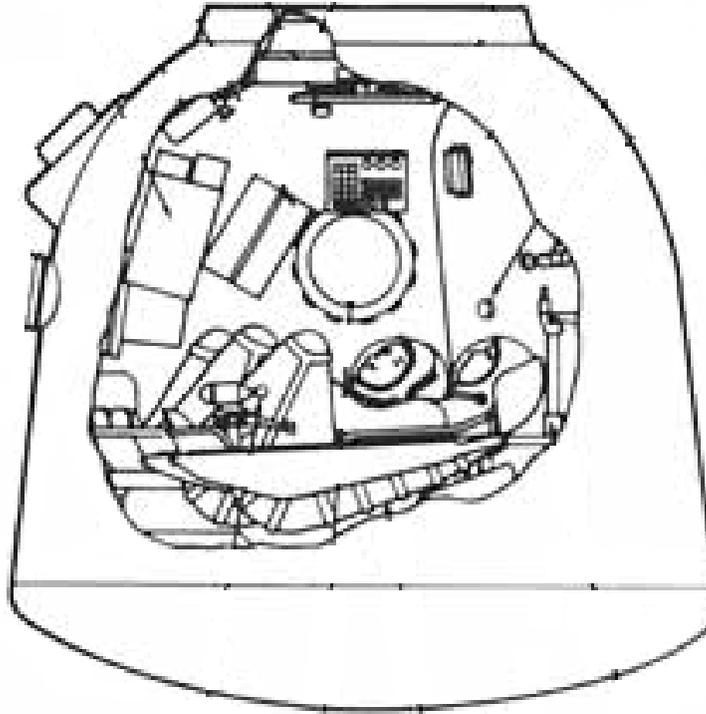
## Soyuz Vehicle Capability and Accommodations (cont.)



**Soyuz Orbital Module (Vertical Cross Section)**



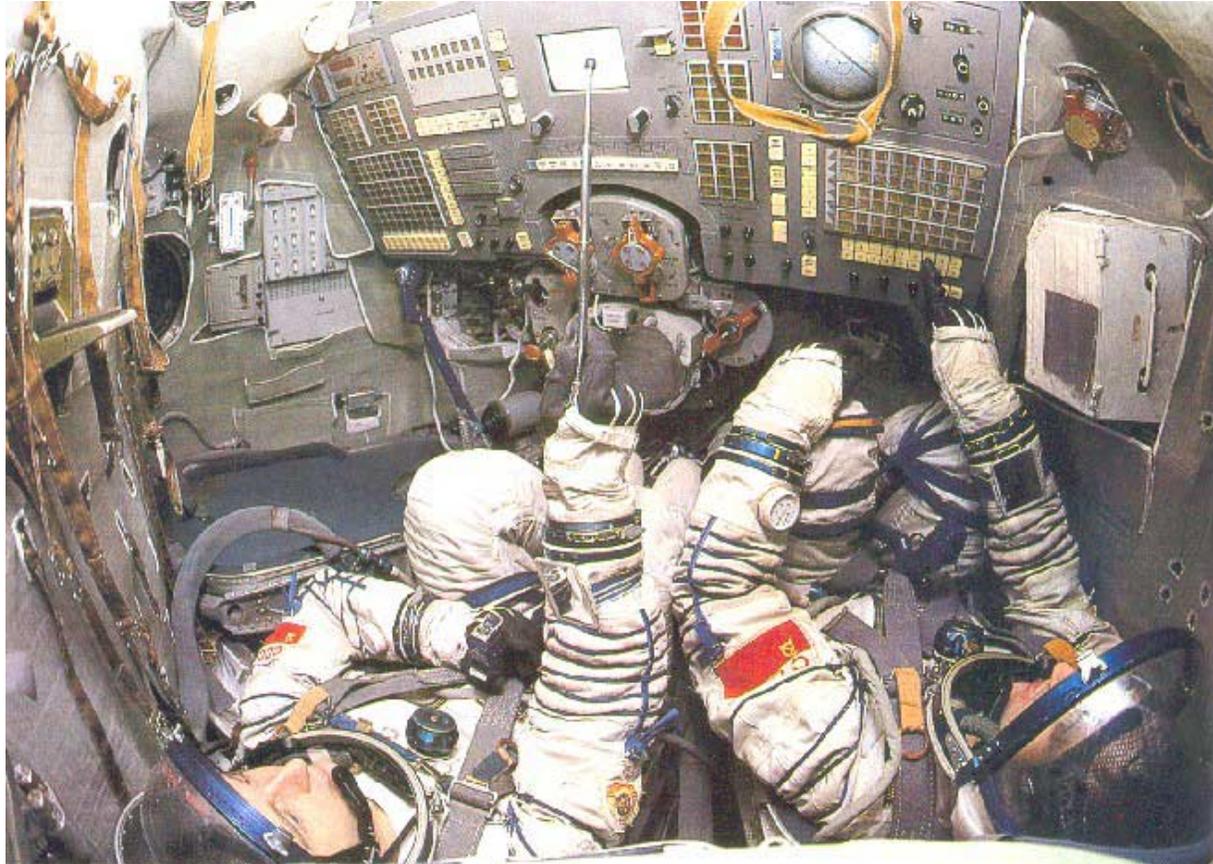
## Soyuz Vehicle Capability and Accommodations (cont.)



**Soyuz Descent Module**



## Soyuz Vehicle Capability and Accommodations (cont.)

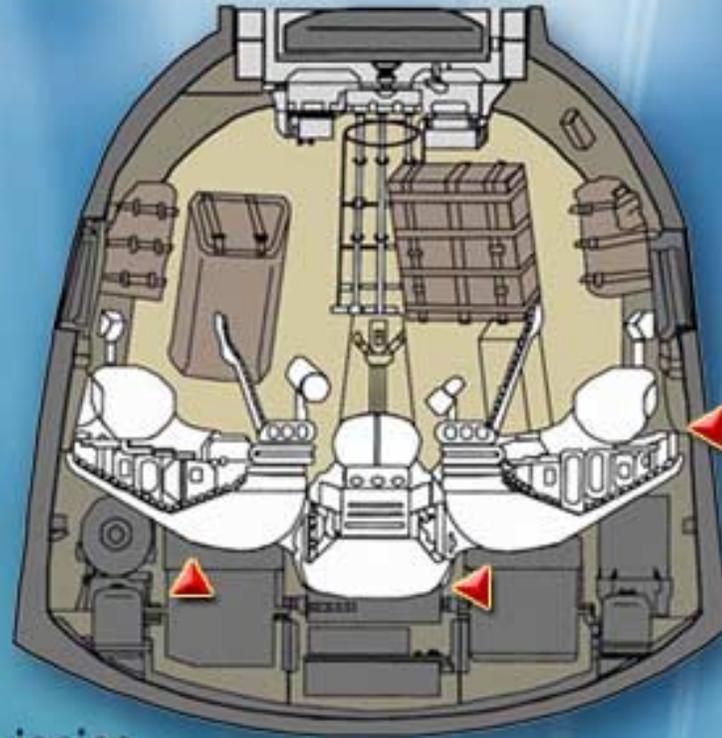


**Interior of Soyuz TM Descent Module with 2 Crewmembers**



## Soyuz TMA Seat Improvements

- 50 mm longer
- Max User Height - 6' 3"  
*(TM was 6' 0")*
- Min User Height - 4' 11"  
*(TM was 5' 4")*
- Max User Mass - 209 lb  
*(TM was 187 lb)*
- Min User Mass - 110 lb  
*(TM was 123 lb)*
- Seat Shock Absorbers  
Modified For New Loads
- Rerouted and redesigned avionics





## Soyuz Vehicle Capability and Accommodations (cont.)



**Interior of Soyuz TMA Descent Module**



## Progress Vehicle Capability and Accommodations

	<u>Progress M</u>	<u>Progress M1</u>
❑ Total mass at launch:	7,290 kg (16,067 lbs)	7,290 kg (16,067 lbs)
❑ Total payload limit:	2,550 kg (5,181 lbs)	2,230-3,200 kg (4,916-7,055 lbs)
❑ Max pressurized cargo:	1,800 kg (3,968 lbs)*	1,800 kg (3,968 lbs)*
❑ Max fresh water:	420 kg (926 lbs)	300 kg (661 lbs) in cargo module
❑ Maximum air or O <sub>2</sub> :	50 kg (110 lbs)	40 kg (88 lbs)
❑ Max refueling propellant:	850 kg (1,874 lbs)	1700 kg (3,748 lbs)
❑ Surplus ISM prop to ISS:	250 kg (551 lbs)	185-250 kg (408-551 lbs)
❑ Trash disposal capacity:	1,000-1,600 kg	1,000-1,600 kg (2,205-3,527 lbs)
❑ Waste water capacity:	400 kg (882 lbs)	300 kg (661 lbs) in cargo module
❑ Cargo module volume:	6.6 m <sup>3</sup> (233 ft <sup>3</sup> )	6.6 m <sup>3</sup> (233 ft <sup>3</sup> )

\* While 1,800 kg is the stated mass limit for Progress pressurized cargo, the practical limit has been 1,600–1,650 kg (3,527-3,638 lbs) due to volume constraints

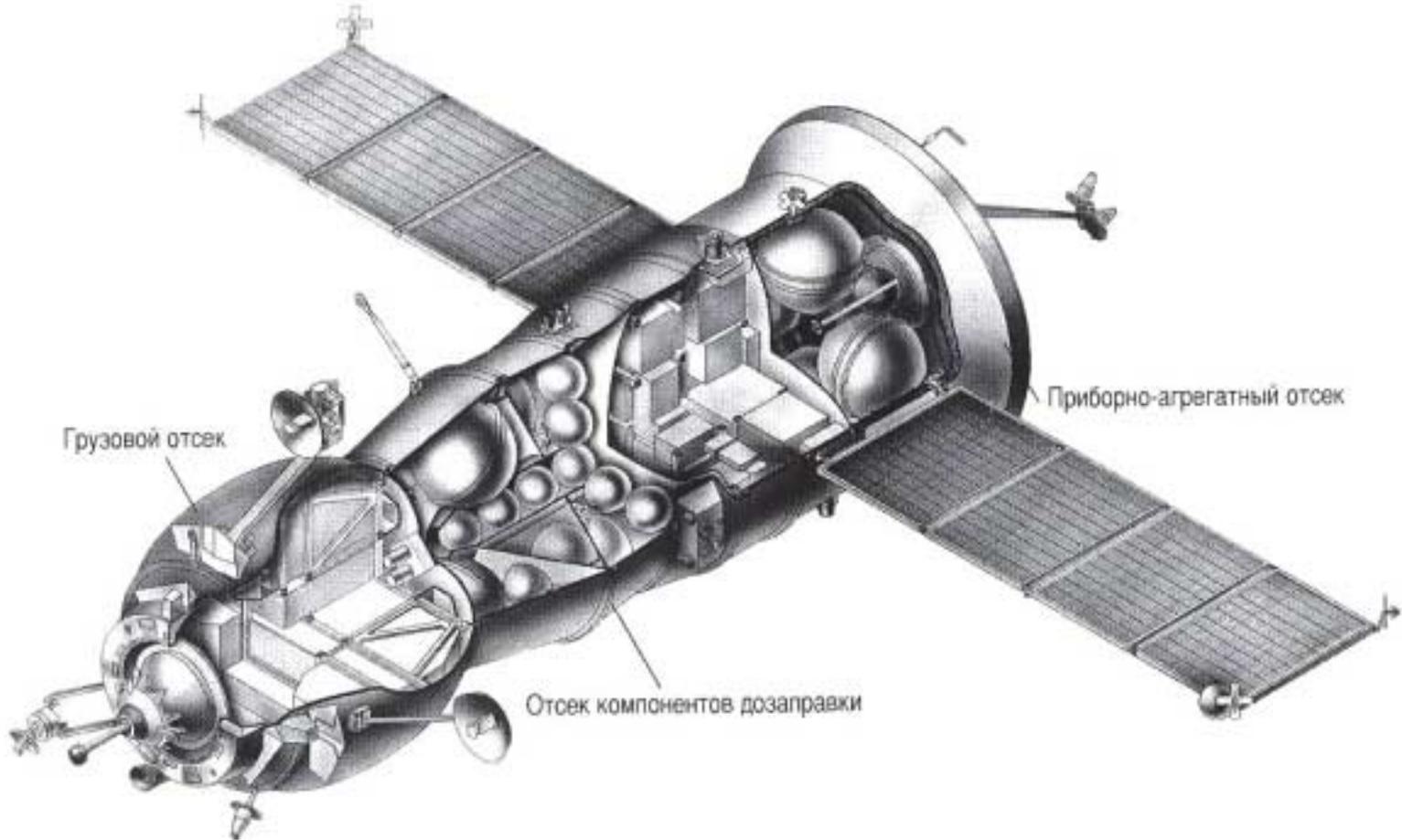


## Progress Vehicle Capability and Accommodations (cont.)

- ❑ Electrical power: 27 VDC (+7, -4 VDC); 3A, 10A, or 20A outlets available
  - Use of electrical power must be negotiated
  - Requires special certification, acceptance, and interface testing
- ❑ Items  $\leq$  8 kg (17.6 lbs) are generally stowed in vehicle stowage containers
- ❑ Items  $>$  8 kg must be hard-mounted on special structure
- ❑ Main hatch diameter: 800 mm (31 in)
- ❑ Late access hatch diameter: 470 mm (19 in)
  - Late stowage (after L-3 to 4 weeks) must be negotiated
  - Volume is extremely limited
  - Typically reserved for limited life and temperature sensitive items such as medicines and fresh food



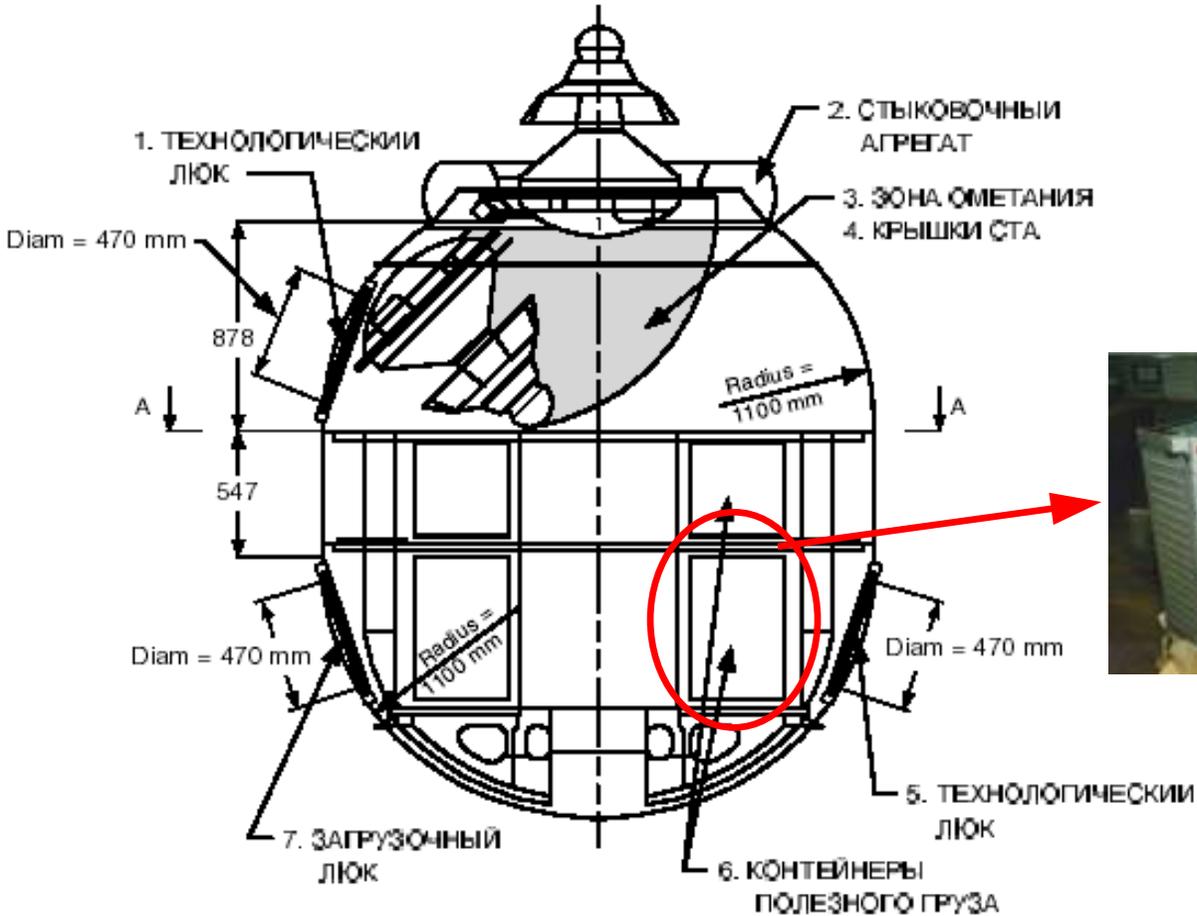
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## Progress M / M1



# Russian Vehicles for ISS Cargo



**Progress Cargo Module (Side View)**

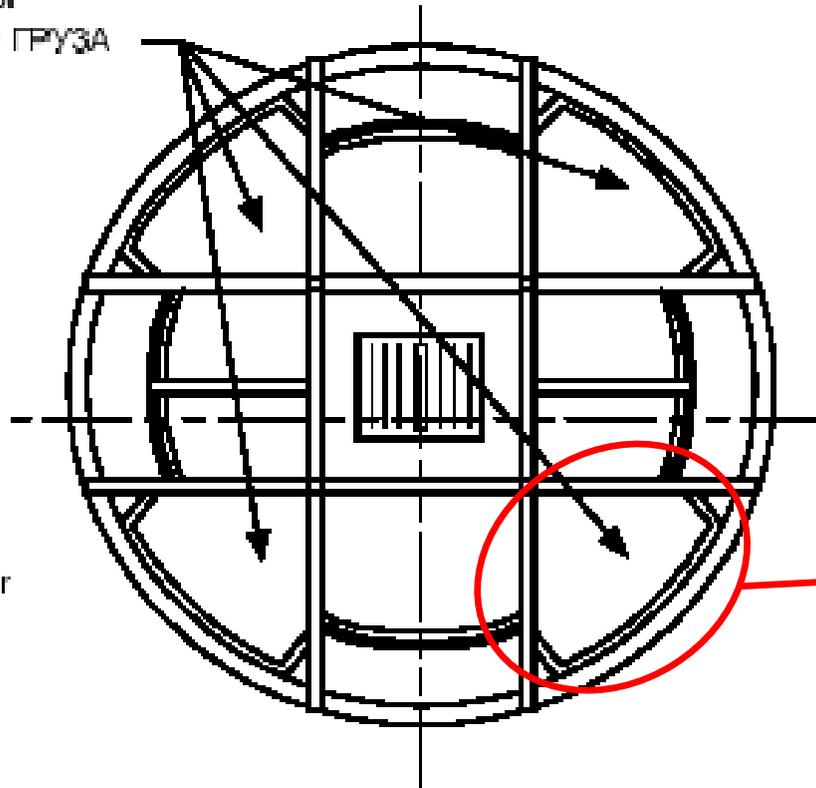


# Russian Vehicles for ISS Cargo



В. КОНТЕЙНЕРЫ  
ПОЛЕЗНОГО ГРУЗА

A-A



Key:

1. Technological hatch
2. Docking assembly
- 3, 4. Dynamic envelope of docking assembly cover
5. Technological hatch
6. Payload containers
7. Loading hatch
8. Payload containers



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## Progress Cargo Module (Plane A-A)



## Progress Stowage Planning





## Progress Stowage for Flight





# Russian Vehicles for ISS Cargo



## Progress Stowage for Flight





## Progress Stowage for Flight





## Vehicle Processing for Flight



Testing of solar arrays



**Progress M1 Vehicles being prepared for flight  
in test stands at the Baikonur Cosmodrome**



# Russian Vehicles for ISS Cargo



## Final Processing for Flight





# Russian Vehicles for ISS Cargo



## Delivery to Pad and Launch





## Rendezvous and Docking





## Caveats for U.S. Cargo Carried in Russian Vehicles

- Significant shipping and customs issues exist for flying U.S. hardware on Soyuz or Progress
  - These issues are primary schedule drivers
  - Obtaining export control approval (State Department license) can be difficult and time consuming, especially if key technologies are involved
- At present, space on Progress and Soyuz vehicles is limited to items required to keep the crew safe and ISS systems operational
  - U.S. payload hardware has been on a space available, courtesy basis
  - Unless and until the Russian government funds additional Progress flights, this will continue to be the case
- Flight of other than small, passive, stowed items requires significant effort
  - Negotiated interface control documents and special testing, possibly with Russian participation
  - Special safety certification



## U.S. Cargo Carried in Russian Vehicles to/from ISS

□ Soyuz TMA-1 (5S) Return:	<u>Mass Allocation</u>	<u>% of Total</u>
○ Other US Hardware:	5.3 kg    11.7 lbs	3.2 %
○ <b>US Payload Hardware:</b>	<b>5.6 kg    12.3 lbs</b>	<b>3.4 %</b>
○ <u>All US Hardware:</u>	<u>10.9 kg    24.0 lbs</u>	<u>6.5 %</u>
○ Vehicle Total:	167.2 kg    368.5 lbs	100.0 %

□ Soyuz TMA-2 (6S) Launch:	<u>Mass Allocation</u>	<u>% of Total</u>
○ US Crew provisions and food:	26.6 kg    58.6 lbs	12.5 %
○ US Logistics and Maintenance:	15.9 kg    35.1 lbs	7.5 %
○ Other US Hardware:	10.7 kg    23.6 lbs	5.0 %
○ <b>US Payload Hardware:</b>	<b>0.5 kg    1.1 lbs</b>	<b>0.2 %</b>
○ <u>All US Hardware:</u>	<u>53.7 kg    118.4 lbs</u>	<u>25.3 %</u>
○ Vehicle Total:	212.2 kg    467.8 lbs	100.0 %



## U.S. Cargo Carried in Russian Vehicles to/from ISS (cont.)

<input type="checkbox"/> Progress M1-10 (11P) Launch:	<u>Mass Allocation</u>		<u>% of Total</u>
○ US Crew provisions and food:	175.7 kg	387.4 lbs	10.9 %
○ US Logistics and Maintenance:	94.4 kg	208.1 lbs	5.8 %
○ Other US Hardware:	38.9 kg	85.7 lbs	2.4 %
○ <b>US Payload Hardware:</b>	<b>0.0 kg</b>	<b>0.0 lbs</b>	<b>0.0 %</b>
○ <u>All US Hardware:</u>	<u>309.0 kg</u>	<u>681.1 lbs</u>	<u>19.1 %</u>
○ Vehicle Total:	1,616.0 kg	3,562.6 lbs	100.0 %