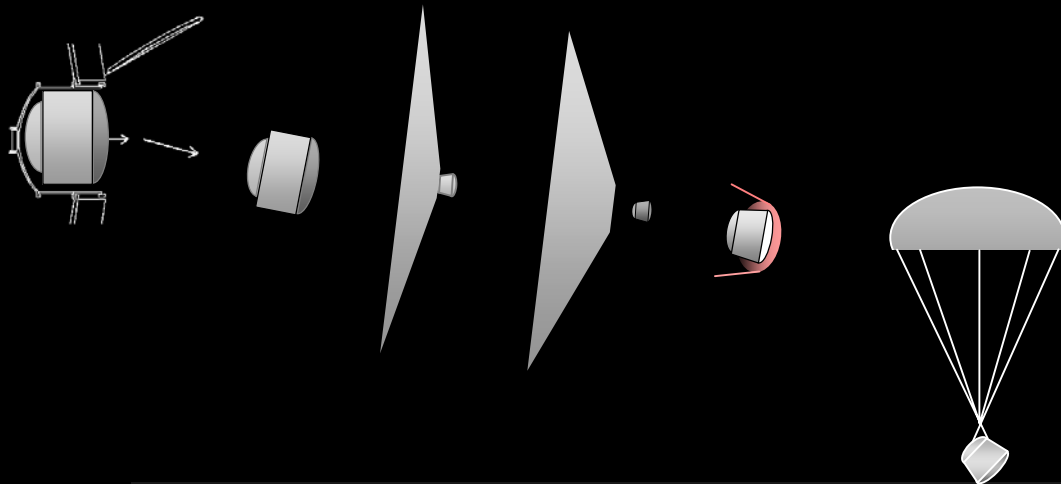


SPEED: Small Payload Express Earth Delivery

IAC-10-A2.6.13
October 1, 2010



Joe Carroll
Tether Applications, Inc.

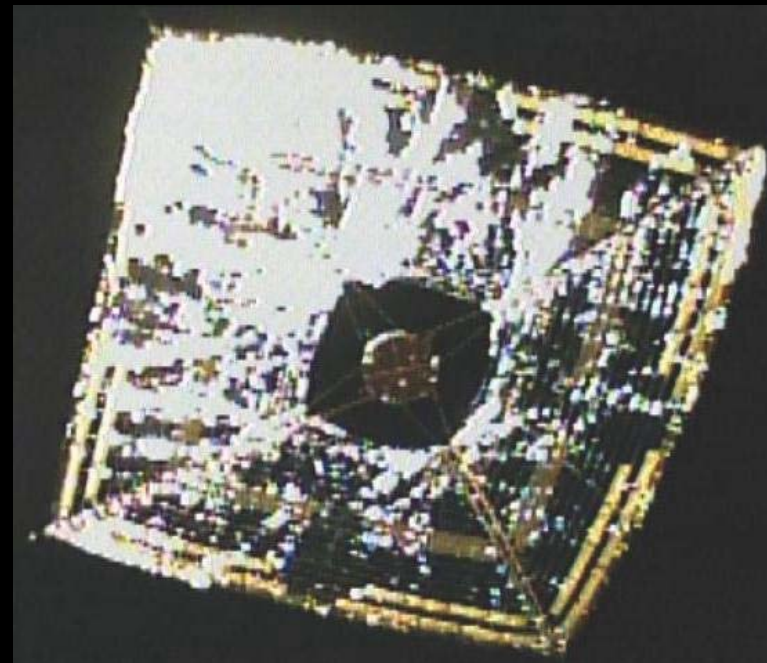
Dr. Dan Rasky
NASA Ames Research Center

Spinning Sail Flight Tests

- Without Progress mass, Znamya could deorbit in hours
- An orbit life that short can even be useful (*if* controllable)
- Znamya test concept led to SPEED spinning-dragsail
- And the IKAROS picture led to sail design refinement



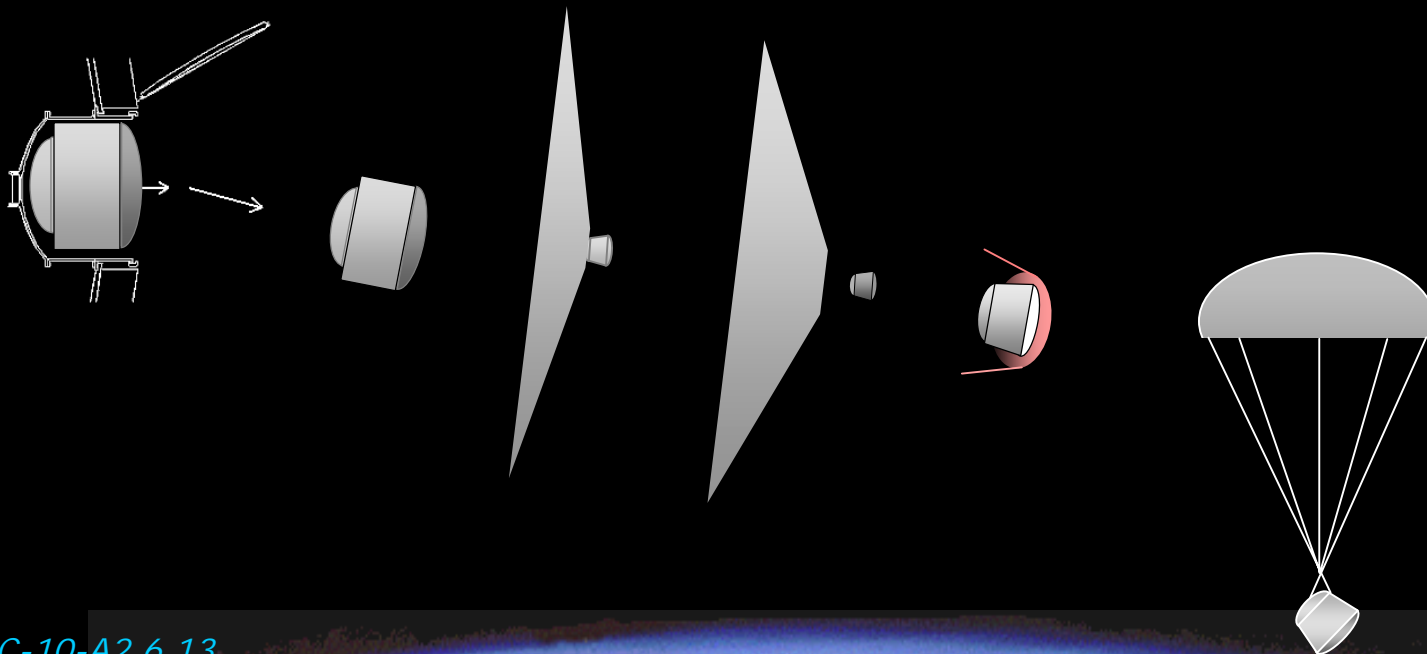
Znamya, as seen from Mir



IKAROS, deployed camera view

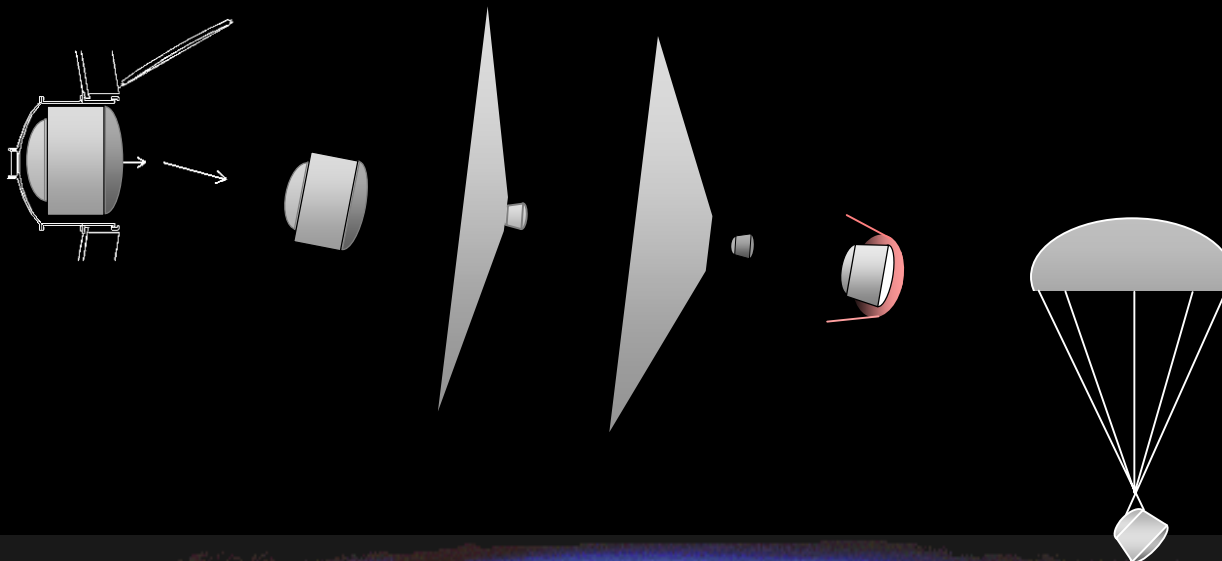
SPEED Scenario

1. Load samples, then balance and seal capsule
2. Leave ISS via airlock (on visiting vehicle?)
3. Deploy 100m² gossamer spinning dragsail
4. Adjust spin rate to modulate sail drag area
5. Release sail ~4 hours later, near 200 km altitude
6. Reenter, deploy chute, and recover in mid-air
7. Distribute samples to users by commercial courier



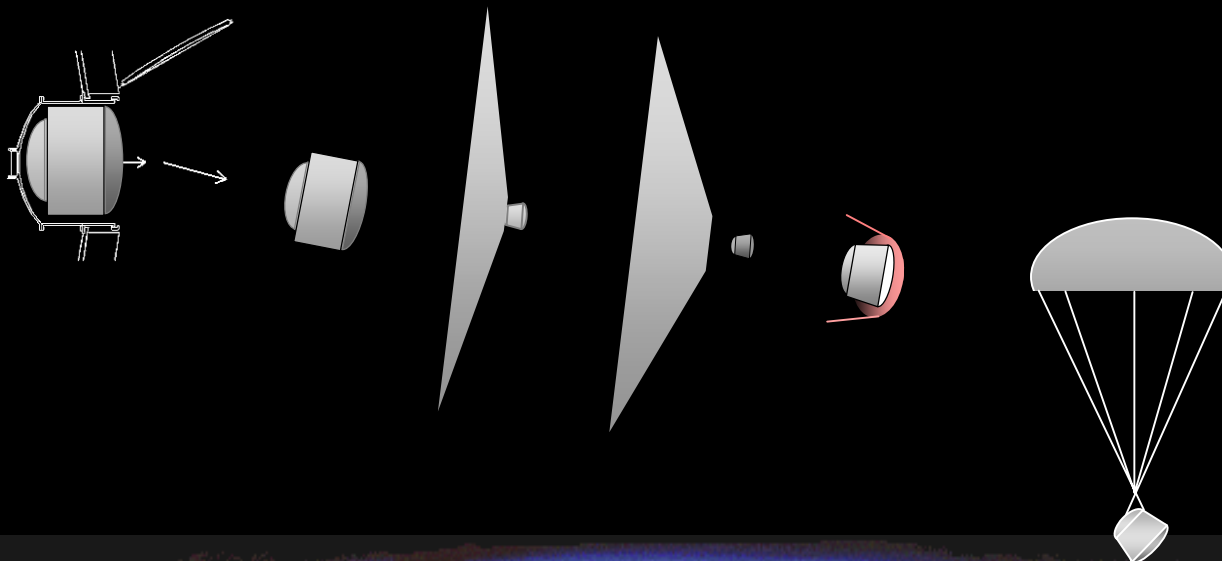
SPEED Uses on ISS

1. Samples for crew countermeasures testing
2. ISS ops, to assess illnesses & ISS habitability
3. Gravitational biology & materials processing
4. On-demand thermosphere & reentry testing
5. Deploying nanosats and probes from ISS
6. Other existing ISS users (US and foreign)
7. New commercial ventures *enabled* by SPEED



Non-ISS Uses of SPEED

1. DragonLab users needing early sample return
2. Bigelow Aerospace and its future customers
3. On-demand probe deorbit from Mars orbiters
4. Sample return during artificial gravity tests
5. Small solar sail missions, especially to NEOs
6. Sample returns from NEOs and Mars moons



Frequency Matters...

Access *from* space is a limiting factor on ISS

- Overall planned launch rates to ISS are ~10/year
 - includes Soyuz, Progress, Dragon, ATV, and HTV
- But return rates are only ~6/year: Soyuz & Dragon
- So access to ISS is better than access from ISS

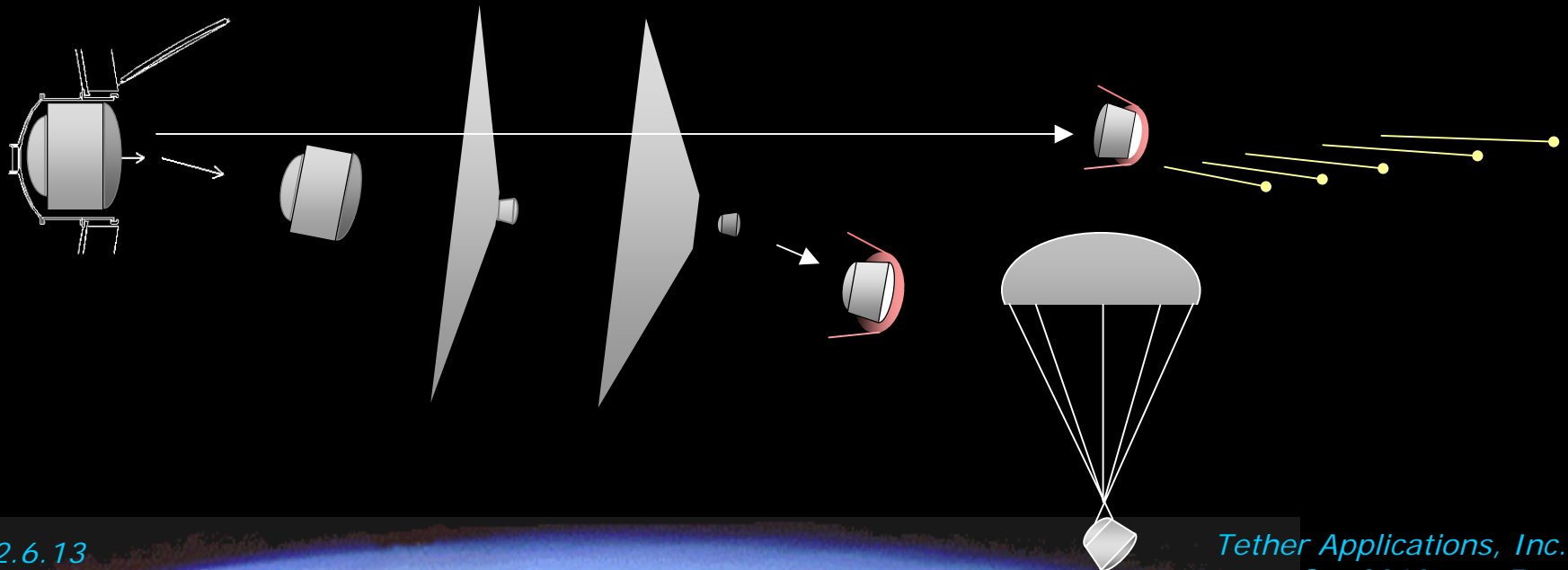
Most research is iterative; cycle times limit viability

- *Any* increase in return rates will benefit existing users
- Nobody knows what impacts larger increases will have
- Nobody knows what new uses of ISS could be enabled

Goal for SPEED: make weekly sample return affordable

Key Constraints Drive Design

- For nano-scale systems on ISS, “First, do no harm.”
- Reliability may be in 3rd place, after safety & cost
- Heatsoak and avionics set limits to miniaturization
- FAA licensing and insurance add to commercial costs
- Shape + CG = bistable; backwards reentry more likely:
 - If dragsail or avionics fail; SPEED is likely to burn up
 - This may actually ease licensing and insurance



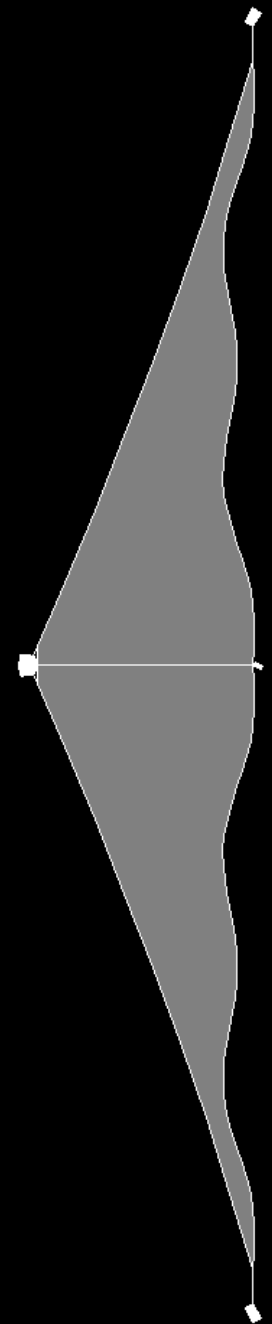
Controlling a Spinning Dragsail

Spinning sail shape and attitude

- Drag sweeps sail back into a “corrugated cone”
- The sweep angle depends on drag and spin rate
- Mean axial edge offset is the drag “torque arm”
- 10° yaw causes torques that pitch sail w/orbit
- Small corner masses aid start of deployment

Sail control is like braking on an icy road

- Brake early, in case “icy patches” are ahead
- Use first-orbit drag to infer next-orbit drag
- “Ease off” by reducing sail normal drag area
- Typical spin is 5 rpm at first, 20 rpm near end.



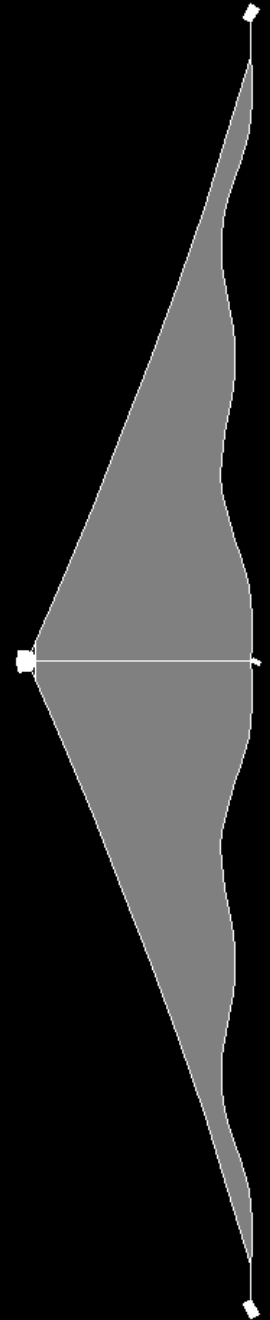
Sample Return Alternatives

Alternatives and their problems

- SEDS-1 & YES2: will ISS approve tether use?
- Raduga: 150 kg; requires deorbit by Progress
- Rockets: ignition hazards inside or near ISS;
capsule could impact ISS at ~ 100 m/s
- Raise Soyuz & Dragon flight rates: expensive

Key challenges facing SPEED

- Dragsail development risks, costs, and delays
- Nanocapsule payload volume and mass fraction
- Adding a small airlock for easy deployment
- Keeping costs low enough to allow weekly use



Conclusions

1. Access from ISS is more limited than access to ISS.
2. *Any* increase in sample return rates will benefit users; but *weekly* sample return might make ISS a runaway success.
3. SPEED is technically challenging, but it may be a far less intimidating integration challenge than alternatives.
4. We plan for SPEED to be a fully commercial service by a focused SpaceHab-like start-up, available to all ISS users
5. To improve reliability while limiting costs, our intent is for the operator to charge *only* for successful returns.