



NESC ACADEMY ONLINE

Aerodynamic Decelerator Systems

Module 1 - Heritage

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Learning from the Past, Looking to the Future



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Purpose

- Not intended to replace AIAA ADS Short Course
- Recommended Reading:
NASA SP-8066
Space Vehicle Design Criteria (Structures)
Deployable Aerodynamic Deceleration Systems
Ewing, 1971

Disclaimer: *Any opinions expressed are my own and do not reflect NASA, NESC, or Pioneer Aerospace Corporation*

Future Modules may contain ITAR/EAC data (and will be marked as such)



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Entry, Descent & Landing

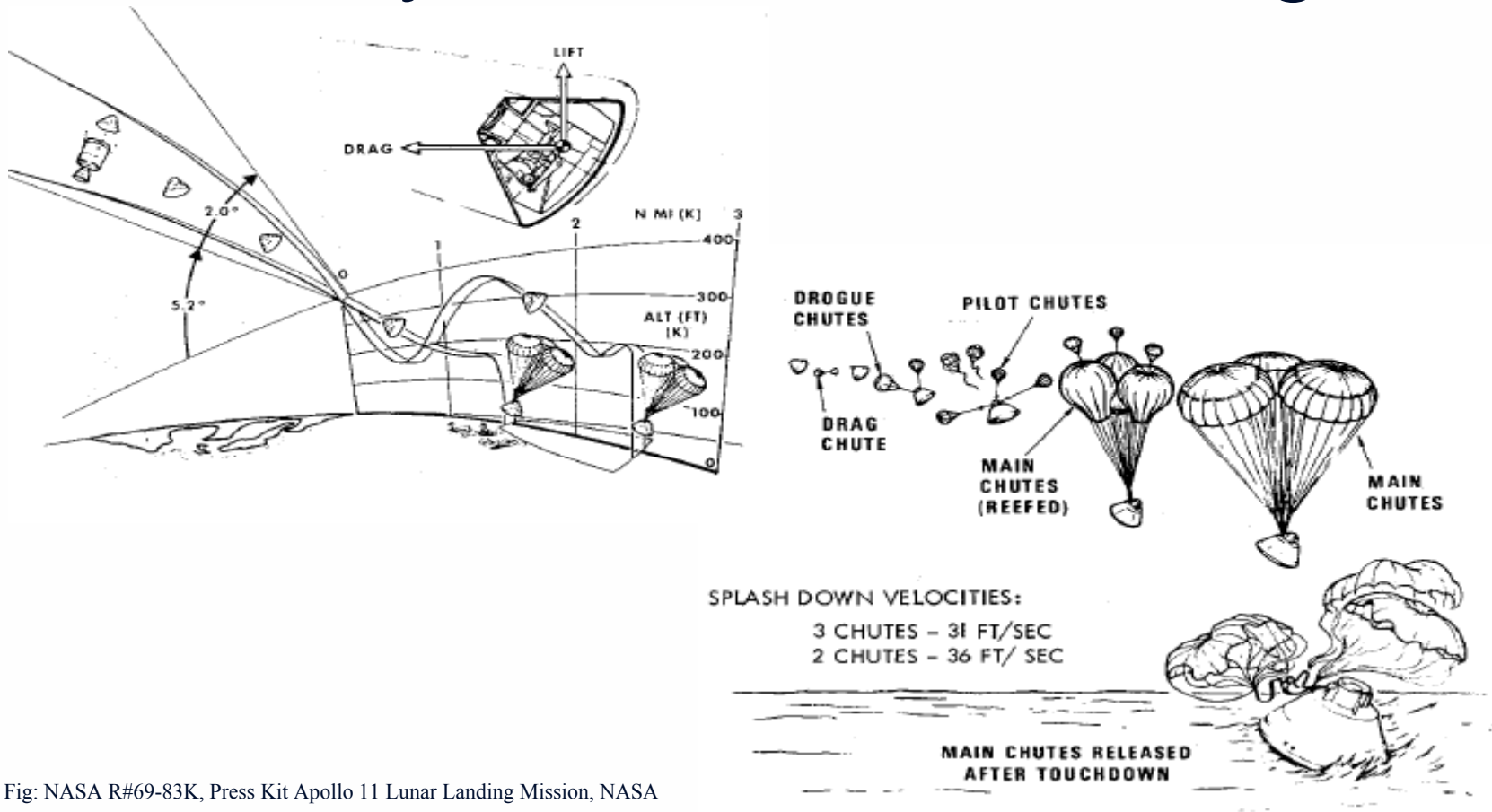


Fig: NASA R#69-83K, Press Kit Apollo 11 Lunar Landing Mission, NASA

Aerodynamic Decelerator Systems – Witkowski/FM-TDT

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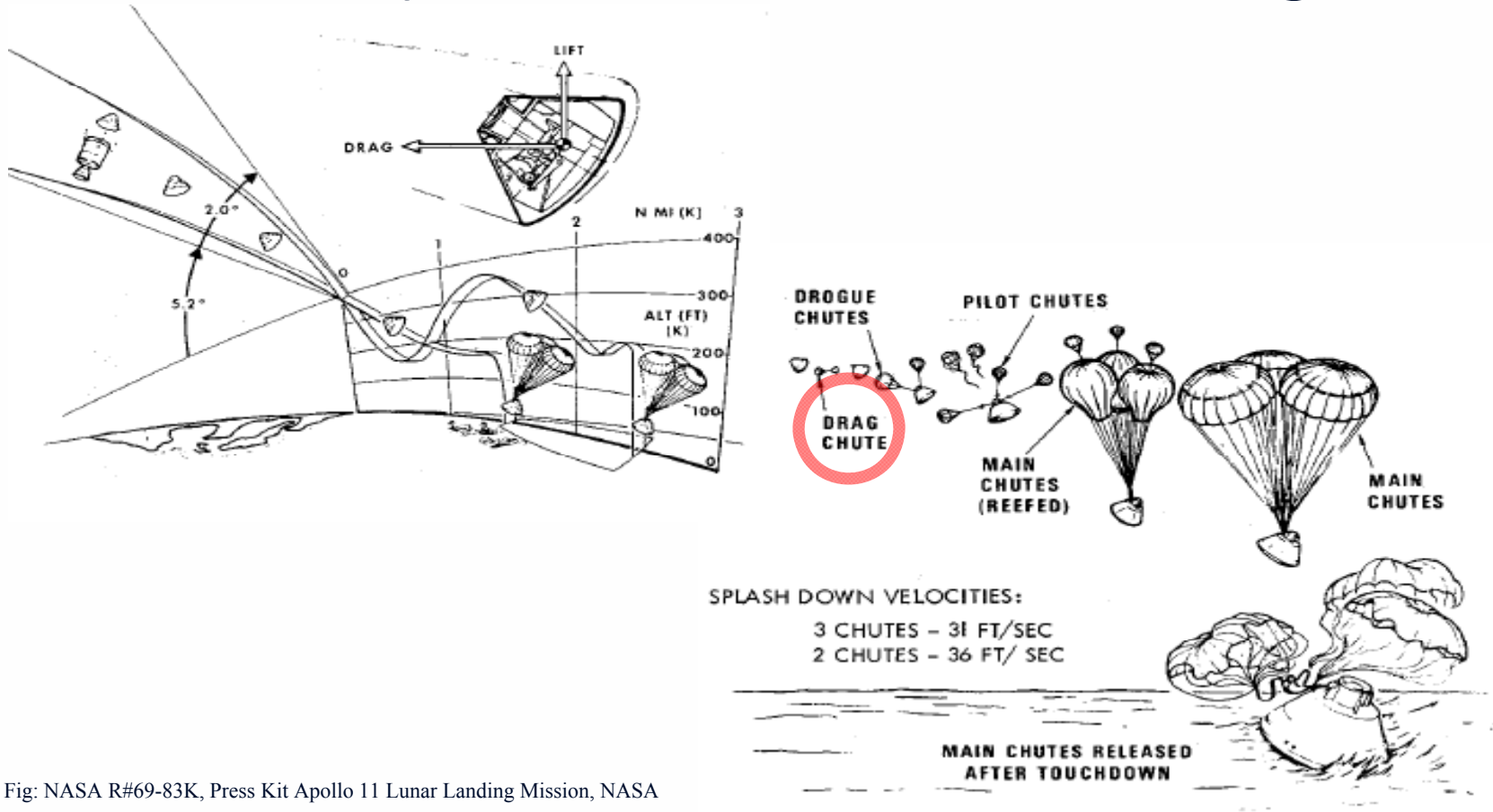


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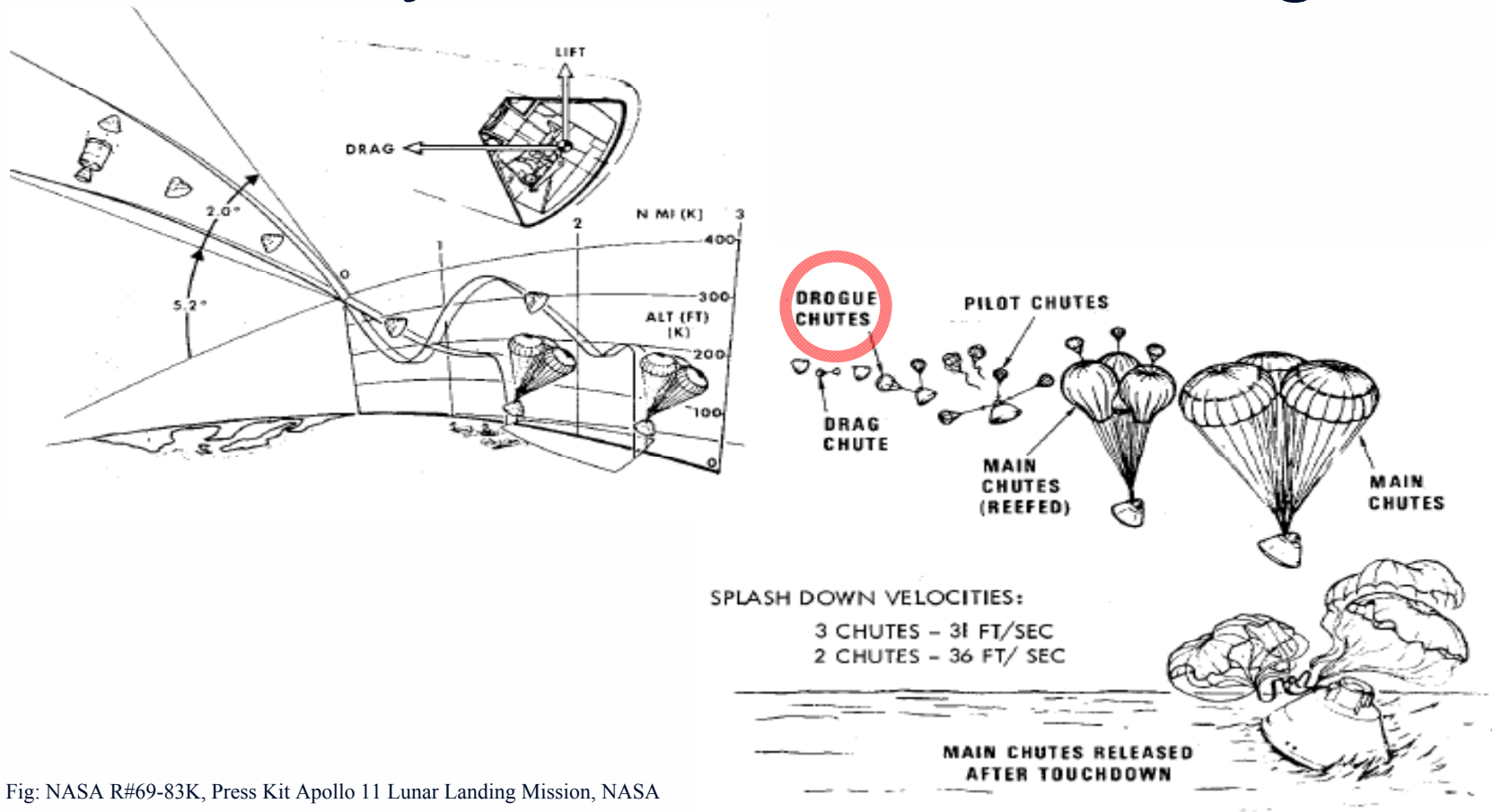


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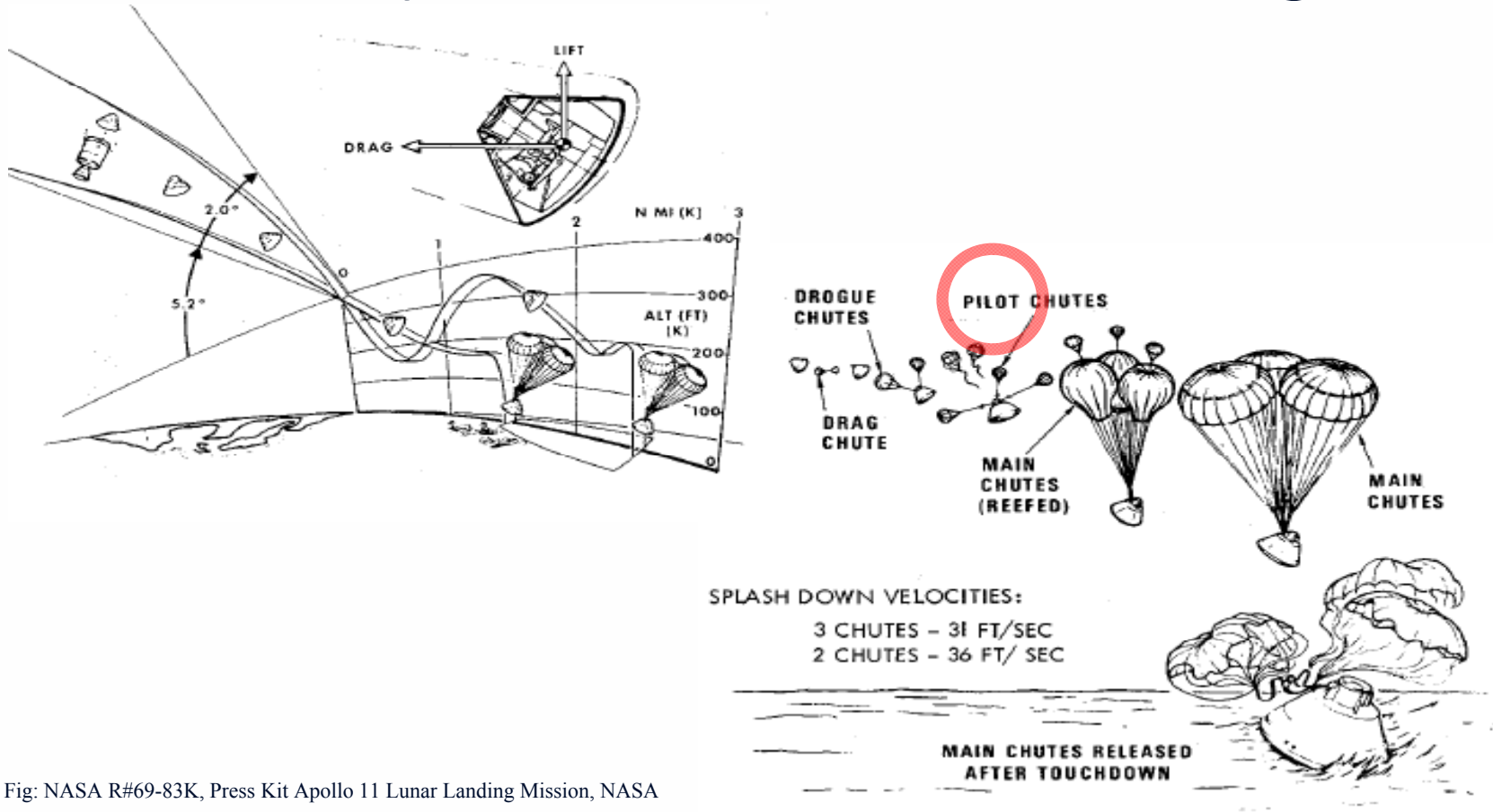


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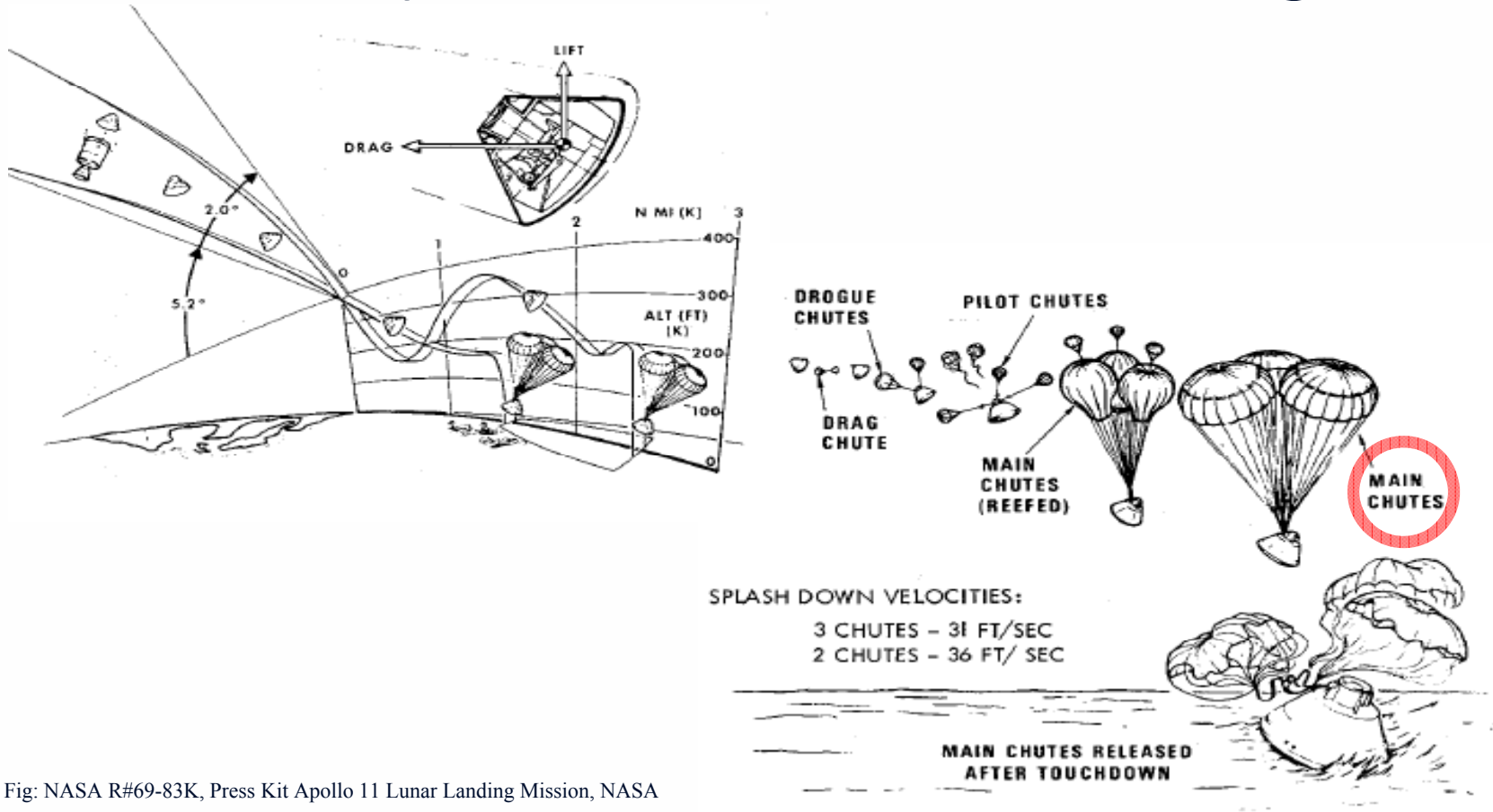


Fig: NASA R#69-83K, Press Kit Apollo 11 Lunar Landing Mission, NASA

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Origin

- Various Chinese Legends
 - Two Bamboo Hats to escape murderous emperor
~ 4000 years ago
 - Acrobats using Umbrellas to entertain emperor
~ 2200 years ago
 - Thief using Umbrellas to steal from emperor
~ 1180





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DaVinci

- DaVinci's Famous Notebook Sketch
~ 1485
(And its modern "test" in 2000)



Fig.: <http://www.dailymail.co.uk/news/article-562445/Parachute-Da-Vinci-drew-work--523-years.html>

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Aeronauts

- Montgolfier 1780's
- Jordaki Kuparento 1808



Fig.: ASD-TR-61-579, Performance and Design Criteria for Deployable Aerodynamic Decelerators, AFFDL

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Fig: <http://www.aerospaceweb.org/question/history/q0154.shtml>

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Flexible (Packable)

Thomas Baldwin 1887

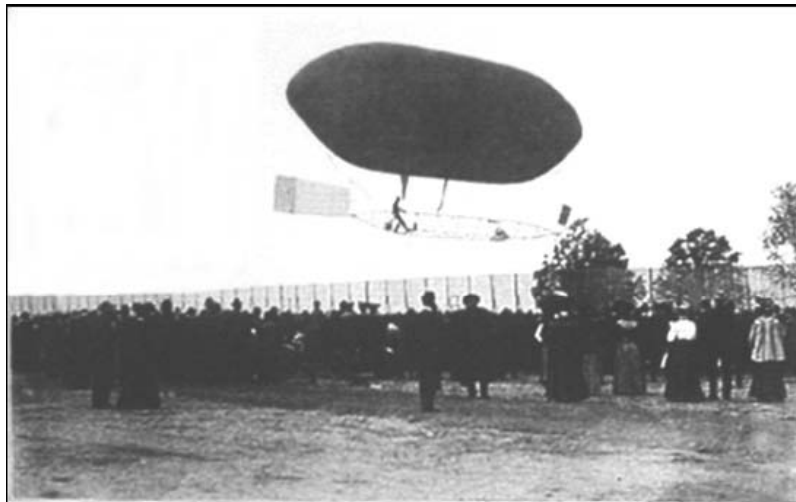
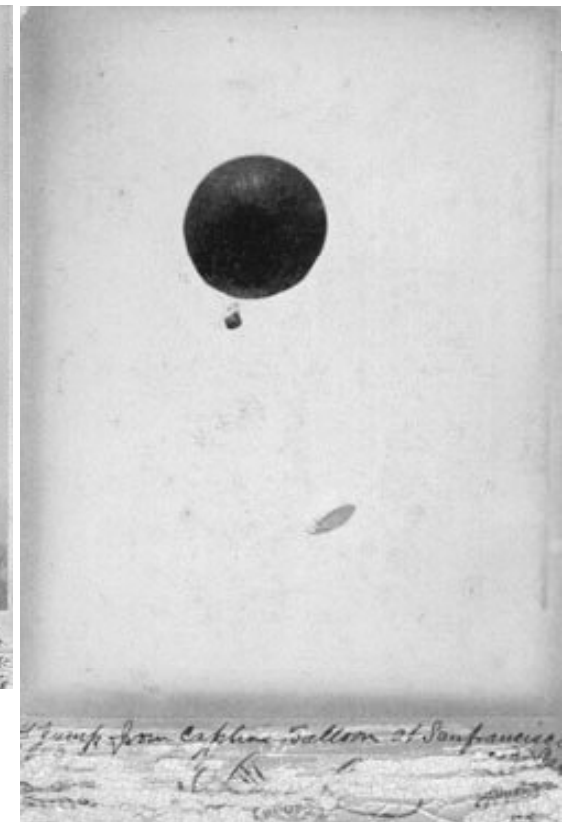


Fig.: <http://earlyaviators.com/ebaldto2.htm>



Fig.: http://www.sfcityguides.org/public_guidelines.html?article=589&submitted=TRUE&srch_text=&submitted2=&topic=Events



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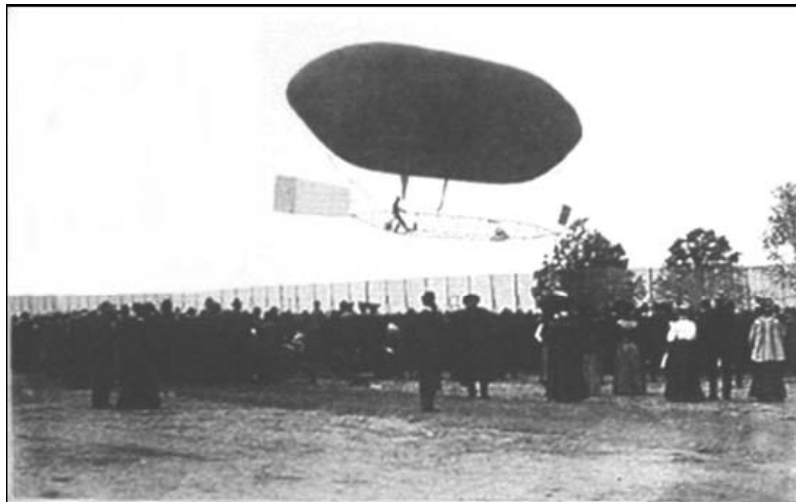


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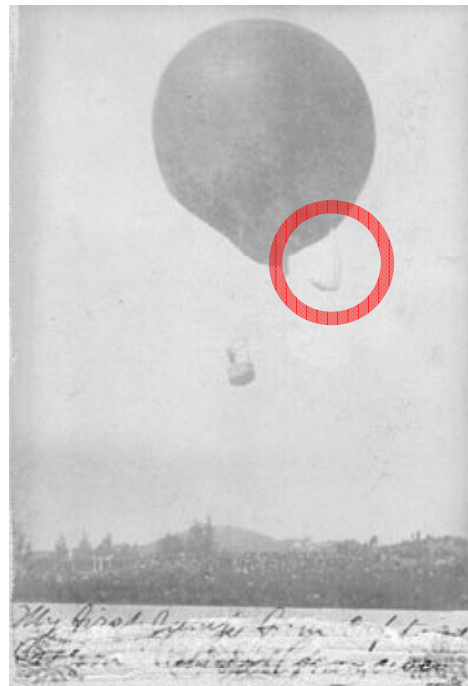
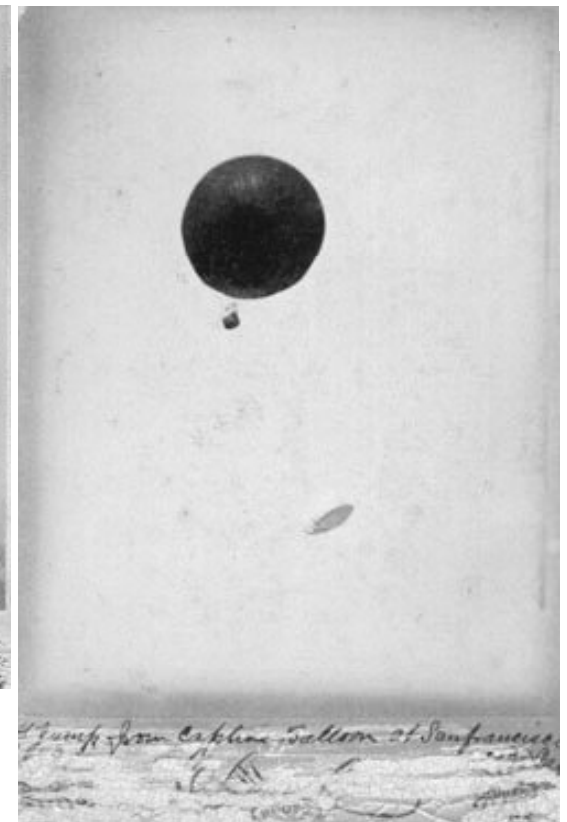


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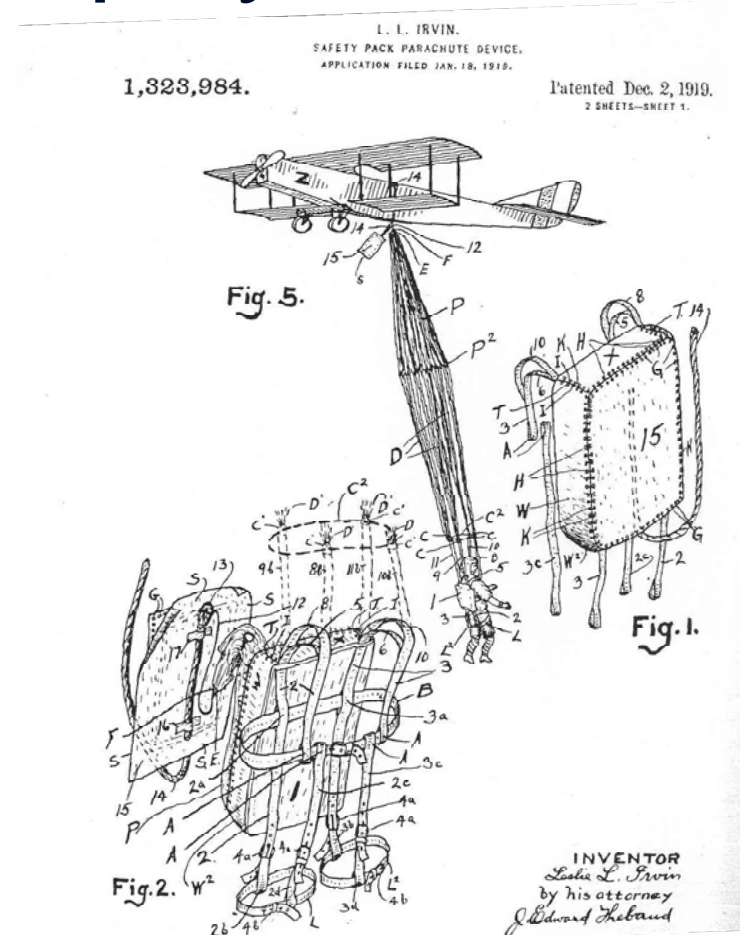
Static Line Deployment

- 1914 to 1919



Image credit Pioneer Aerospace

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Ripcord

- 1919

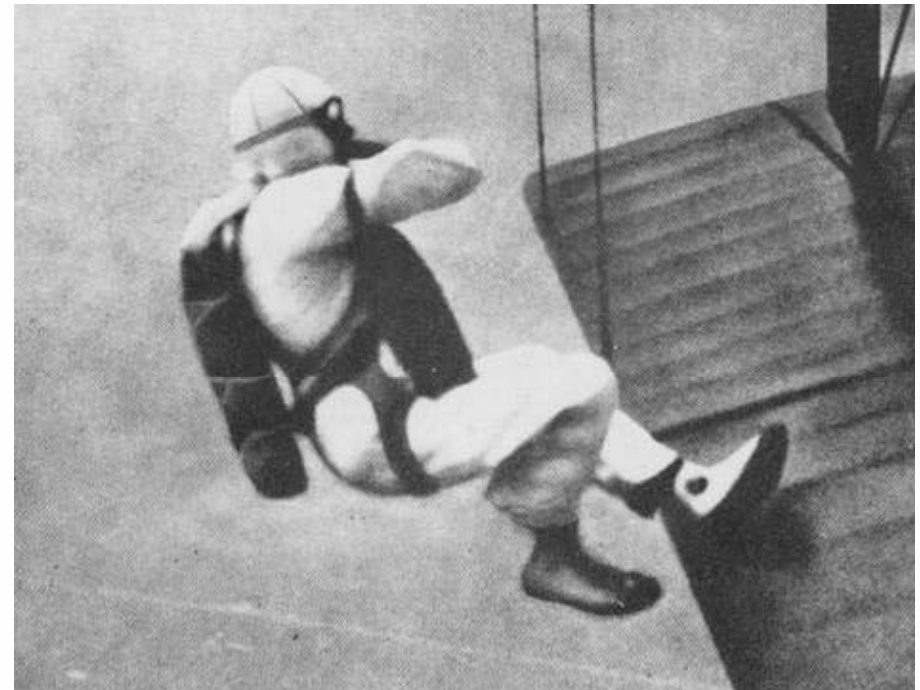
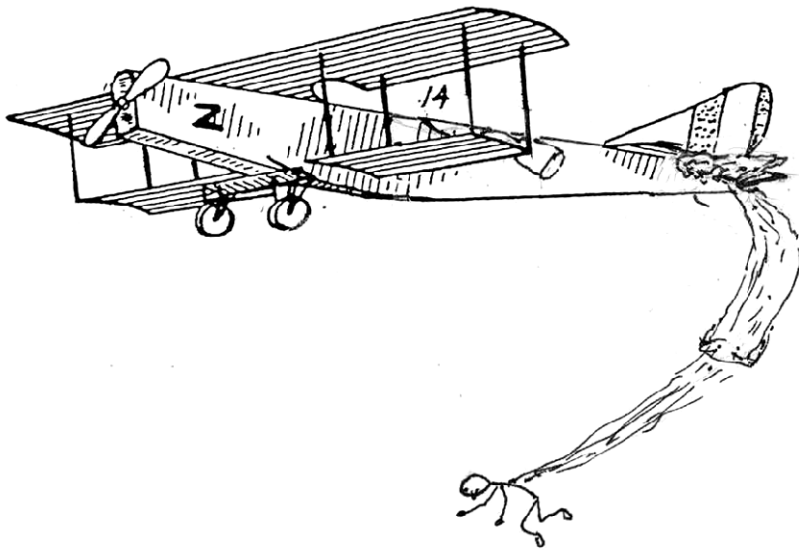


Fig.: Lyman Ford before he became President of Pioneer Parachute

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Ripcord

Irvin:

Airborne Systems

Smith:

Pioneer Aerospace



Fig.: 1929 advertisement in Aero Digest

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Non-Emergency

- Paratroopers
1928



Fig.: <http://blog.mysanantonio.com/vault/2010/08/from-the-vault-brooks-field-and-paratroopers/>

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Cluster

- Air Drop of Heavy Equipment 1941

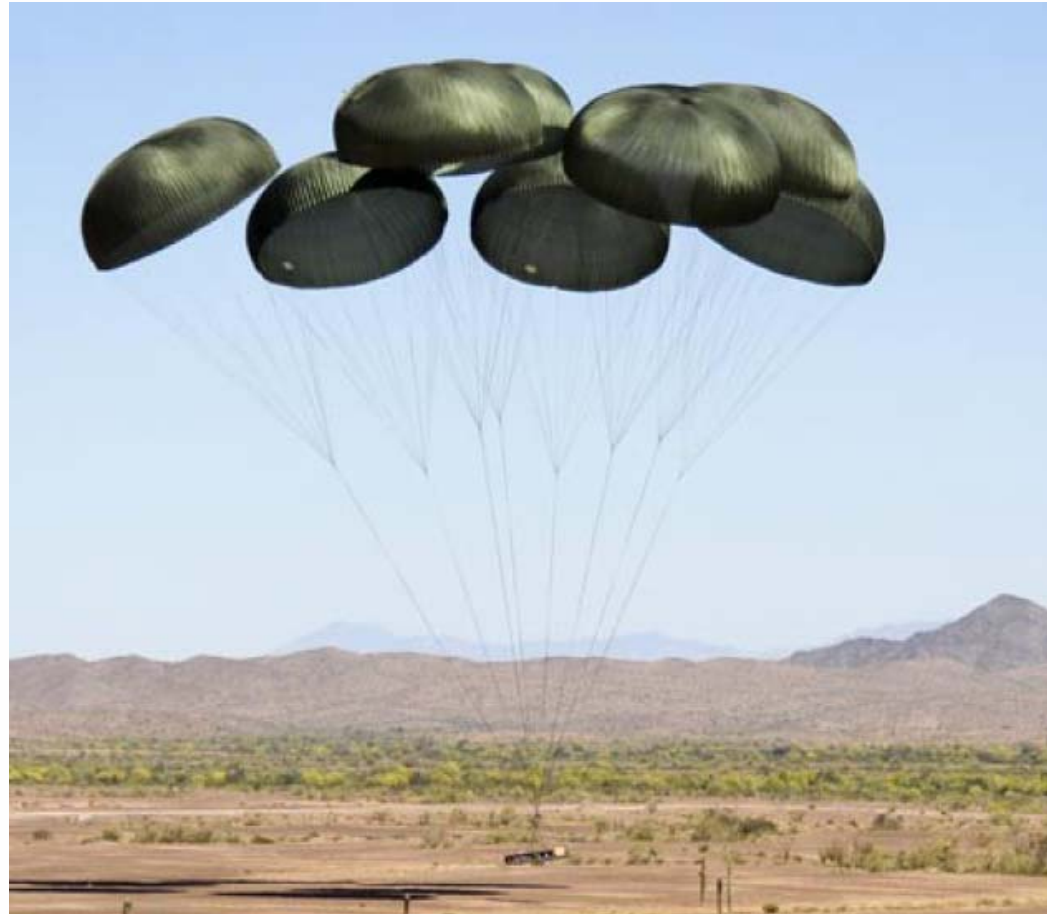


Fig.: AIAA-2011-2595, Ballistic Precision Aerial Delivery System, Woodruff/Tardiff

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“Scientific Approach”

- United Kingdom and Germany ~ 1940

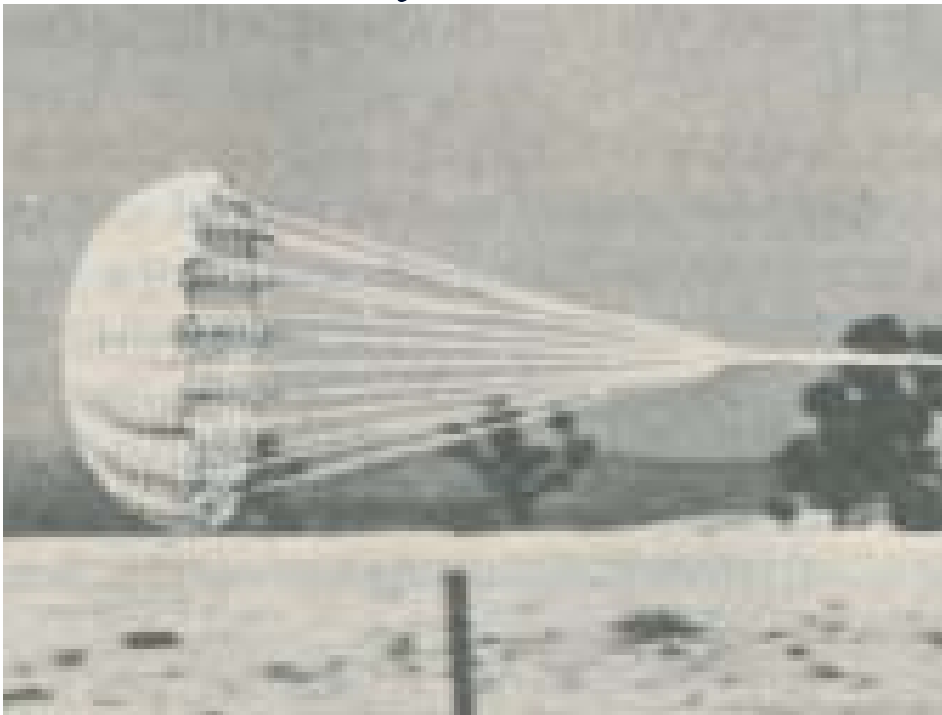
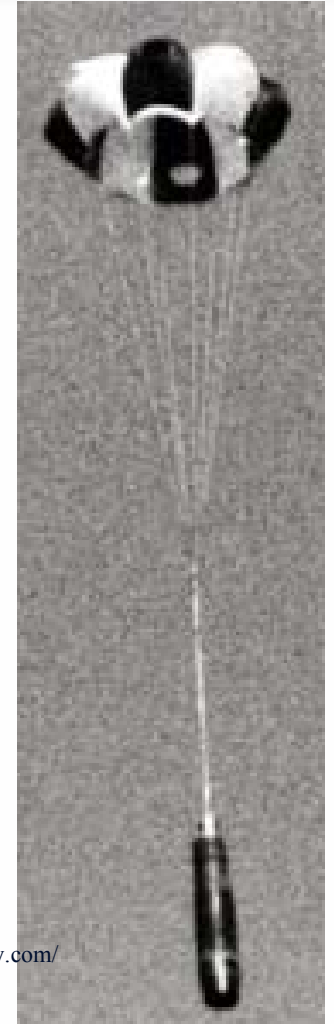


Fig.: WADC-TR-55-265, USAF Parachute Handbook, WADC

Heinrich:
Guide Surface Canopy



Madelung & Knacke:
Ribbon Canopy

Fig: <http://www.parachutehistory.com/eng/drs.html>

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Ejection Seat

1st use 1942



Fig.: <http://www.wired.com/thisdayintech/2011/01/0113ejection-seat/>

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Higher and Faster



Altitude:

- 40 kft 1940
- 103 kft 1960

Image credit Pioneer Aerospace

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Higher and Faster

Speed:

- Mach 10 1962 (ballute)
- Mach 8 1970 (parachute)

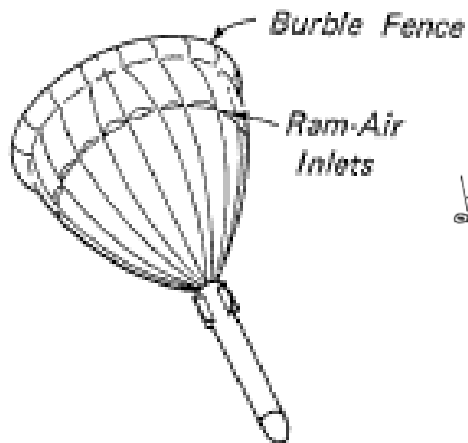


Fig: AFFDL-TR-78-151, Recovery Systems Design Manual, AFFDL

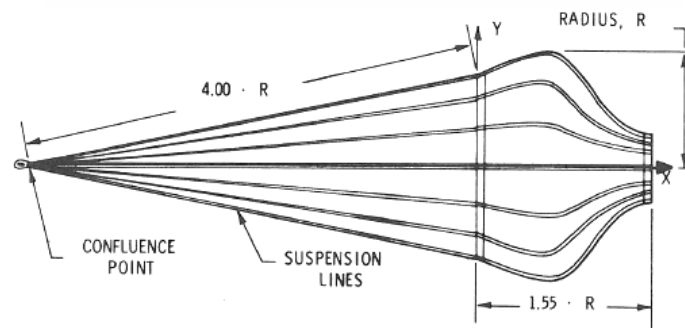


Fig.: AIAA-70-1173, Continuous Surface of Revolution Parachute for Supersonic/Hypersonic Speeds, Babish III

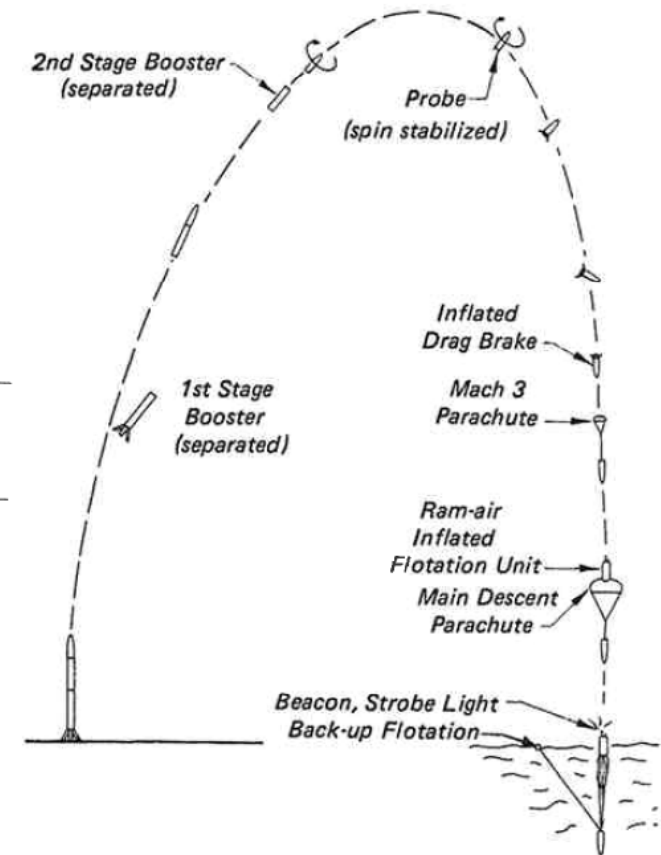


Fig: AFFDL-TR-78-151, Recovery Systems Design Manual, AFFDL



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Mid-Air Retrieval

Discoverer (Corona)

- Discoverer 13
1st recovery from space Aug 1960
- Discoverer 14
1st mid-air recovery Aug 1960



Image credit Pioneer Aerospace

Aerodynamic Decelerator Systems – Witkowski/FM-TDT

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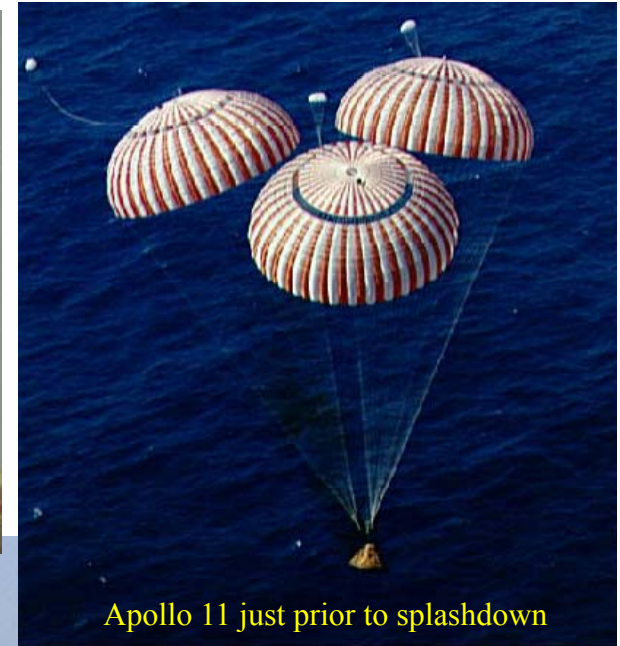
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Manned Landing

Gemini development test with parasail and retrorockets



Mercury capsule with single 19.2 m RingSail



Apollo 11 just prior to splashdown



Shuttle Landing Brake Ribbon

All images credit NASA

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Large Systems

Space Shuttle SRB

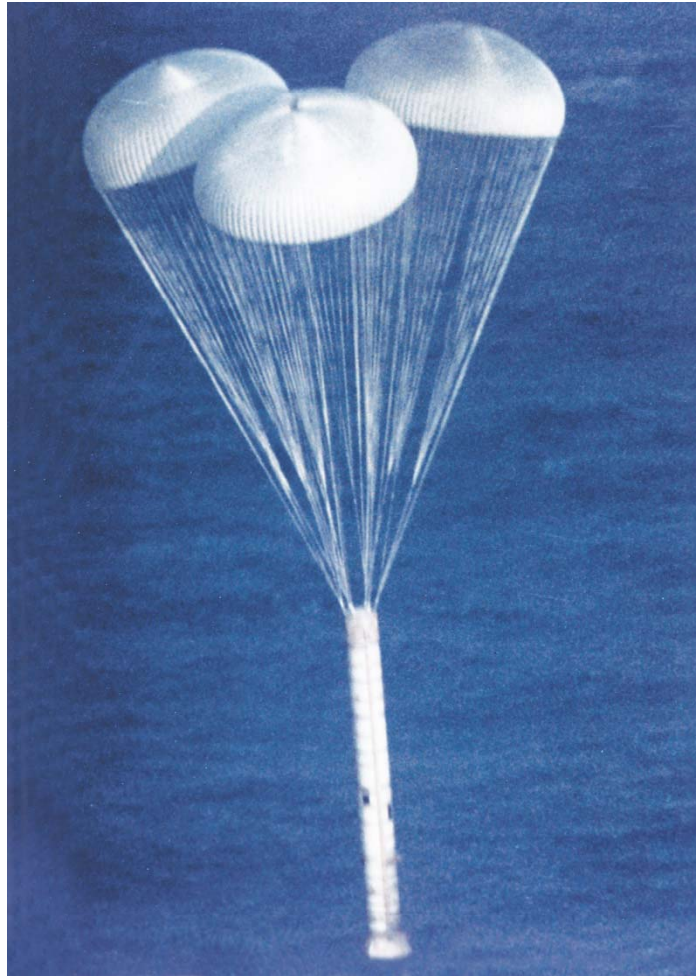


Image credit NASA

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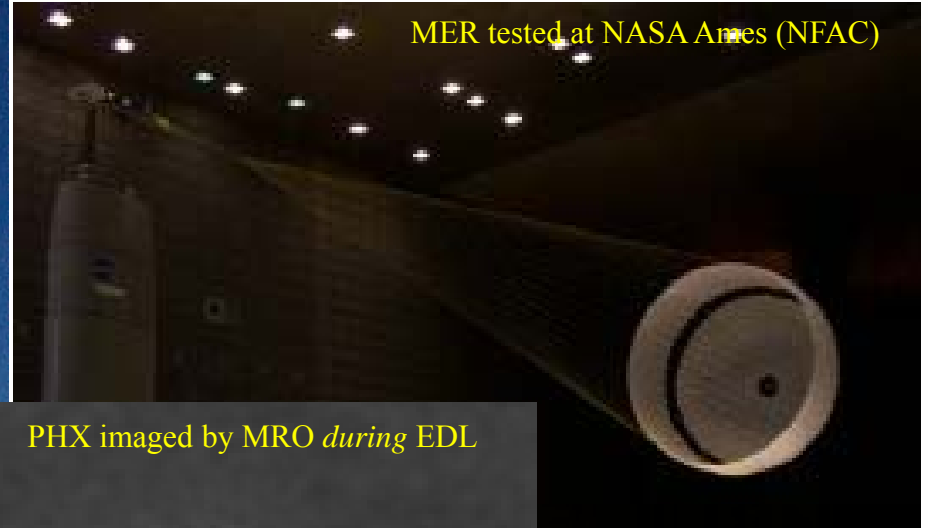
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Mars Landing

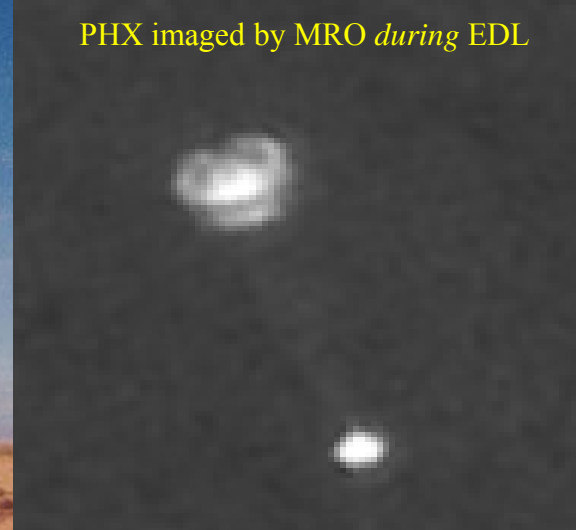
MPF after low alt drop test



MER tested at NASA Ames (NFAC)



PHX imaged by MRO during EDL



Viking just after a successful test



All images except MPF: photo credit NASA, MPF photo credit Pioneer Aerospace

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Planetary Probes



PVLP Art



Galileo Probe Art



Genesis Capture Test



Stardust in Smithsonian on National Mall

All images except Stardust: credit
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High Altitude Recovery

- Columbia Scientific Balloon Facility



Fig.: AIAA- 2005-1659, High Altitude Test Program
For a Mars Subsonic Parachute, Mitcheltree et al

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High Altitude Recovery

- Columbia Scientific Balloon Facility

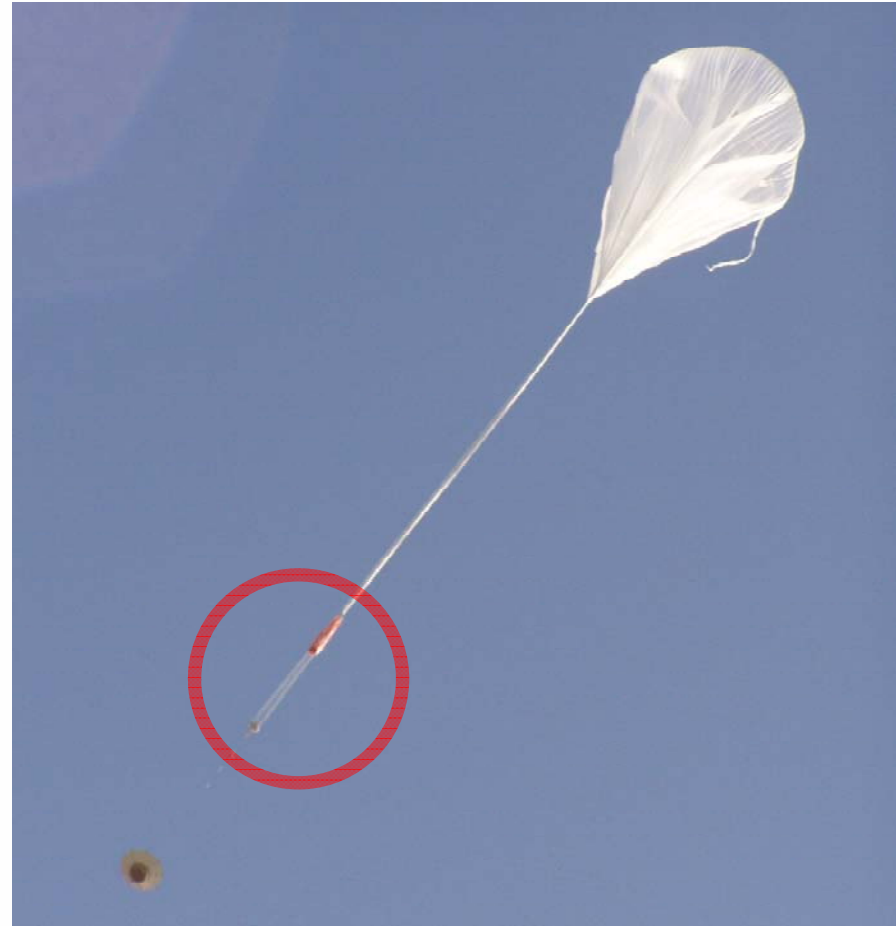


Fig.: AIAA- 2005-1659, High Altitude Test Program
For a Mars Subsonic Parachute, Mitcheltree et al



Conclusion

- Aerodynamic Decelerators have been around for centuries
 - Fully “Packable”/Deployable for 125 years
- Wide Trade Space
 - Altitude (Earth): $\sim 0 \geq H \text{ (m)} \leq \sim 100,000$
 - Speed: $\sim 0.003 \geq \text{Mach} \leq \sim 10$
 - Dynamic Pressure: $\sim 0.2 \geq Q \text{ (Pa)} \leq \sim 500,000$



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Future Lectures

- For Engineers incorporating these devices/systems:
 - Lectures to provide insight on design and modeling “pitfalls”
- For Principle Investigators and their design teams:
 - A separate lecture on each project to date with details on what was used and how it was developed
- For Systems Engineering and Project Management:
 - Lectures on lessons learned and insight regarding modeling and testing interdependence with overall mission
- For Quality Engineering:
 - Lectures on materials and construction techniques