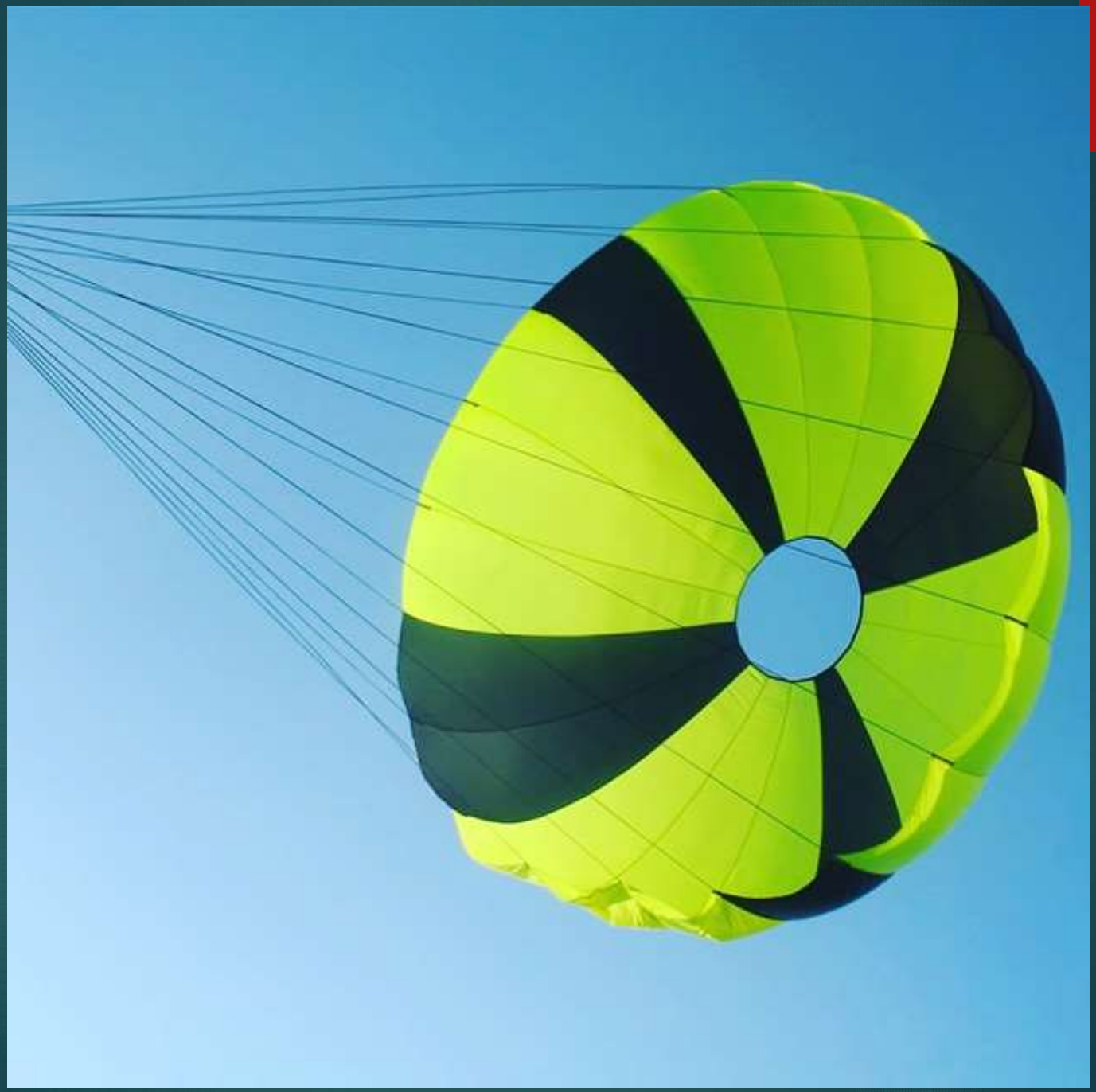
PREVIEW OF PROPOSED PART 107 FLIGHT OVER PEOPLE PARACHUTE RECOVERY SYSTEM REQUIREMENTS

- WHY YOU NEED IT
- ASSURE STUDY
- ASTM COMMITTEE TO DEFINE A PARACHUTE RECOVERY SYSTEM (PRS)
- PRS COMPONENTS
- ASTM PARACHUTE CERTIFICATION STANDARD
- WHO DOES CERTIFICATION
- QUESTIONS

Who is Fruity Chutes

- Started with hobby rocketry recovery in 2007.
- Began to sell to emerging sUAS users around 2009.
- Sold well over 1000 UAS systems to large range of customers. Many companies are integrating now.
- Celebrating 11 Year Anniversary!



Why do I need a Parachute Recovery System (PRS)

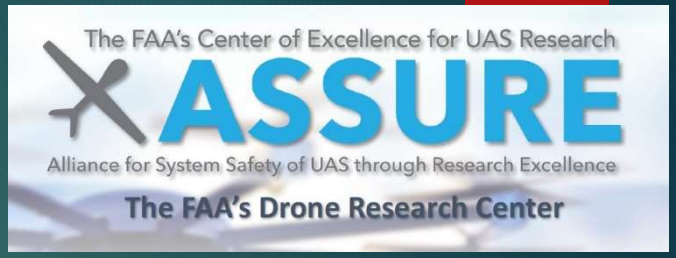
- **Safety** – Protect people and property.
- **Regulatory** – FAA and government.
- **Insurance** – Lower premium rates or even mandate to get insurance.
- **Cost of Failure Mitigation** – Parachute safety is a fraction of the cost of failure.
- **Business Continuance** – A bad crash can equal data loss or even put you out of business.

Drivers to Adoption

To summarize the drives to wide adoption will be:

- Government regulatory mandates
- Insurance mandates to get coverage and lower premiums
- Very high value payloads, too expensive to risk
- Education about the benefits of PRS

Let's focus on safety!



- FAA ASSURE group sponsored the study of ASSURE's Ground Collision Severity Research.
- Started in 2016, research released April 2017.
- Goal – How to safely fly UAS over people, minimal risk to serious injury.
- Dimensions – impact energy, materials the sUAS is constructed from, angles and direction of impact, point of impact on the person.

PRS Designed for Safety First

- Low descent speeds & low impact, energy limit or remove sUAS damage.
- Guarantee business continuance.
- Insurance likes it.
- Meet Regulatory Requirements .
- Certified system means PART 107 waiver and flight over people!

Limiting impact energy lowers risk

- Impact energy to around 35J – 69J helps, higher possible with other mitigations or allowable con-ops (concept of operations).
- Likely FAA Part 107 waiver strategy will be to limit allowable energy depending on the con-ops for the particular mission.
- Lower energy limits mean smaller sUAS to keep parachute size reasonable.

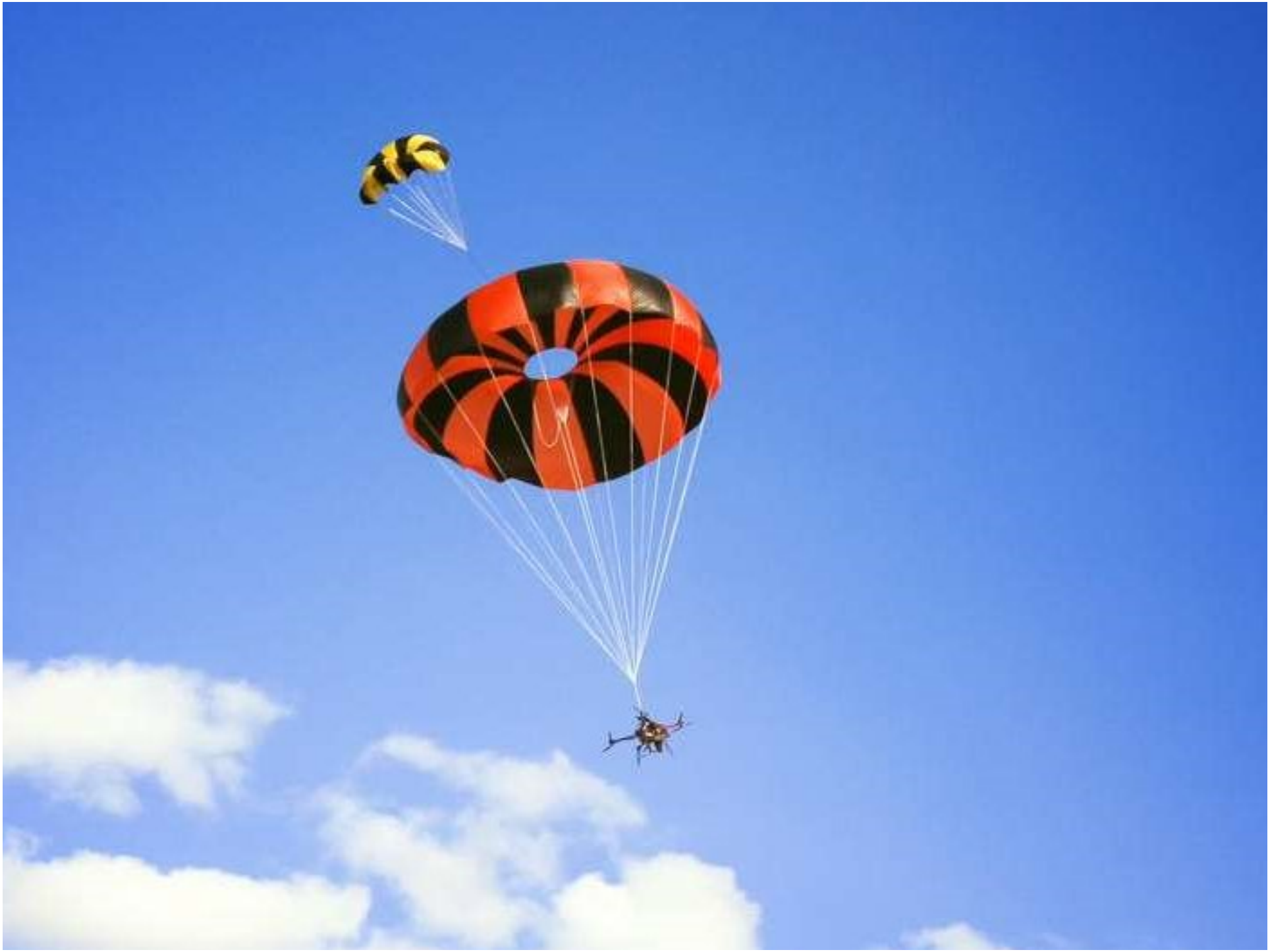
ASTM Committees currently in progress to work out proposed requirements

- ASTM WK59171 workgroup stood up in May 2017 to develop PRS requirements and certification standards that would allow Part 107 flight over people waivers. Committee met weekly for approximately 8 months on the standard.
- Went through two rounds of voting and addressing reviewer comments. All comments must be addressed.
- Committee just received an affirmative vote in August 2018 to approve the draft standard. ASTM now working to publish the final standard.

Next step is to have the FAA adopt the standard!

PRS and sUAS Part 107 Certification

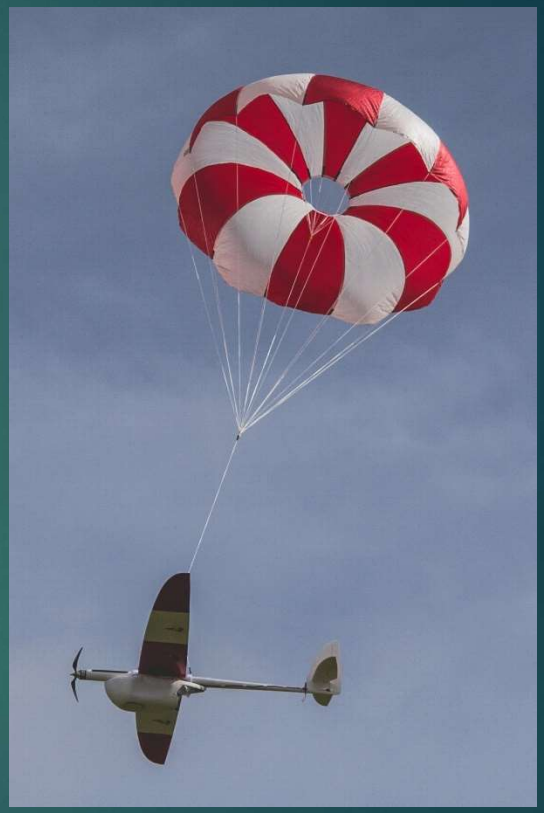
- Allowable Impact energy + sUAS weight = Required parachute size
- sUAS certified for Part 107 over people is not a mix and match methodology
- sUAS and PRS are tested as an integrated system in order to be certified
- Any combo of PRS and sUAS can be certified with passage of the air worthiness requirements and flight test suite



PRS Components and what they do

At the highest level a PRS requires:

- The Parachute, rigging, harnesses
- Parachute Deployment System
- Automatic Trigger System (ATS)
- Flight Termination System (FTS)



Parachute

- With sUAS weight, target descent rate or impact energy: parachute manufacturer can recommend a size.
- In most cases the parachute lowers impact energy from 100% if no parachute to 2% or less with a parachute.
- Choose a parachute that is as light as possible, has good strength, and is efficient.

Parachute Deployment System

- **Passive** - Fixed Wing UAS Recovery using a Deployment Bag
- **Ballistic Low Energy** - Compression Spring Parachute Launchers
- **Ballistic High Energy** – CO2, Compressed Gas, Pyro Gas Generator

Automatic Trigger System (ATS)

- Detect flight problems. Automatically deploy the parachute.
- Ex. MARS MAYDAY, ParaZero Smart Air, PixHawk configurable parachute channel.

Flight Termination Systems (FTS)

- Stop rotors once deployment happens .
- Need support from sUAS airframe manufacturers to implement.
- DIY drones, or drone using auto-pilot such as the Pixhawk are better suited to add this capability.
- Popular Drones like the Inspire, Phantom, others have no FTS support. M210 recently introduced this capability via the API.
- Work around, upon deployment pilot needs to stop rotors manually.
- Harness materials use Spectra that can not be cut by rotors.

ASTM Parachute Certification Standard

- PRS is "Certified" for use with a given sUAS, or family of sUAS like Inspire 1, Inspire 2, different cameras, etc.
- PRS will lower impact energy to a specified energy level, for example 35 J. Parachute sized to achieve target energy. Target energy for a give sUAS is not part of our group, separate ASTM group is working on this.
- PRS must work reliably over entire flight envelope, expected weights, and failure types.
- Standard calls out design requirements via documentation, manufacturer standards (PIA, MIL-C, MIL-W, etc), lab strength testing.
- Actual flight testing to validate operation over entire flight envelope.
- Flight Testing is done at a FAA testing location and overseen by 3rd party testing agency (3PTA).
- Suite of different flight test type must be passed, for drones 5 test types, 5 to 10 flight trials each.

Certification System Requirements

Aside from flight testing the system to be certified PRS needs to meet other standards. For the parachute:

- sUAS Expected maximum dynamic shock load (MDSL) when the parachute opens. This means max weight and at max speed.
- sUAS MDSL can be determined via tools like Park College OSCALC. OSCALC uses parachute size (canopy area), deployment velocity (fps), and mass (slugs) and gives a range of opening shock loads. FC can help with this.
- The Parachute is certified by the manufactures to have a specified MDSL rating. Parachute rated MDSL needs to be 2 x sUAS MDSL.
- Parachute strength is determined, combination of materials certification, and actual materials strength testing.
- Typical shock loads can be high. An Inspire 2 parachute deployment at 60mps can have loads as high as 650lbs.
- All other harness and rigging connecting the parachute to the sUAS must also meet 2:1 strength requirement.

Certification System Requirements (cont.)

Other requirements

- ATS Requirements:
  - Dual power sources form the sUAS, and internal.
  - Autonomous operation independent from auto-pilot.
  - Does not interfere in any way with auto-pilot.
  - Automatic detection of flight issues, like power fail, or mechanical fail.
  - Provide signal back to sUAS to kill rotors (FTS).
  - Black-box feature records critical flight data at time of failure, such as failure altitude, then record descent rate, landing time.
- sUAS Requirements:
  - FTS support, given a signal from ATS to kill rotor power (stop rotors).
  - PRS mounting point – provisions to mount the PRS.
  - Hard points for the harness to connect to. In many cases these can be the rotor booms.

Overview of Flight Testing

- For multi-copters there are 5 test types. For each test type there are 5 trial flights. For these 1 uses remote eject by PIC, 4 by ATS.
- Test Type Overvierw
  1. FS1 - Hover, power cut – 5 @ minTow, 5 @ maxTow
  2. FS2 - Hover, critical rotor failure - 5 @ minTow, 5 @ maxTow
  3. FS3 - Full forward speed, power cut - 5 @ minTow, 5 @ maxTow
  4. FS4 - Max forward speed, critical rotor failure - 5 @ minTow, 5 @ maxTow
  5. FS5 – MDSL Testing - 5 @ maxTow
- 45 Tests Total. All suite of 5 trials must pass w/o failure or it is repeated.

Overview of Flight Testing (cont.)

- For testing the sUAS is outfitted with extra electronics and a receiver that can initiate failures, mostly override ESC to stop rotors (interrupt servo channel signal). This is done remotely by 3PTA.
- Power cut tests – Simple cut of all rotors.
- Critical rotor failure – This means cutting power to only to enough rotors to cause loss of stability, other rotors stay powered. Example quads lose one rotor. Octocopters loose 3 adjacent rotors. Copter expected to flip and rotate quickly.
- MDSL Testing – Maximum dynamic shock load test is designed to put the absolute maximum stress is the PRS parachute and rigging. This can be a fall from altitude to terminal velocity and deploy. Or max forward speed and in a dive. This is done as maxTOW.

Determining minimum operational altitude (MOA)

- Flight testing will show the minimum altitude the PRS is rated for. This is determined by analysis of the black-box recorded data showing the failure initiation altitude, and the steady state descent rate under chute for tests FS1 – FS4. Then looking at the maximum failure to steady state fall height of all tests.
- So for example if FS2 (hover with critical failure) initiated at 250ft, and steady state descent is 150ft this is 100ft of altitude loss. Added to this is 2 x the total length of the parachute and harness assembly.
- If the assembly length is 20 ft we have:

  100ft + (20ft * 2) = 140ft MOA

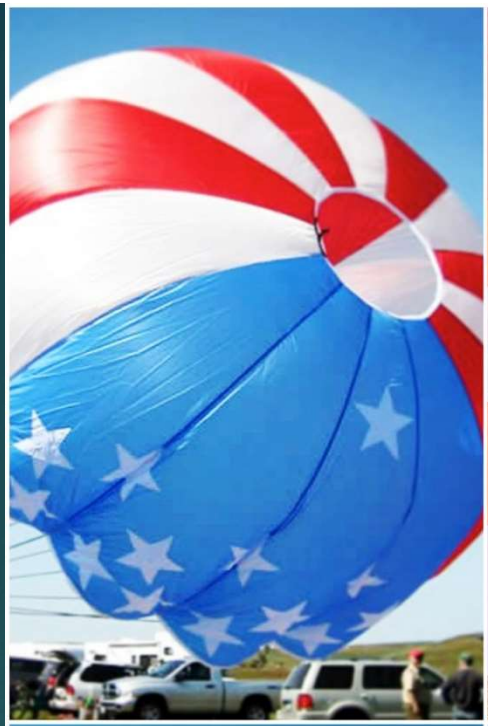
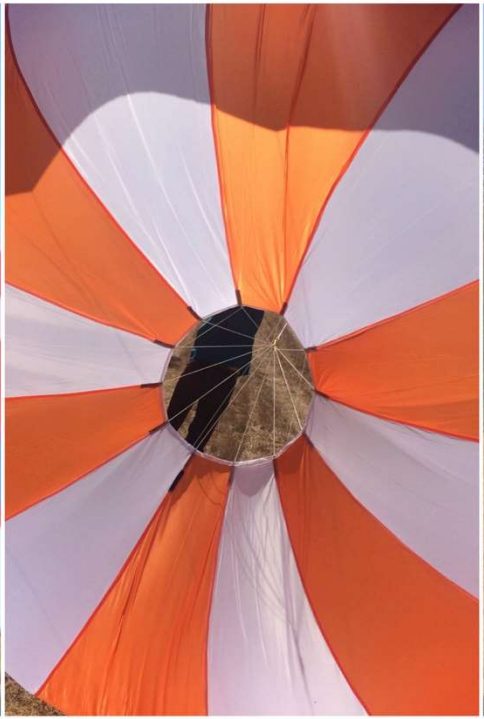
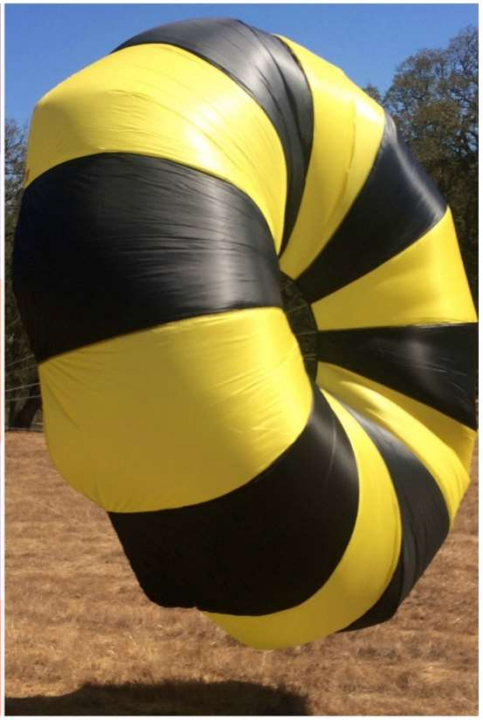
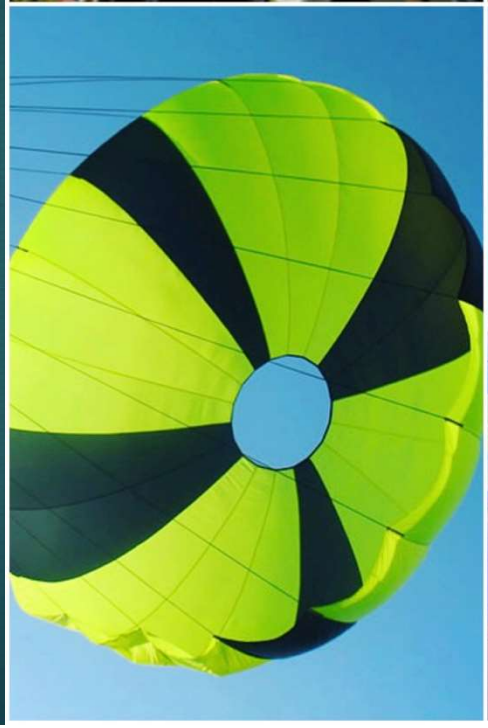
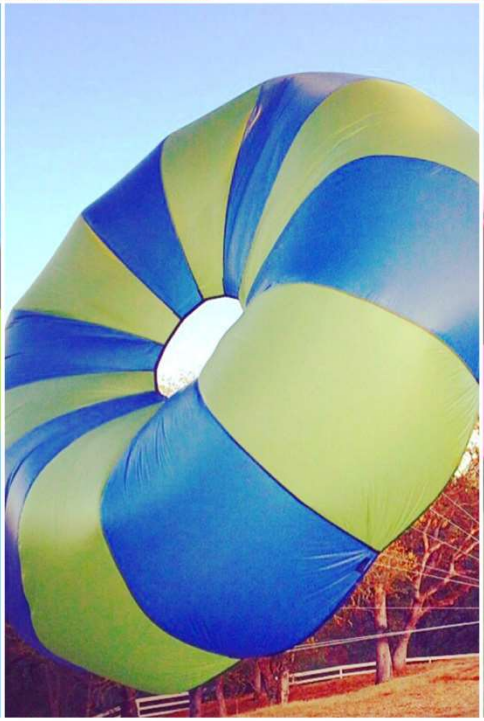
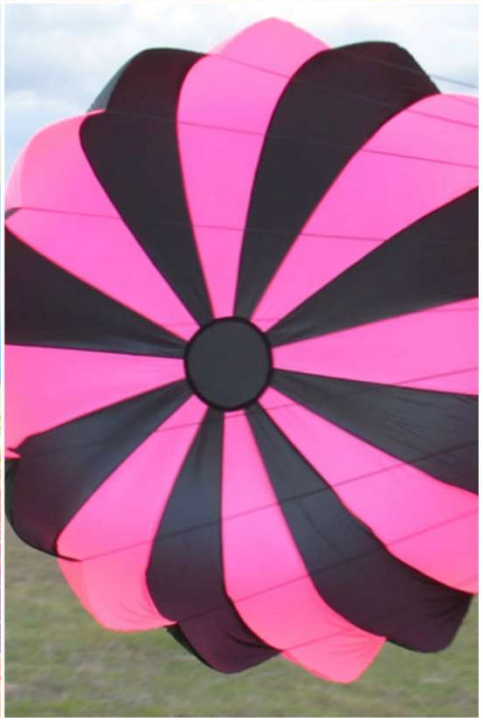
- All operations over people must stay at or above this altitude at all times.

More about Testing

- Failures are initiated by 3PTA.
- No warning is give to PIC.
- Black box records all flight data.
- Video taken of all flights.

Who does the certification?

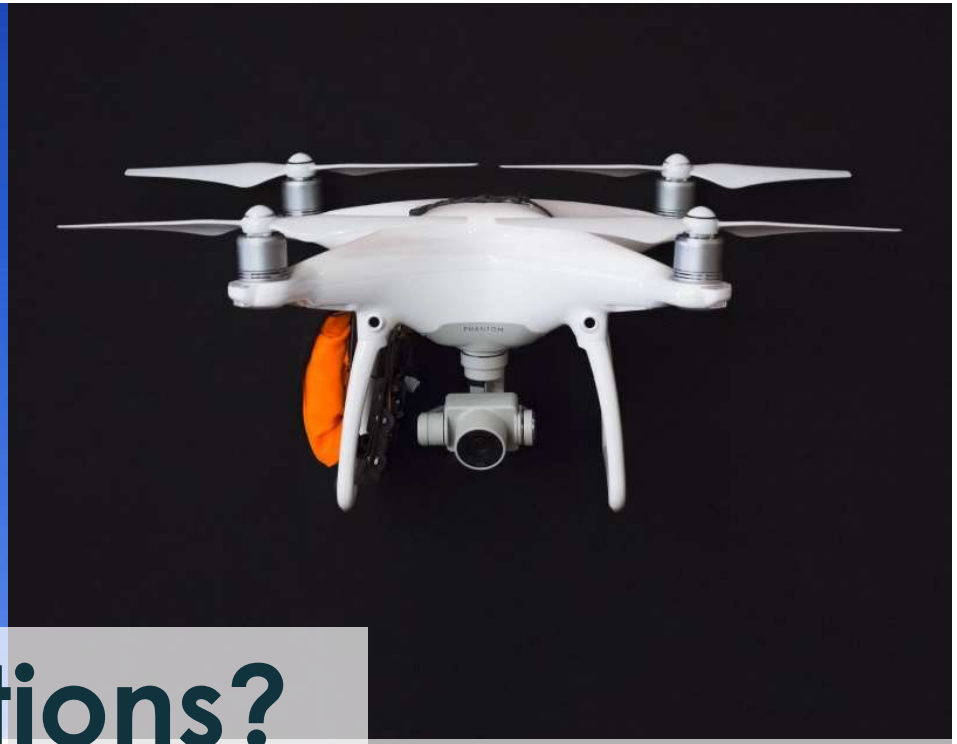
- Certification can be done by Drone mfgr, PRS mfgr, VAR, Reseller, anyone!
- In the ASTM Standard entity coordinating certification is called the "Integrator". They are the point person for the process. Again this can be anyone.
- Integrator pulls together needed PRS documentation working with Drone and PRS manufactures.
- Coordinates with FAA.

Further Information:

- Download this presentation here: http://bit.ly/2wef1ol
- Parachute Recovery Tutorial: https://goo.gl/6NBvRu
- Our Blog: https://fruitychutes.com/genes_blog
- Online Help Resources: https://fruitychutes.com/help_for_parachutes.htm

THANK YOU!



Questions?