Water Rocket Recovery Index

What is a recovery system?

A recovery system is a feature of a rocket that allows it to come back to Earth with minimal damage.

Introduction

This guide is intended to serve as a starting point for water rocketeers wanting to add a recovery system to their water rocket. Understanding of what a recovery system is, being aware of concepts and drawing on the experience of many water rocketeers will help in the design and construction of your own recovery systems.

Acknowledgements

A big thank you goes to **Air Command Rockets** for the information and diagrams, (http://www.aircommandrockets.com/recovery_guide.htm) where you can find much more information about water rockets and how to make them etc.

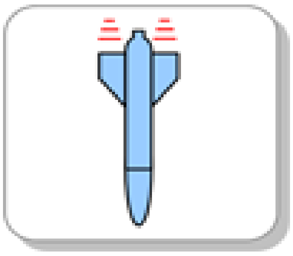
Classes of recovery system

There are two main classes of recovery systems: *passive* and *active*. Passive recovery systems have no moving parts and are a part of the rocket design. Active recovery systems typically contain moving parts that activate at some point in flight to slow the rocket down.

Passive Recovery

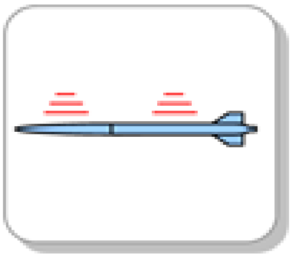
In general passive recovery systems are simple, inexpensive and reliable, however, they are usually only suitable for lightweight rockets without fragile payloads.

Passive recovery systems include:

	**Lawndart** The rocket goes straight up and comes down nose first at high speed.	**Advantages** - Simple - Lightweight - Inexpensive - Reliable	**Disadvantages** - High speed return - Only for small rockets - Dangerous - Unsuitable for fragile payloads

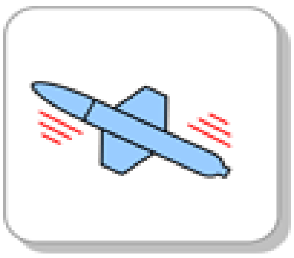
Note

A rocket is typically equipped with either a padded nosecone to absorb the shock, or a long hard spike that can penetrate the ground to slow the rocket down.

	**Backgliding / Backsliding** The rocket is marginally stable. Rocket goes up straight but comes down sideways.	**Advantages** - Simple - Lightweight - Inexpensive - Reliable	**Disadvantages** - Limited rocket design - Not suitable for heavy rockets

Note -

These rockets need to be carefully designed so that the center of gravity (Cg) is within a specific position relative to the center of pressure (Cp) and Center of lateral area (CLA). Rockets of this type are typically long and narrow.

	**Tumble** The rocket is designed to be unstable. Generally used for small boosters in multi stage rockets.	**Advantages** - Simple - Lightweight - Inexpensive - Reliable	**Disadvantages** - Cannot fly by themselves - Only suitable for small boosters

Note

The rocket will often have fins half way along the body or no fins at all. The rocket will not fly straight by itself and needs to be attached to a stable rocket during ascent.

Active Recovery

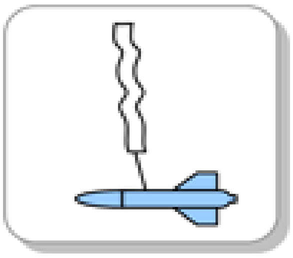
Active recovery systems offer flexible design that can be configured and adjusted for a variety of flight profiles and payloads. They are also typically used in large rockets. This, however, comes at the cost of complexity, expense and reduced reliability.

Examples of active recovery systems include:

	**Parachute** The rocket uses a parachute to increase drag to slow its descent.	**Advantages** - Lightweight - Compact - Suitable for large rockets	**Disadvantages** - Tangles - Problematic high speed deploys - Drift

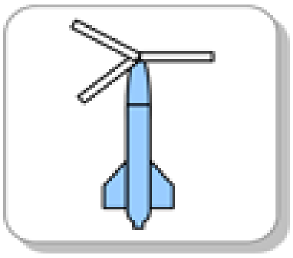
Note

By far the most common recovery system. The parachute is either deployed in-line with the rocket or uses side deployment. Separated below into two separate sections.

	**Streamer** The rocket uses a ribbon instead of a parachute to create drag.	**Advantages** - Lightweight - Compact - Low drift	**Disadvantages** - Suitable only for small rockets - Higher speed descent

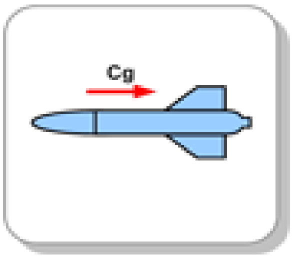
Note

A streamer is typically deployed in very similar ways to parachutes.

	**Helicopter** A set of blades are deployed that spin up the rocket up and the lift generated by the blades slows the rocket down.	**Advantages** - Compact - No tangles	**Disadvantages** - Complex - Moderately heavy - Unsuitable for descent footage from camera

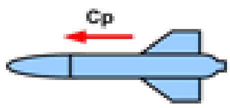
Note

The helicopter blades are usually folded against the body and spring loaded to open when deployed. The entire rocket usually spins on the way down.

	**Moving Cg** The rocket redistributes its weight to cause the rocket to use backsliding or tumble recovery. Typically the weight would move towards the Cp.	**Advantages** - Compact	**Disadvantages** - Complex - Suitable for light rockets only

Note

Changing the Center of Gravity (CG) usually involves moving a weight on the rocket, or discarding a weight from the rocket in order to affect its flight stability.



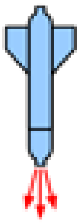
Moving Cp

The rocket changes its Cp so that it uses tumble or back sliding recovery. Typically it would move towards the Cg.

Advantages
- Lightweight

Disadvantages
- Complex
- Suitable for light rockets only

Note
Changing the Center of Pressure (CP) usually involves moving air surfaces in order to affect the rockets flight stability.



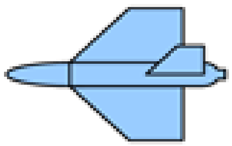
Retro

The rocket fires a retro rocket (air/air & water) to slow itself just before impacting with the ground.

Advantages
- Minimal drift
- Minimal air time

Disadvantages
- Heavy
- Difficult timing
- Unsuitable for larger rockets

Note
The rocket contains a small air/water rocket pointed in the opposite direction of travel that provides thrust in order to slow the rocket down. This is usually activated in very close proximity to the ground.



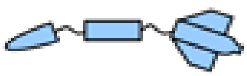
Glide

The rocket is equipped with wings that generate lift and the rocket glides to a soft landing.

Advantages
- Long flight duration
- Landing accuracy

Disadvantages
- High drag on takeoff
- Lift needs to change in flight
- Complex

Note
Wings are typically fixed to the rocket and may either have active remote control or passive control of the air surfaces.



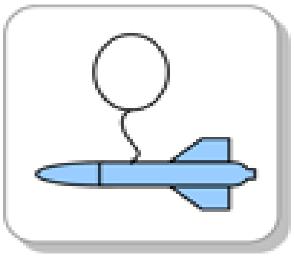
Separation

The rocket separates into a number of parts each of which can use any other of the passive or active recovery systems.

Advantages
- Lightweight

Disadvantages
- Complex
- Suitable for light rockets only

Note
The rocket is held together untill it's time to recover the rocket safely, were it then seperates into pieces and can return to earth by many other types of recovery systems, i.e. Parachute, glide, streemer etc.

	Balloon	Advantages	Disadvantages
	The rocket inflates a balloon to either increase drag or when combined with a lighter-than-air gas, produce lift.	- Potentially very long duration flight time	- Complex - Suitable for lightweight rockets only

Note
A balloon can be inflated from an internally stored pressure chamber in order to increase the rocket's drag or when used with lighter than air gas to slow the rocket via increased buoyancy.

Active Recovery Phases
While passive recovery is simple there are phases that typically take place in active recovery systems.

1. Pre-flight stowage;

2. Pre-flight /Arming;

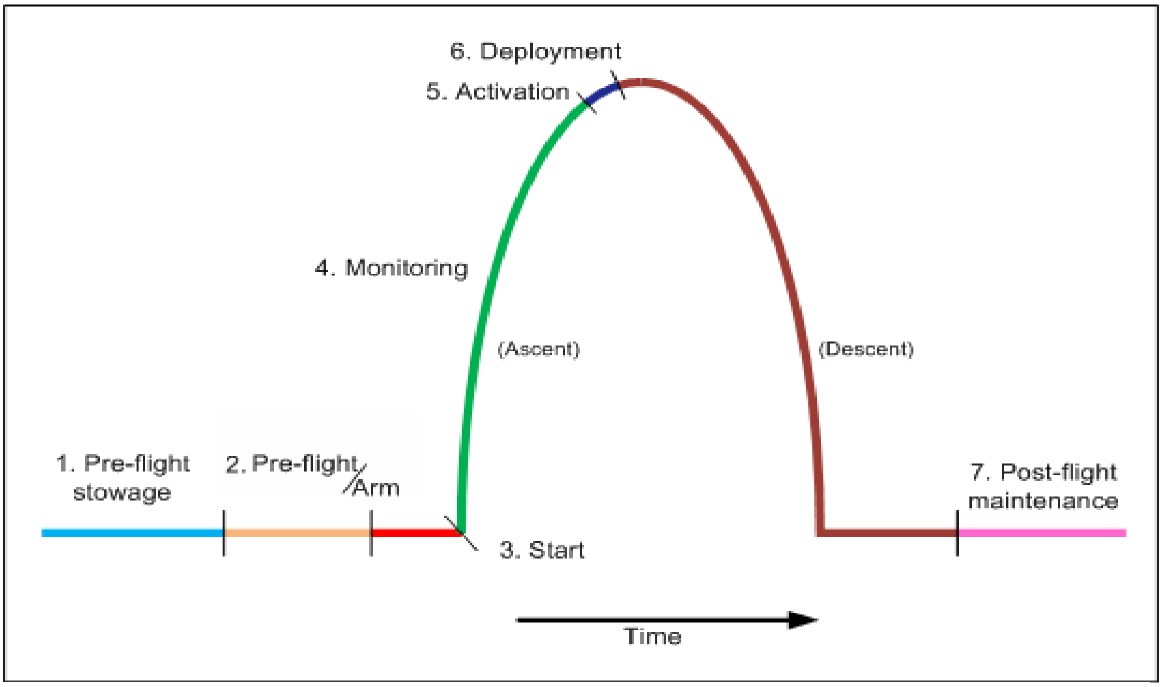
3. Start;

4. Monitoring;

5. Activation;

6. Deployment;

7. Post-flight maintenance.



Active Recovery Phases
While passive recovery is simple there are phases that typically take place in active recovery systems.

1. Pre-flight stowage
This includes the folding of parachutes and placing them in their compartments, rolling up streamers, cleaning out chemical reservoirs, etc. These are tasks that need to be performed before each launch. This phase also includes the process of placing the rocket on the launch pad and how to safe the recovery system during this procedure.

2. Pre-flight/Arming
This phase is usually performed just prior to launch and typically prior to pressurisation. This involves priming the recovery system for activation. The rocket remains in this state until launch. For example timers are initialised or wound up, chemical reactants are loaded, air flaps latched etc.

3. Start
Start occurs when some event during or just prior to the flight takes place that causes the recovery system to enter the monitoring phase. A start can occur in different phases of flight.

4. Monitoring
After the system is started the recovery system enters the monitoring phase. Monitoring involves the recovery system monitoring some parameter(s) for change or exceed some preset threshold value. When this happens the recovery system enters the activation phase. Monitoring can be electronic, chemical or purely mechanical. There are numerous trade-offs between the various monitoring approaches. Monitoring mechanisms initiate the deployment sequence.

5. Activation
Activation is the recovery system's response to when the monitored parameter(s) exceeds the preset value. This most commonly is the act of releasing a latching mechanism.

6. Deployment
Deployment is the actual mechanical operation of the recovery system in slowing down the rocket. This also includes things like opening doors, pushing parachutes out with springs, releasing helicopter blades, moving weights, separating the fuselage etc.

7. Post flight maintenance
After landing this phase includes tasks such as turning off powered electronics to conserve batteries, replacing or fixing components that may have been lost, damaged or consumed.

There are numerous designs for each of the above phases. Some designs are popular while others are experimental or theoretical. Typically a rocketeer will choose a particular design aspect for each of the above phases. Obviously not every combination makes sense, but there are many valid combinations that will work.

Counter-intuitive concepts
Following are a number of concepts that many rocketeers base their first recovery systems on only to be disappointed with less than ideal results. Sometimes these methods appear to work, but usually due to luck rather than based on good design. This does not mean the concepts should not be experimented with, but in general attempts are abandoned.

Assumed rocket behaviour at apogee
Relying on the rocket to go straight up and start to come down backwards at apogee. This technique is often considered for "catching" the air under nosecone flaps in order to remove the nosecone. Another form of this approach is draping the parachute over the nosecone, hoping that as the rocket comes down backwards the parachute will open.

In real life this happens very rarely and generally all rockets fly in an arc, keeping a positive airflow over the rocket at all times.

Deployment at burnout
In this technique the recovery system is deployed when the rocket stops producing thrust. The aspect that is overlooked in this instance is the long coast phase to apogee that follows burnout. The rocket generally experiences the highest velocity at burnout so deploying a recovery system at this point is not recommended. Parachutes may be ripped from the rocket.

Gravity based deployment
This is the most common first design that rocketeers attempt because it looks deceptively simple and works well while testing it on the ground. The general incarnation of this design is a form of "hanging weight" attached to the latching mechanism. It is incorrectly assumed that the hanging weight will keep pointing down for the entire flight. When the rocket pitches over at apogee the weight is supposed to turn in relation to the rocket to activate the latch.

In practice there are two problems with this technique.

1. When the rocket stops producing thrust soon after takeoff, drag on the rocket will induce a substantial -ve acceleration on the rocket, and the hanging weight will want to hang upwards, deploying the parachute. This is the most common failure mode of these systems. Sometimes it may take a second or two for a parachute to fully deploy if it is released at burnout and depending on how the parachute is packed, the system may appear to work, but for the wrong reasons.
2. After the initial -ve Gs of the burnout the rocket and all internal components are essentially in free fall. (weightless) This free fall state continues from burn out through apogee all the way to the ground. The only force acting on the system is drag and vibration from buffeting. Gravity does not magically only act on the hanging weight at apogee. The relative force between the rocket body (due to drag) and the weight near apogee is extremely small. What ends up happening is that there will be little movement between the weight and the rocket body.

Variations on this theme include a mercury tilt switch.

Ref:- http://www.aircommandrockets.com/recovery_guide.htm