Q: How is the LiquidPiston X Engine different from the Wankel?
A:
The Wankel rotary engine (image below, LEFT) was developed in the 1960s as an alternative engine architecture. The Wankel engine demonstrated excellent power to weight characteristics and exhibited low vibration even at high RPM. The engine was also very responsive, making for a fun driving sports car in the Mazda RX series. Despite these advantages, the Wankel was always plagued by poor fuel economy, emissions problems, and durability issues, especially in the apex / tip seals. These challenges are due to a number of inherent issues: 1) a narrow combustion chamber prevents adequate flame propagation, while also having high surface to volume ratio which cools the charge and reduces efficiency; 2) the engine is poorly sealed, leading to significant blowby, thereby decreasing efficiency; 3) the Wankel engine operates on the same conventional 4-stroke Otto cycle with spark ignition as a piston engine; however there are inherent challenges to operate > 10:1 compression ratio, and this engine was forced to compete with piston engines that had over one hundred years of prior development; and 4) the tip seals, in addition to being difficult to seal, are also difficult to lubricate; oil must be injected into the charge, with the majority of the oil burned in order to lubricate the gas seals.

The 'X' engine essentially "inverts" the Wankel engine (see the comparison image below). While a Wankel engine has a 3-sided triangular rotor, within a 2-lobed oval housing, the X engine has a 2-lobed oval rotor in a 3-sided housing. The X engine captures the main advantages of the Wankel, including 1) high power-to-weight ratio [a one rotor X engine behaves like a 3-cylinder 4-stroke]; 2) simplicity – having only 2 moving parts – a rotor, and a shaft; and 3) like the Wankel - the X engine is inherently balanced with no oscillating components, therefore having minimal vibration. Unlike the Wankel however, there are several key differentiators which address the bulk of the older Wankel's design deficiencies:

- The combustion chamber in the X engine is located in the stationary housing, with most of the gas displaced during compression into this stationary combustion chamber. This makes the X engine uniquely suitable for high compression ratio operation with Direct Injection and Compression Ignition on heavy fuel (which is not possible in the Wankel without boosting or a second compression rotor). Additionally, the combustion chamber can take any geometry, and can be approximately spherical, optimized for surface to volume ratio, thereby improving combustion efficiency and reducing heat transfer.
- The apex seals of the X engine are located within the stationary housing, and do not move with the rotor. The seals do not experience centrifugal forces, and can be lubricated directly by metering small amounts of oil directly to the sealing

surface through the housings, which means that oil consumption can be reduced to levels potentially comparable to that of a 4-stroke piston engine (essentially negligible).

- The unique sealing geometry of the X engine has 3-5 times less blowby than the Wankel rotary. This is mainly because 1) the Wankel requires clearance at the corners between its side/face seals and its apex seals, while the X engine does not; and 2) the Wankel seals traverse across holes that contain spark plug(s), whereas the X engine does not. The sealing strategy, seal modeling, and testing validation is described in detail in an [SAE Paper].