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THE CHINESE SUPER-SMALL SOLID-PROPELLANT FT-1 LAUNCH VEHICLE AND ITS POTENTIAL FOR COMMERCIAL SUPPLY TO THE WORLD MARKET

A REPORT IN CONFIDENCE TO

CST MEMBERS, ASSOCIATES

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INTRODUCTION

Launching small satellites of masses less than 1 ton, was, and continues to be one of the most in demand areas of space business, with regard to launch services, although this area is neither the most profitable, nor even notable by annual numbers of launches. The moderate position for this specific segment of the global launch services market, can be explained by a range of interconnected reasons: thus, operation of these small satellites, cannot bring profits significantly less than profits from operation of geostationary communication satellites, whilst specific prices for launching these geostationary satellites, are comparable with those for Low Earth Orbit (LEO) small satellites. Indeed, a launch of a geostationary communication satellite, with a launch mass of 5 tons, into a Geostationary Transfer Orbit (GTO), by a heavy launch vehicle, for a launch price of US$ 150 million, corresponds to a specific launch price of US$ 30,000 per kg of payload, whilst a launch of a Low Earth Orbit (LEO) small satellite with a mass less than 1 ton (600-800 kg), by a small class launch vehicle, costs currently about US$ 25-30 million, which approximates the same level of specific launch price.

Meanwhile, the current progress of technology, especially in the field of electronics, now enables the construction of satellites of less than 100-kg mass, that can provide approximately the same mission capabilities as satellites with masses of one ton or more, for similar specific launch prices to 10-15 years ago. This achievement significantly expands the circle of satellite developers/builders – while, earlier, this role, and the power associated with it, was held by state-owned enterprises, and specialised large private companies, a number of small scientific organisations, and even groups of students in higher-education institutions, have the opportunity to develop and to build their own satellites for scientific or even applied purposes, with sufficiently low financial outlay.

However, complete realisation of this opportunity i.e. not only self-building micro-satellites, but also launching them into a required orbit, comes face to face with the problem of finding a suitable launch vehicle for the mission. Even the smallest launch vehicles and systems in the world's launch inventory at large, have payload capabilities that exceed the required figure of 100 kg several times over.

One current solution for this problem, is to launch these super-small (micro- and nano-class) satellites in clusters, on small class launch vehicles. Unfortunately, this method is not entirely suitable for a significant share of the micro-satellite owners. There are two main reasons for that. One reason is that launch prices for these shared launches are too high, nevertheless, for those micro-satellite builders that have very limited funds for their space activities (as a rule, higher-education institutions, and those small private companies that are only starting their

businesses). For this main reason, the issue of launch price reduction remains important for developers and operators of small class launchers, even more so than that for their colleagues who are developing and operating launchers for GTO missions. With this, whilst an enhancement of a launcher's payload capability is a positive factor for GTO-intended launch vehicles, an opposite factor of payload capability reduction is positive for small launch vehicles, since this approximates the characteristic to the value of 100 kg, which would be optimum for launching nano- and micro-satellites for which a boom in demand (at low launch prices) has just begun.

Unfortunately, special studies dedicated to solving this problem, for instance, [1], have shown that the required super-small launcher, with an acceptable specific launch price is not likely to be developed in the near future. A compromise ratio of payload capability/launch price could be achieved at the level of payload capability at around 500 kg (the launch vehicle of this and less payload capability can be attributed to a sub-class of super-small launch vehicles). Achieving low launch costs (that define correspondingly similar launch prices) for these launchers is a complex problem too, but there is a specific opportunity that was already realised for several small launch vehicles, and could be realised for others of a similar type.

These launchers were, are and would be those converted from ballistic missiles with a relatively small amount of modification. As a rule, the basic missiles are transferred for conversion into space launchers, when their guaranteed lifetimes reach their expiry date, and, due to the concept of 'to use or to lose', prices for purchasing these basic missiles from militaries are then very low, which is what enables the low launch costs of the converted missiles.

In fact, taking advantage of this opportunity both in Russia and in the United States, provided a real boom in using these converted launch vehicles, and a number of them continue to be operated up until the present. Unfortunately, using this method for newer, later generation ballistic missiles, which replace the earlier missiles, is impossible due to specific technical features of the new missiles[#].

However, one other country in the world has ballistic missiles with less advanced flight profiles, and provides space activities including a supply of launch services on a commercial basis, and could supply super-small launch vehicles converted from its ballistic missiles to the world's launch services market at relatively low launch prices. This country is China.

The identified demand for launching super-small satellites for low prices, has coincided with the appearance of information on the intentions of Chinese operators to enter into this

[#] For instance, more modern missiles have new flight profiles that are quite unacceptable for space injection trajectories.

market with suitable launch vehicles, converted from Chinese solid-propellant ballistic missiles. This has generated the issuing of this report, dedicated to an assessment of prospects for a global supply of launch services of these launch vehicles commercially.

The first attempts to create a super-small launch vehicle based on a solid-propellant ballistic missile were undertaken in China in the early 2000s. This launcher, called the KT-1 ('Kaituozhe'), underwent multiple launch attempts with real small satellites, but these attempts failed. Following on from this, another, improved version of this launch vehicle was developed, and its further upgrades led to the creation of the 'Kuaizhou' launch vehicle that has recently carried out successful launches of two Chinese small satellites, and is currently proposed to be offered for commercial applications under the FT-1 ('FeiTian-1') name.

The history of the development of these converted small launch vehicles until the present time, with brief descriptions of the missiles they are based on, and competitors being developed in China in parallel, is presented in **Section 1**. With this, the complete history of these launcher's development is overviewed in **Sub-section 1.1**, the FT-1, as the first candidate for commercial operations amongst this launcher class, is described separately in **Sub-section 1.2** with a presentation of its characteristics and features of operation; recent launches and announced prospects for commercial operations in the interests of international customers. However, besides the existence of the small launch vehicle, its availability for these operations at relatively low launch prices, the success of this operation (i.e. bringing sufficient profits), would be achieved only if the situation in the corresponding segment of the global launch service market, is favourable for entering the new launcher into this market. In other words, the existence of demand for corresponding launch services is required, with the possibility of this demand meeting with the supply of these services, at launch prices that would be acceptable for this launcher's profitable operation.

An assessment of the FT-1 launch vehicle's potential for commercial operations is carried out in **Section 2**. Initially, the experience of the preceeding operation of converted solid-propellant launch vehicles is summarised, and analysed in **Sub-section 2.1**, especially of the Russian 'Start-1', which is a direct analogue of the FT-1, both in terms of attribution of their basic missiles to mobile solid-propellant ballistic missiles, and the availability of these converted missiles for foreign commercially ordered launches. General prospects for commercial applications of this type of small launch vehicle, which are defined by this analysis, are used in **Sub-section 2.2** for a definition of a predicted international market for the FT-1, and for an assessment of this launcher's potential to meeting a demand of this market.

In any case, achieving this potential has to require proper launcher marketing. Items of this marketing programme are discussed in **Section 3** including a comparative assessment of possibilities to provide this marketing via various Chinese companies/operators; CST experience in the field of similar marketing is described briefly, and suggestions for adopting this experience are given.

The **Conclusions** contain a brief summary of the information presented in the report.

It should be noted that the available information, the basis of which is used to prepare this report, is limited in depth and detail. Due to this, a significant share of assessments and analysis within this report; is done on the basis of deductions and suppositions. As more verifiable information is received in the future, the results of these assessments and analysis could be corrected or updated where applicable.

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