ASAP AND FUTURE CONCEPTS

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ABSTRACT: For any satellite customer, the key to "mission success" starts with the launch phase, one of the most important and sensitive periods in the whole development chain. This is especially the case for small missions built on small size platforms, for which clear rules and dedicated interface specifications must be established and followed to reach success. Although launch cost is a major driver for such missions, well established standards and corresponding experience must remain the basic parameters to keep in mind while selecting the launch service provider.
This paper will first address Arianespace's broad experience in launching small satellites from the company's earliest days, thanks to the well mastered launch service and to "solution-oriented" hardware developed for such projects, in particular the ASAP structures and the dedicated "User's Manual".
Then future activities will be addressed, describing the ideas and new concepts currently under study. This approach takes into account the increasing demand for even higher unit mass and size, and the coherence between the three launch vehicles of the Arianespace family: Vega, Soyuz and Ariane 5.

INTRODUCTION

As small satellites are moving from their early phase, characterized by simplicity and passivity, to an evolved phase, characterized by much more complexity and autonomy, launch services must evolve accordingly from a simple marginal allocation to a more conventional launch configuration. No more than 15/10 years ago, small satellites (mainly the so called micro and mini satellites) were considered as objects for amateurs. Right now, their design is much closer to conventional satellite systems, competing with more ambitious large missions. For that reason, the concept of "mission success", obvious for main passengers, applies as well. It starts from the launch phase, which is one of the most important and sensitive period in the whole mission chain. For small missions built on small size platforms, clear rules and dedicated interface specifications must therefore be established and followed to reach success, as for any big spacecraft. Although launch cost is a major driver for such missions, well established standards and corresponding experience must remain the basic parameters to keep in mind while selecting the launch service provider.

THE PAST: EXPERIENCES & SUCCESSES

Arianespace has already launched 233 satellites up to now, 50 of them being auxiliary passengers (within 22 flights), micro or mini satellites. A synthesis of the historical mass distribution is shown here-below:

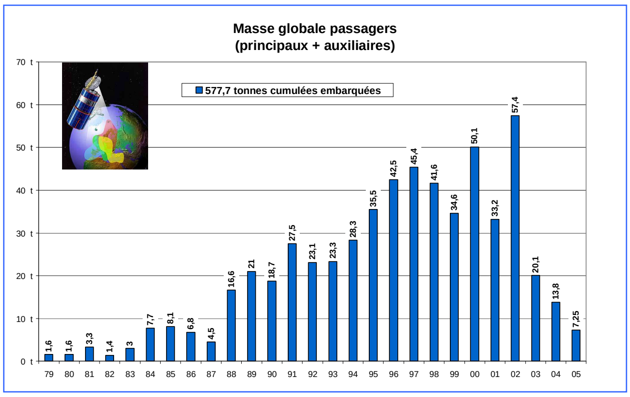

Fig. 1 – historical satellite mass launched by Arianespace

The history of small satellites with Ariane began at the very early days of the launch vehicle activity, even before the first mission under the Arianespace responsibility (V9). Later on, during the 80's, it became obvious that a particular service needed to be developed to provide a recurring low cost access to space for very small technological experiments.
The key element of this service was the development of a specific tool able to carry micro-satellites: the ASAP structure (Ariane Structure for Auxiliary Payloads). This structure, a platform ring attached to the bottom of the main passenger adapter, was originally conceived to fly on Ariane 4 and to carry up to 6 satellites together. Note that this accommodation was an extension of the Arianespace well known and experienced strategy to propose shared launches for the main passengers.

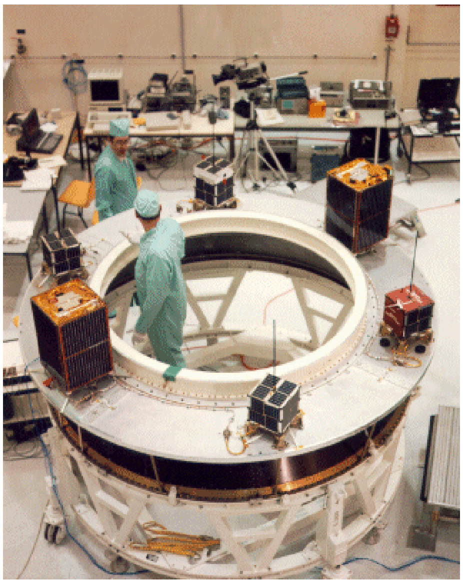

Fig. 2 – ASAP 4 Multi-satellite Platform for Ariane 4

While putting this hardware in place, a dedicated interface specification, the ASAP User's Manual, was issued in order to provide a coherent and exhaustive technical framework for the whole community. In parallel, a dedicated auxiliary payload standard contract was established, in line with the nature of these payloads: the aim was to avoid any perturbation of the main passenger(s), on a non-profit basis for the benefit of very low budget scientific groups (Universities).
The first mission occurred on the January 22nd, 1990 on board an Ariane 40, where no less than 6 satellites embarked on the first flight ASAP 4 structure as per the here-below drawing (4 MICROSAT and 2 UoSAT units).

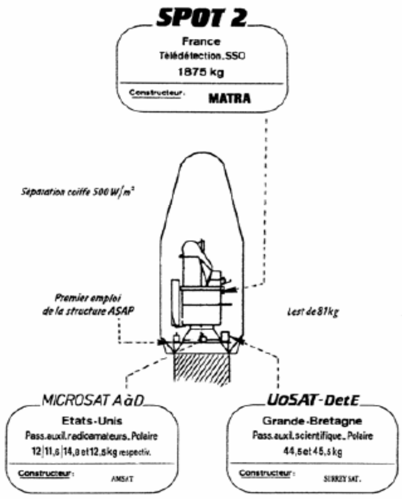

Fig. 3 – ASAP4 configuration for 6 micro-satellites

Since then, this approach has proved to be a success as no less than 32 micro-satellites have been launched on various orbits and all Ariane versions until now, with some others to come.

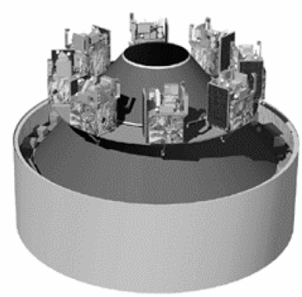

Fig. 4 – ASAP 5 Multi-satellite Platforms for Ariane 5

The major element of success of the ASAP 4 and subsequently the ASAP 5 systems was to

have created a coherent standard, with similar envelopes and dimensioning parameters to be used for any kind of mission. However, thanks to the experience accumulated and the release of performance margins, flexibility was granted in some cases to solve specific constraints (mass, volume, two consecutive separation points used by the same payload, and so on).
The satellites classification we have considered consists of micro-satellites (less than 120 kg) and mini-satellites (between 150 and 600 kg); each of them are of course associated with a typical size, as better explained below.

- A typical "micro-satellite", corresponding to the ASAP5 has evolved from less than 50kg on Ariane 4 to 80 kg and even ultimately 120 kg on Ariane 5. The volume itself grew accordingly to the maximum dimensions specified in the latest version of the ASAP 5 User's Manual (600x600mm cross section, 700mm tall), not to say slightly above. Such an evolution was due to several success-factors for this category of satellites:
  - increasing experience of small manufacturers / research entities
  - electronic miniaturization
  - increased power availability
  - subsystems equivalent to bigger size payloads
  - availability of low cost launch opportunities (mainly former ICBM)

As it appears to Arianespace, the demand is focused on even bigger units for the future, questioning the pertinence of our present "micro-satellite" offer (which actually transfers to a bigger satellite class, with even more needs and less constraints awaited). The graph below shows the distribution of micro-satellites with respect to time.

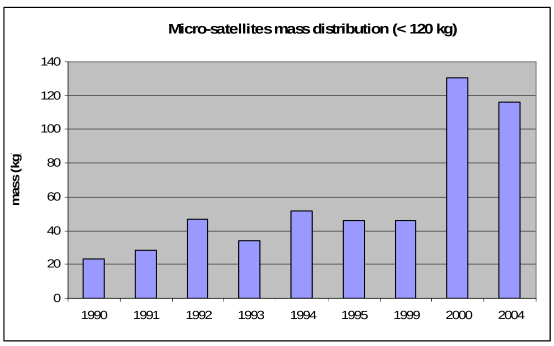

Fig. 5 – mass of micro-satellite launched by Arianespace

In addition to the ASAP structures and the corresponding micro-satellites framework, bigger smallsat missions born in the same experimental spirit, which size exceeds above limits, were also considered as auxiliary "mini-satellite" payloads, providing their mass and dimensions remains within acceptable ranges. These satellites mainly benefited of a specific central accommodation, inside a Ø1920mm (Ariane 4) or Ø2624mm (Ariane 5) carrying structure, beneath the main passengers.
An example of a mini-satellite accommodation with a dual launch was the Ariane 5 flight L516 (see figure below).

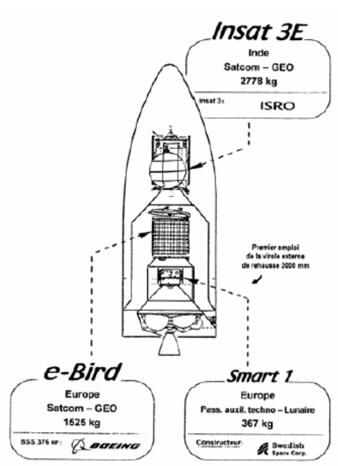

Fig. 6 – ASAP5 for the flight L516

- A typical so called "mini-satellite" has a mass ranging from 200 to 600kg and an envelope of about 2m in diameter and 1m in height. The main characteristics for the launcher upper payload compartment were:
  - Possibility to be coupled with a single main payload on Ariane 4
  - Possibility to be coupled with double main payloads on Ariane 5

Fig. 7 – ASAP 5 Multi-satellite Platform for Ariane 5

(Note that the ASAP 5 has been also developed with an option for clusters of 2 or 4 300 kg class mini-satellites, with dedicated specifications in the ASAP 5 User's Manual, but this configuration was never used due to the lack of corresponding market).

Graph below shows instead the distribution of mini-satellites with respect to time.

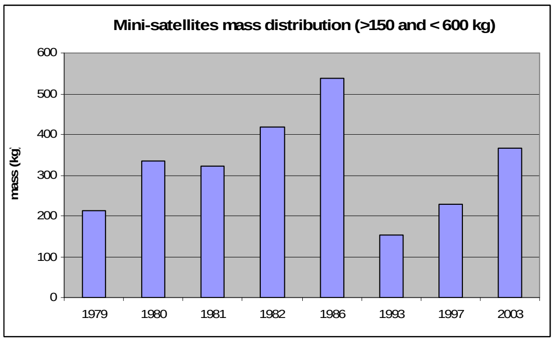

Fig. 8 – mass of micro-satellite launched by Arianespace

As for the micro-satellites, distinctive traits of the mini-satellite class are here-again related to contractual and technical framework:

- Specific contractual terms and conditions at a very attractive price (auxiliary passenger means limited rights and additional constraints)
- Specific technical interfaces, dimensioning and limitations

Note that nowadays, as for the micro-satellites evolution and success factors mentioned previously, 500kg class satellites are more likely to allow missions which would have needed much bigger units before, and thus less likely payloads built in the same experimental low cost scheme.

THE LAUNCH VEHICLES FAMILY

As the market leader in providing launch services worldwide, Arianespace has given a great contribution to space evolution at both governmental and commercial levels. The current offer will benefit from our acquired experience and the enlarged launch vehicle family will support this offer thanks to its wide range capability. Vega, Soyuz and Ariane 5 represent the Arianespace launcher fleet capable to put any mass in any orbit, of course this is true also for NGTO, and even more for small satellites. To give an idea of this capability, each launcher is below briefly described in terms of performance and characteristics.

VEGA: the small launcher offering big solutions

Vega is a four stages launch vehicle, 30 meters long and weighting 130 tons at lift-off. First three stages are based on solid rocket motor technology (named P80FW, Z23 and Z9), while the fourth one is module based on a liquid propulsion system (AVUM) capable to perform orbital injection with high level of accuracy.

Fig. 9 – VEGA during its ascent trajectory

Current standard payload adapter is coming from the Ariane4 heritage (the ACU 937B); furthermore the payload fairing is the "Ogival" shaped (also adapted from Ariane4) with a usable internal volume diameter of 2380 mm.
The reference performance set point required for the VEGA launch vehicle launched from French Guiana is: 1500kg at 700km in circular polar orbit, anyway the performance map shown in fig.10 covers various potential payload needs.

Availability: November 2007
A Multiple launch capability is under study for mini/micro-satellites launch configuration to be tuned to actual and potential needs. VEGA

will be capable to cover all the possible mission spectra in the LEO domain.

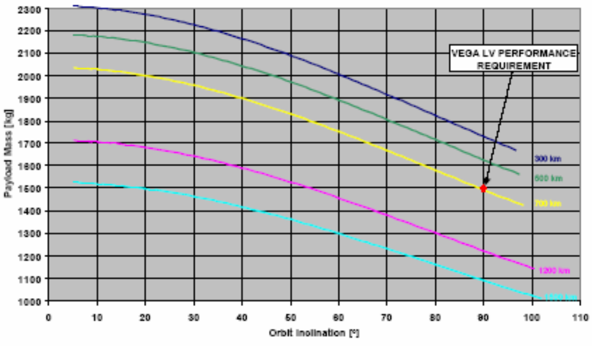

Fig. 10 – VEGA performance map

Fig. 11 – VEGA fairing and adapter for micro-satellites

SOYUZ: History + Man-rated + Reliability

Soyuz has a unique record of successes, we can only outline few:

- 1957: Sputnik, first artificial satellite
- 1961: Gagarin, first man in space
- 2000: first crew to ISS

After 1697 flights (the highest in the space history), there is no much more to say.

The Soyuz capabilities, ranging from LEO to GEO scenarios, are in accordance with the following table, which refers to Guiana launch site:

	ST 2-1a	ST 2-1b
• GTO	2730 kg	3060 kg
• SSO	4450 kg	4900 kg
(performance including the adapter)		

Fig. 12 – the venerable SOYUZ during lift-off

Availability in French Guiana: first half 2008 (currently available from Baikonur launch site). The payload fairing is capable to satisfy all the customer needs as shown by the following picture.

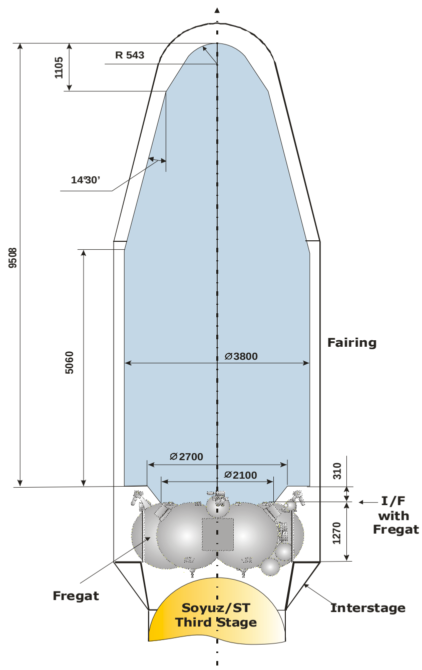

Fig. 13 – SOYUZ fairing size

ARIANE 5: the evolution of the species

ARIANE5 is the workhorse of Arianespace launch family. It is the evolution of the successful Ariane4 and it is currently one of the most performant and reliable launcher in the world.

Fig. 14 – ARIANE5 during lift-off

Performance and characteristics of Ariane 5 are capable to offer any mass in any orbit; as regard mini- and micro-satellites, the launcher can technically accomplish any request coming from the mission architecture.
Availability: Ariane5 is operational from 1999.

CURRENT SCENARIO

As mentioned earlier, the current small-satellites are evolving to more sophisticated missions, due to the larger domain of applications allowed with the modern technology on board. Not only mass and volume requirements are increasing, but also more accurate orbital parameters, separation conditions, mechanical and electrical links, … are awaited, and, last but not least, more programmatic constraints and contractual rights are expected. In other words, the challenge we are facing now is the adequacy of our past and present auxiliary payload launch contract scheme with demands which are much closer, if not identical sometimes, to main big passengers, with in particular the same amount of system analysis treatment and manifesting rights. Clearly in that context, the historical marginal influence of such missions is dismissed, but of course the capability to serve them fully remains through adapted technical and contractual solutions to be developed, a pole of excellence of Arianespace.
Considering the number of potential missions planned up to 2010, it is possible to show an average mass distribution, for both micro- and mini-satellites, accordingly to the next graphs.

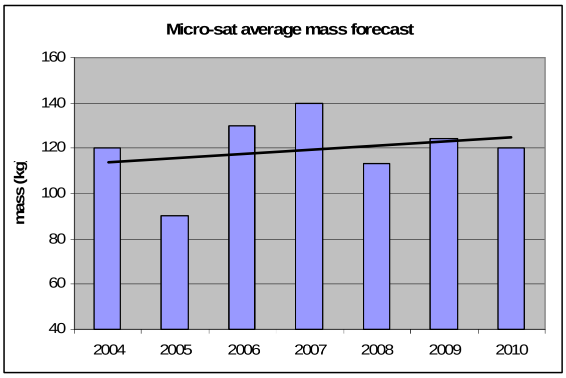

Fig. 15 – Micro-satellites average mass forecast

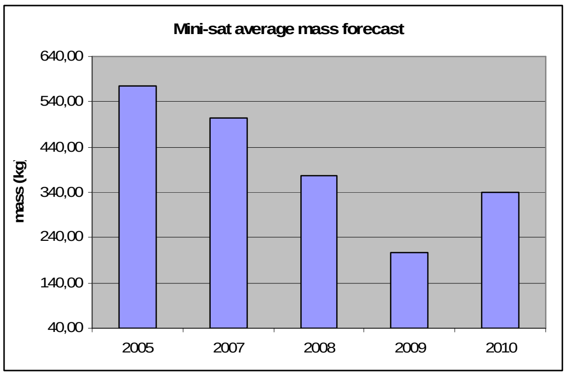

Fig. 16 – Mini-satellites average mass forecast

THE FUTURE: ARIANESPACE LAUNCH CONCEPTS AND SOLUTIONS UNDER STUDY

The core business for Ariane 5 is the GTO market, complemented with some fully dedicated high energy and LEO missions; in this frame it is not excluded to have an auxiliary payload linked with a main scientific dedicated mission.

The “micro-satellite” market for GTO looks very weak when considering the current demands received by Arianespace, far from filling the 8 positions available with an ASAP 5 mission. On the other hand, and independently of the orbit itself, the mass and size of most of the current demands for micro-missions exceeds the ASAP 5 limitations. We are therefore seriously considering the end of the story for this structure as it is dimensioned today.

Since the demands for small satellites, in particular micros, is mostly oriented to Polar/SSO missions, it is important to re-analyze and re-orient our offer accordingly, thanks to the present wider possibilities of the Arianespace fleet of launchers, and not only Ariane 5.

A study has been initiated to understand how and in which conditions it may be feasible to propose an extension of our adapted launch services for the next generations of small payloads, keeping in mind the key historical elements of success:

- A well defined framework
- Clear technical standards
- Attractive contractual terms and conditions

and taking into account the following basic hypothesis:

- ➢ Ariane 5 mainly for the GTO market
- ➢ Soyuz covering both LEO and high energy missions (GTO)
- ➢ Vega for the LEO market
- ➢ As much as possible, common interfaces specifications for the entire fleet

Not forgetting the major element: smallsats to fly with main passengers only.

<u>The “microsatellites” case:</u>

Many technical and non technical parameters must be analyzed to define a potential framework. The mass, volume and orbit are the most immediately significant, with obvious interactions.

- Dimensions of the satellites (cross section and height) are key parameters when evaluating the potential configurations and the number of units to be launched together. Whatever the launcher of the fleet, there are basically two ways to accommodate such payloads:
  - “external” mounting on a continuous ring or more discrete positions around the main passenger support structure (ASAP concept)

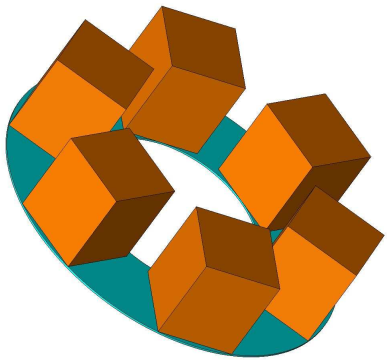

Fig. 17 – external mounting concept

  - “internal” mounting on a plate, beneath a carrying structure for the upper main passenger

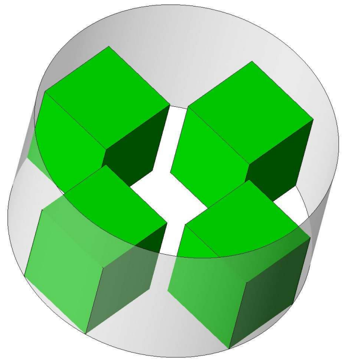

Fig. 18 – internal mounting concept

“External” mounting is very unlikely to cope with the biggest micros, as the allowable cross section hardly exceed the present 600x600mm ASAP 5 requirement, even if the central cylinder diameter is reduced to the max. “Internal” arrangement offers more possibility, but will greatly limit the number of micros launched at the same time (refer to further remark on the market ability to allow several satellites at the same time).

- Mass is a big issue as well, with dimensioning impacts on the adapter and structures, and considering the performance left by the main passengers (especially when several micros are launched together). The 120kg ASAP 5 limit is in some cases violated by the current demands, and we are evaluating the possibility to raise it slightly (around 150 kg).

- Orbit tuning will remain a strong limit. Such payloads are not expected to fly alone, and the main passenger obviously pays to be served as expected. Thus, the microsats may not ask for very specific orbital elements. As historically achieved, the “GTO” or “SSO” types of orbits may be granted, without further commitment on the details.

- Behind these main technical parameters, some others shall be constrained as well, to allow easy feasibility evaluation and to prevent costly studies (mechanical properties, separation conditions, …)

Not only the here-above constraints have consequences on the launch conditions: the number of satellites available for a given launch has a dramatic impact on the economical equation (the costs are better shared on a multi-launch scheme). Thus the market ability to allow such a situation is mandatory.

The “mini-satellites” case:

The market for auxiliary passengers which mass and volume exceed the above micro-satellite envelope (roughly 200 to 600 kg, 2m diameter and 1m high) has not historically been very important. Our perception of the future for this segment of the market is rather unclear, as the corresponding envelope hits the demand for more ambitious main passengers with full contractual and technical rights.

Should any demand for a passenger of that size, compliant with auxiliary payload conditions, arises in the future, the obvious configuration would be a centered positioning beneath a carrying structure for the upper main payload, in line with our past experience. Such a payload should remain very flat, with a diameter constrained to less than 2m (numbers TBD).

Dual launch for two main passengers:

Our study is also addressing the case of more ambitious missions, needing the same level of technical and contractual needs compared to current main big passengers, thus not auxiliary payloads, but nevertheless with limited mass and size (200 kg - 1000 kg range).

The evaluation has been initiated with the Soyuz launch vehicle, as both the fairing volume and performance are quite large compared to the current requirement for most missions (not taking into account the specific telecom GTO market). The natural response to help optimize the launch conditions for such payloads is the dual launch capability, a unique Arianespace solution well experienced with the Ariane vehicles since the early days.

Such an accommodation would allow to launch two similar satellites with rather big dimensions (up to 2 metric tons for a SSO orbit, with about 2,5 meters in diameter and 3 meters in height). The initial phase for the corresponding structure evaluation has been already launched.

However, coupling satellites on the same launch means inherently compliance with common standard orbital elements. For NGTO orbits, this indicates that such common requirements shall be frozen at the earliest phase of any project (as for example: identical local time for SSO missions).

ADDRESSING THE MARKET

The above Arianespace evaluation, aiming at providing a future to the present auxiliary payload policy using the fleet of launchers, needs an urgent feedback from the market to better assess the relevant inputs and the strategy to implement. The present economical pressure does not allow us to develop many different configuration options without a clear identification of the need and the flexibility: we have unfortunately the example of the 300kg mini-satellite ASAP 5 which was developed and qualified without any application, a situation we shall avoid in the future

Addressing the market means at least the following:

- Number of satellites to sustain this activity, possibility to really accommodate several at the same time
- Technical flexibility to cope with the inherent auxiliary payload constraints versus main passengers
- Programmatic flexibility to cope with the main passenger constraints

CONCLUSIONS

Small satellites have now enough technological maturity and capacity to accomplish a complete mission, even ambitious, despite their reduced mass. On such a context launch vehicles are even less a marginal phase of the whole mission, but a dedicated activity which requires experience and capability. Arianespace, with more than 25 years experience and a fleet of 3 different launchers, can offer "any mass to any orbit" approach and then solutions for small satellites.

The evolution of both mass and mission has pushed Arianespace to search for the best solution in terms of payload accommodation, launch flexibility and associated services. We can support with our solutions the success of any mission.

The new ASAP will come **A**s **S**oon **A**s **P**ossible!

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