plastron
mobile satellite cleanrooms

innovation & growth in the newspace era

A sector in change where high-tech supply chains, bespoke product development and hazardous safety oversight interact in a conservative setting. This frame-of-reference is being used to understand the trajectory of the space industry as it experiences an unprecedented period of commercial expansion. The expansion brings immense opportunities, supported by top-down initiatives and bottom-up disruption. Yet, during periods of change, it's easy to lose an appreciation of the primary focus and the fundamental building blocks required for on-going success.

A proliferation of NewSpace launch projects worldwide, involving new rockets launching from existing launch sites and new spaceports. Critically, specialist facilities and expertise are required for preparing the ever-increasing quantity of small (up to 500kg) satellites using these services. These must assure human safety from uncontrolled explosions, limit satellite contamination from poor quality air, gas and chemical products as well as meet exacting standards that manufacturers, customers and insurers require for their satellite and their launches.

Given this growth rate, there is undoubtedly insufficient experience available for designing, manufacturing and operating these facilities professionally and the risk of catastrophic accidents or equipment failure, resulting in delays, payload damage or launch cancellations could seriously undermine satellite launch infrastructure capabilities, not to mention the human cost. This would be unwelcome at a time where more business sectors than ever before – agriculture, maritime shipping, defence, healthcare, climate monitoring, telecommunications - are becoming increasingly dependent on the capabilities afforded by orbital technology.

In addition, the spacecraft manufacturing cluster is under pressure to deliver much more: evolving well established business practices and timeframes so that, for instance, the current trend for constellations can be achieved with the entire fleet built, launched and orbited successfully on time.

THE ROOT CAUSE IS GROWTH

Advanced manufacturing and ever-more powerful technologies are fueling not just the small satellite market, but also the launcher market. 2020 and beyond may prove to be a watershed from past practices - as satellite and rocket manufacturing enters an era of rapid commercialisation. The road ahead will bear economic and social benefits, but it will come with risks, measurable through the statistics of industrial bluntness; since the Apollo era, launcher failures have remained consistently low at 6.1% despite changes in volumes and types of launchers in use. Comparatively, small satellite failure rates have consistently run much higher - between 40 - 50% for the past 20 years.

For an industry built on exacting standards, with a tradition for highly-skilled manual expertise, this failure rate is surprisingly high. And as the commercialisation of space is opening the market to disruptive and innovative evolution, how is this failure rate going to respond? And what steps should the industry be taking to reduce such remarkable failure rates? The question is whether commercial modernisation of the industry will not only prove to be economically viable, but if higher levels of product quality can be achieved. Because if it worsens, this will also put safety at risk.

With high failure rates, for which production processes and perhaps the appropriation of more affordable COTS components can take some responsibility for, we also have to assess whether the skills in use have access to industrial wisdom borne from historically important mistakes.

With advances in both technology and manufacturing practices as well as a more refined, systems-based approach to manufacturing and launch, the commercial objectives of the NewSpace sector have a chance to be realised, without putting the sector, nor it's employees at risk.

It's never easy to alter a business in flight, let alone an entire industrial sector,

But two outcomes will quickly make themselves evident – continue along this rapid, unstructured trajectory until an inevitable crisis occurs – or understand how the industry supply chain needs to evolve, introduce supportive building blocks and assure the effective and safe maturation of the sector.

To contextualise the risks associated with these and other transformative forces, it remains fundamental that all participants understand the end-to-end satellite supply chain as a whole system. In this way, innovative and meaningful contributions avoid wasted resource and investment and net gains benefit many more stakeholders consequently.

With the number of spaceports doubling in the next five years and small satellite launches expected to double by 2028, high-quality, evidence-based systemic innovation will be critical to the economic stability and sustainability of national and commercial space infrastructure worldwide.

This maturing will always be the more evident during launch and orbit, as the front end where infrastructure, processing and hazardous activities have to function in concert. This presents challenges and opportunities to space agencies, industry primes, the expansive SME market as well as professionals and new entrants.

THE CURRENT PERSPECTIVE

Access to Space – how you get there. Without understanding the complexity of why the space industry functions the way it does, the art of preparing a satellite for launch can appear a dark and time-consuming art-form. But, based on industrial history and experience, it involves fundamentally important activities, which are required before the satellite can be launched. Any failure during these activities can have small-to-massive ramifications up and down the supply chain, so it should ensure the system is focused on one requirement: that the satellite is a precious cargo, the most vital component of a production cycle (which can run for up to several years). Centring all the thinking of the launch process around the needs of the satellite customer quickly re-inforces an important reality: launchers are worthy for the service they provide – getting satellites into orbit; secondly, launch facilities are the critical underlay to all the launch preps themselves, but,

...if it weren't for the satellites themselves, all this infrastructure and flight tech becomes essentially worthless...

The advent of NewSpace is seeing a robust beachhead being established across the upstream sectors of the industy; success will rely on efficiency, safety and professional knowledge because, quite simply, if the means for preparing a satellite are not efficient, safe and properly managed, the risk of harm will eventually be superseded by satellite customers voting with their feet.

CAUSALITIES IN THE SYSTEM

An interesting crucible for sector transformation is the separation now happening between launch sites and the launchers they host. And it is this evolution of the launch ranges, where technical expertise is most lacking, that the greatest risks to the system exist.

From a time of industrialised, funded military and government agency-led launch sites, modern SpacePorts will be different: success will come through commercial astuteness – lean operating processes, agile management and commercial prowess will be vital skillsets on the ground. But this step change needs guidance – to clearly illustrate what standards these facilities need to be set at and maintained – and why.

The options for large-scale investment into these sites is unlikely, but options for innovation are available and can generate operational and economic gains whilst assuring industry expectations and safety needs.

The space industry sector is in a period of unprecedented growth and transformation, with our current timeframe marking the first five years of a 2-3 decade period of industry-wide transformation.

Given business growth trajectories across the key parts of the upstream value chain, it is necessary to evaluate the changes facing the industry at scale. Times of change encourage disrupters to agitate the incumbents, and, when an early mover is successful, such as SpaceX, they claim an opportunity to set new directions of travel for how their industry peers operate. But, the pace of adaptation they require from across the industry can disrupt and destabilise as well as enable.

MECHANISMS FOR TRANSFORMATION

So, to take a glimpse at the future, we need to make some predictive insights on what can be expected in the next 5 - 10 years; and how will that influence Access to Space?

- Growth in the smallSats market
- Constellation build & processing
- From bespoke to COTS supply
- Evolution of propellants
- Disruptive launch phase practices
- Change in a conservative sector

Consider when high-quality practices have to adapt, leading to an unexpected error. The paradox is, once you have achieved high standards, partial blindness to new problems can occur. Plus, a new problem without precedent for which the analytics and expertise to fix it may not be available could at worse, negatively affect the market integrity of a supplier. This is not the kind of disruption any industry sector would welcome.

There are other factors to consider, which can help us understand how the health of the supply chain generates consequences for launch ecosystems. By appreciating how these factors contribute to launch outcomes, all aspects of the supply chain can adapt in parallel.

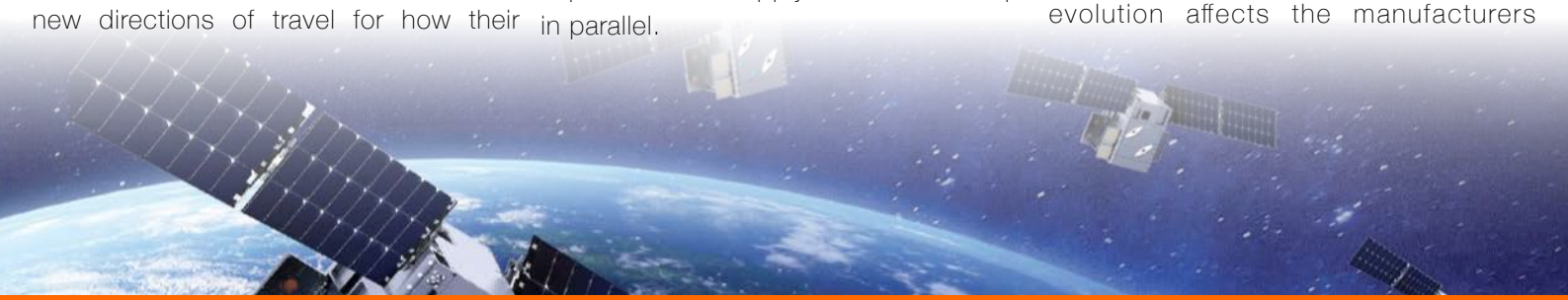
Growth of the small satellite manufacturing sector

The market is in accelerated growth now that small satellites (ranging from 500kg downwards) have proven their viability for commercial activities. The sheer volume of satellites being incorporated into constellation design is staggering, and perhaps worrisome too.

The trends of technology dictate that size will reduce as the power of the function increases and satellites will justly benefit. The challenge here is how to find the optimal land between expert design and manufacture and reliable COTS product appropriation. The less bespoke the item, the quicker the manufacture, that stands to reason. But as long as increased output doesn't compromise manufacturing quality, then it's all good. If, however, this change in output forces the supply chain to bend towards delivery limits, the stress this can place on the workforce will result in errors. So the key thing to discover over time is where is stress being generated in the system and how much slack is there before the stress has a reactive impact?

Agile satellite processing for constellations

The advent of the satellite constellation concept has pushed an industry to reconsider how it designs, procures and produces far larger volumes of spacecraft than ever before. The pressure resulting from this focused evolution affects the manufacturers



organisationally as well as delivery capabilities of their supply chain.

This is a system-wide adaptation, which is having an effect across the system, requiring more efficient project management practices and supply and demand processes. How delivery is transformed is already being further disrupted by Covid-19, which by definition is showing industrial sectors new areas of weakness and unsustainability. Fundamentally, agile working practices can alter the working habits and behaviours of team members – and lead to more cohesive, self-organising teams, with common lexicons used to describe and interpret product requirements in a common way.

Advanced engineering tools and techniques

The expansion of Additive Manufacturing across business sectors is still gathering pace, but it has quickly found a home in those industries where advanced materials and high-specfication technology are commonplace.

They stand to be, currently, the second most disruptive force in the space sector after constellations, based on the immediate trends available. The reason being: the technology is already influencing how existing items can be manufactured more efficiently. Numerous rocket engines and parts are now printed, this adaptation is helping to maintain high quality production standards, whilst evolving the way they design and manufacture engines and their components. This leads to critical improvements to the supply chain as well as reduced launch mass – benefits which make businesses more cost effective as well as contribute to end-customer gains.

Evolution of propellants and their safe handling

The clock is ticking for hydrazine, well with some exceptions, it now appears. But yes, propellants have not really evolved in the last century. Some are dirty, some claim to be green and a couple actually are. But in one way or other and given the nature of their purpose, they're all dangerous and that's why safety around them is a paramount need across the system.

Whilst we may still have a few more years before a truly green propellant becomes available (ask us about any green propellant, we've got an opinion which extends across the colour spectrum), right now we can be smarter about how we handle and transport existing propellants and equipment across the system. Virgin Orbit are already thinking about it – proposing delivering pre-fueled satellites to launch ranges could help to reduce launch campaign durations.

We consider satellite propellant handling as a key area for improvement – from our ongoing work in the sector, we understand how these changes can be beneficial and how safety has to be maintained. By improving the way loading equipment is connected, how the environment is monitored and how hazardous logistics are managed, such systems-based thinking can contribute towards a safe reality for ideas such as that one above, as well as provide SpacePorts with the evidence, knowledge and practices to efficiently ameliorate their operations.

Disruptive launch practices

We've already mentioned how Virgin Orbit foresee ways to shorten launch campaigns. But they added a new dimension to launches, previously only commercially attempted by Boeing Sea Launch in the late 90's: the ability to launch from where you want, not where infrastructure is based. Optimising the launch trajectory to the specific needs of the customer offers gains measurable in payload mass savings for satellite programmes.

The ability to launch in a mobile manner requires one thing, though; the launch facility has to travel with the launcher. This means compact, light-weight and adaptable resources are required. And they need to be durable, easy to assemble and provide a safe and clean environment for all necessary pre-launch preparations. It's no coincidence that this is the arena where Plastron is closely involved; converting traditional, heavy duty, fixed infrastructure into a mobile design is an interesting process. It must incorporate a whole range of support systems to ensure the cleanroom volume is as usable and technically as good as that on offer from any fixed structure.

Could it be feasible to transport fully fueled satellites to launch ranges, rather than loading them at the launch site - as per convention?

The 'why' is an important one, as it puts responsibility for adaptation onto manufacturers, who will now need to make a considerable investment. It also places responsibility on government agencies to ensure it is technically safe and viable.

The question of where benefits from a system step-change lie is an important part of the feasibility analysis.

Pace of change in a conservative sector

The satellite manufacturing industry in the UK was borne out of a space programme, originally focused on launcher ballistics. Prior to ESA, but during the time of its predecessors, ESRO and ELDO, the shift of the aerospace industry into the burgeoning space industry began. This led to a

heavy bias where large industrials provided 'primary' contracting services to government to design and build major infrastructure.

By contrast, we are now at a time where the large 'primes' are having to evolve even as the sector begins to consolidate agile methods, advanced design and evidence-based, fail-fast innovation approaches.

This means that there are incremental steps being taken to manage risk more effectively whilst also speeding up delivery. The benefits from such steps will lead to concepts, which eventually, and over time combine, resulting in ground-changing adaptations; ones which also happen to be safe.

THE IMPACT ON THE SYSTEM

Even as these concepts move from ideation into industrial step-change and policy, industry leaders will be assessing medium to long-term industry forecasts. Scanning the horizon somewhat, this section looks at the future drivers for all aspects of the industry, but from the perspective of how our mobile satellite cleanrooms have the versatility to support an industry in growth, safely.

In designing the Plastron mobile satellite cleanroom, we have focused on combining our up to date knowledge of the sector, with an appreciation of the needs of both incumbents and new entrants. This has led to a cleanroom design that aligns with the needs of manufacturers, whilst reducing risk in hazardous activities for range operators.

We've also taken a forward view on the anticipated needs of the industry, which the following case studies illustrate - the change the system is beginning to experience, and how our technology can underpin success.

Case Study 1
New commercial SpacePorts

New Spaceports need to guarantee satellite customers have access to high quality handling facilities so that satellites can be prepared efficiently in an industry-compliant setting. SpacePorts do not have the expertise or investment to build facilities to this standard.

Plastron mobile satellite cleanrooms can be leased at a fraction of the cost of a standard facility, with support and operational oversight from industry experts ensuring the SpacePort delivers on quality, safety and efficiency.

Case Study 2
Existing industrial launch ranges

Existing launch-site infrastructure was designed for launching large satellites, thus possessing capacity for no more than four customers or 5 satellites on site at any time. The exponential growth in small satellite constellations has resulted in individual launches of 10 or more satellites at a time. Without the capacity to handle this type of quantity in parallel, these sites are missing out on a launch sector experiencing massive growth.

Plastron mobile satellite cleanrooms can be used to store and process several small satellites in parallel and can be joined to create a processing hub for large quantity campaigns without having to build new, expensive infrastructure.

Case Study 3
Launcher services

Many new launch services businesses have been focused on developing leading edge rockets which offer unique launch capabilities to satellite customers. Most will be deployed at new SpacePorts where neither they nor the site will have infrastructure for the satellite customers. Thus, even with a launch range and a functional rocket, the launch service provider cannot offer usable facilities to their customers who need to prepare their satellites for launch.

Plastron mobile satellite cleanrooms can be packed down for transport in 20ft shipping containers by the land, air and sea transport services used to ship launchers around the world.

Case Study 4
Satellite constellation manufacturing

The manufacturing and launch of constellation fleets has led to the unprecedented scaling of build environments to ensure the production timescale and volumes can be met on schedule. However, these facilities are not just required for building the satellites, they are also required for completing pre-launch testing as well as launch preparations themselves. With the volumes of satellites involved, bespoke facilities designed to ensure limited downtime and rapid mobilisation for production activities helps to keep the overheads down to a minimum as well as limit the effect of supply chain

fluctuations on delivery schedules.

Customising Plastron mobile satellite cleanrooms for an entire programme of satellites means the facilities can be rapidly erected and disassembled for each stage of a programme at the locations being used.

Case Study 5
Launch manifest fallibility

Commercial launch campaigns are costly and are precisely planned in advance with continual revision as required. Whilst the launch value chain can be broken in a myriad of ways, such as launch vehicle delays, satellite handling problems or missed launch windows, the knock-on effect can be felt by campaigns planned for months later downstream. With limited facility infrastructure available at a launch site to handle this compression, a suite of

Plastron mobile satellite cleanrooms can take the pressure off all moving parts and reduce the over-run costs during down-time:

- *For a small satellite joining a large commercial campaign, preparations can be completed away and in parallel to other activities; the launch-ready satellite is then handed over to the launch facility operations to store until ready for launch.*
- *For a large satellite caught up in a campaign delay due to problems with the launcher, the satellite can be stored in an offline configuration, even if fueled, in a Plastron mobile satellite cleanroom so that the following campaign can have full access to their paid-for facilities.*
- *For the launcher and launch range, any form of delay can be minimised by ensuring all preparations for the current and following campaigns can still continue, which in itself helps to reduce over-run costs and penalties as a result.*

DEVELOPING A SAFE AND RELIABLE FUTURE FOR THE SPACE INDUSTRY

Here at Plastron, we combine up to date industry experience from handling satellites to develop a unique, industry-aligned mobile satellite cleanroom facility. Because we understand the cleanroom is pivotal to the successful build, test and launch profile of every satellite campaign. Over 70 years of leading industry expertise in UK and international space projects have led us to the position of delivering this highly competent and confident proposition to a knowingly conservative sector. Our work is designed to support safety and safe operating standards across the system, steps which are also contributing to our ideas for what we think the future of NewSpace holds. To talk to us about your ideas as well as learn more about Plastron mobile satellite cleanrooms, visit our website www.plastron.uk or contact us below.

charlie young
Head of Design

Charlie has over a decade of experience working across the upstream supply chain in the space industry. With knowledge of satellite propulsion system design, test and launch, alongside launch systems engineering and launchsite facilities management, combined with two decades as a specialist systems designer for high risk and hazardous service environments, Charlie's expertise drives the design and innovative enhancements to Plastron mobile satellite cleanrooms.

Charlie Young

charlie@plastron.uk

+44 7383 998 939

chris smith
Managing Director (Technical)

Chris is one of the UK's most respected propellant chemists. Working from the UK with global space sector agencies and industry peers to provide expert propellant handling advice and leadership. Guided by 35 years of first-hand experience, Chris continues to conduct propellant handling operations internationally, which ensures his technical and industrial knowledge directly influence the effectiveness and safe conduct of satellite operations in Plastron mobile satellite cleanrooms.

Chris Smith

chris@plastron.uk

+44 7766 164 633

plastron mobile satellite cleanrooms

A plastron mobile satellite cleanroom is a radical departure from existing processing facilities, in that it is fully mobile and can be transported to sites without specialist transport.

The structure provides a high-quality cleanroom footprint of 80sqm diameter, which is sufficient to support the processing of up to four smallSats.

Within the cleanroom, satellite customers have access to all necessary functionality and systems in order to complete all non-hazardous and hazardous activities demanded of them during a launch campaign.

Assembling and commissioning a Plastron cleanroom takes less than a working week.

The cleanroom has human and technology airlocks built in to the design. These are designed to integrate with common transportation container profiles, enabling standard shipping containers as well as satellite containers to connect effectively with the structure.

Our cleanrooms can be used in a variety of ways, largely dependent on the needs of our customers. From standalone structures serving new SpacePorts, they can be incorporated into existing facilities to provide a 'cleanroom within a cleanroom' for either specialist or security-level work to be carried out. And as suggested in the case studies, they can be introduced at commercial ranges to as a part of a low-cost expansion to accomodate the parallel processing of constellation satellites for a launch campaign.

Presented here is such a scenario, whereby a Plastron village combines six cleanroom structures to support mass processing of constellation satellites prior to encapsulation and launch.

In this configuration, the six cleanrooms are fully integrated to create a cleanroom production-line facility. Satellites are received in the far-right-hand cleanroom where initial processing takes place. As the spacecraft complete each production activity, they are transported to the adjacent cleanroom. This culminates into a configuration where two cleanrooms provide parallel processing space. This ensures, slower and more complex processing phases can be completed, without causing a bottleneck, which would slow down upstream activities.