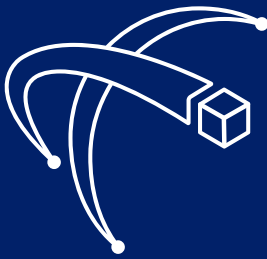


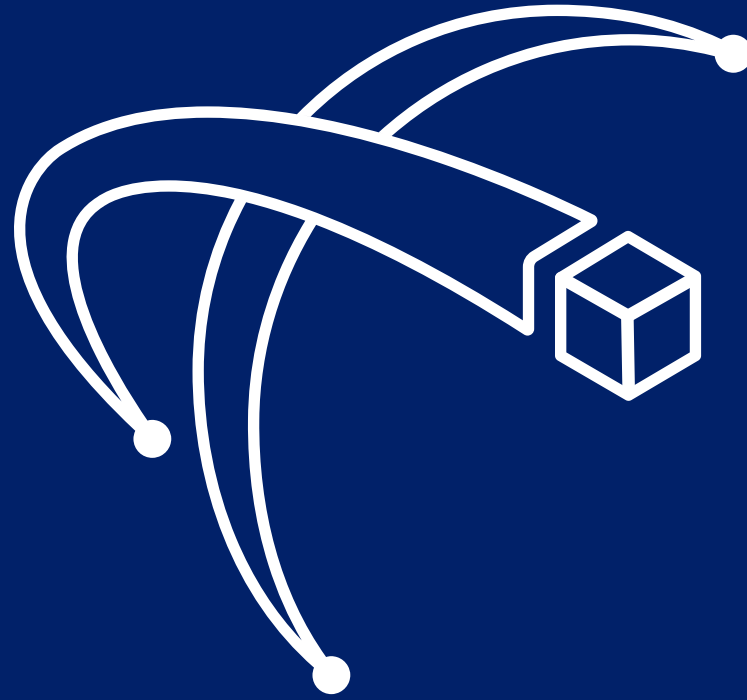
CITYSPACE

**Bulk Spacecraft Manufacture
for CubeSat Constellations**

From 1-2 to 50-100

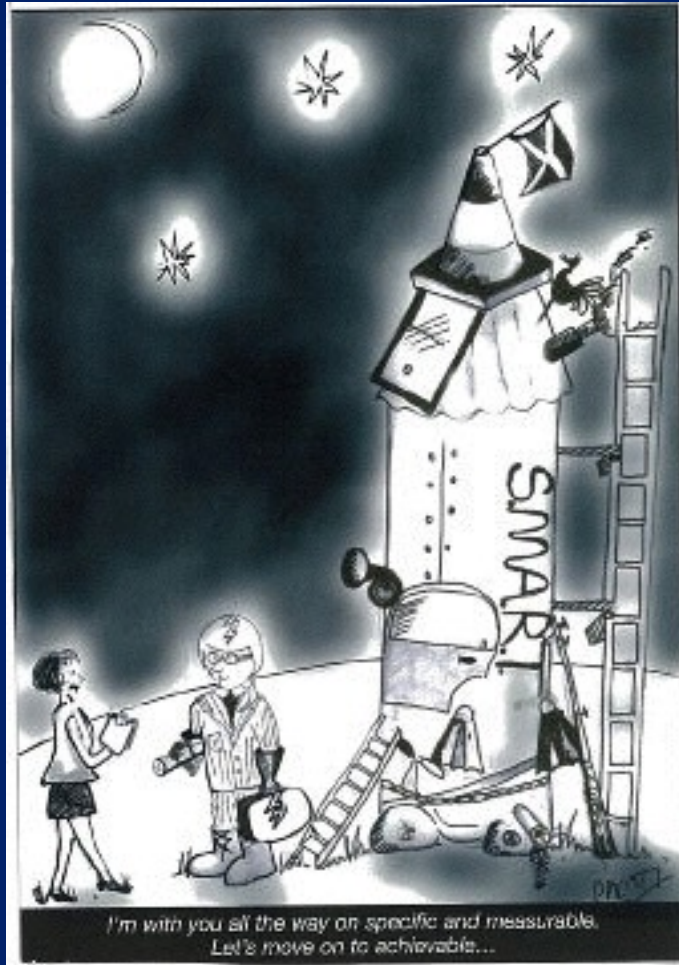
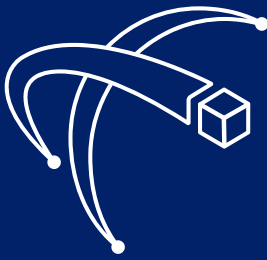


- Since 2005 the CubeSat community has been predicting mega constellations.
- 5-7 years ago NRO and US Army were ordering 10 OFF platforms, but wasn't enough to significantly change production practices.
- QB50 was not a production driver.
- Only a gradual increase in production quantities from CubeSat suppliers.
- When the commercial space sector arrived at the CubeSat vendors' door in full constellation mode, no-one was ready.

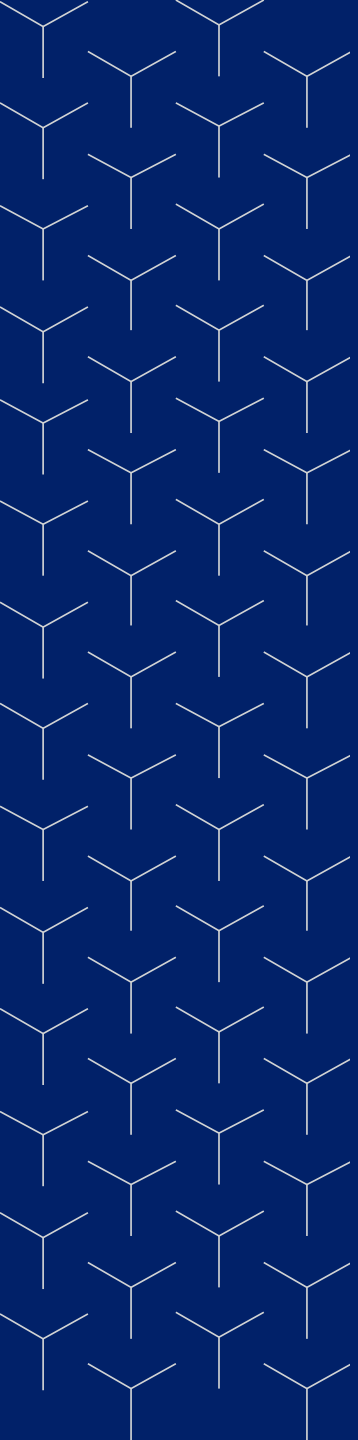


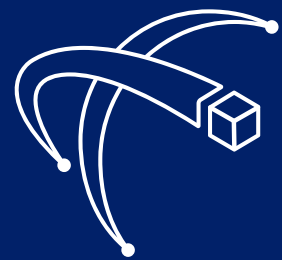
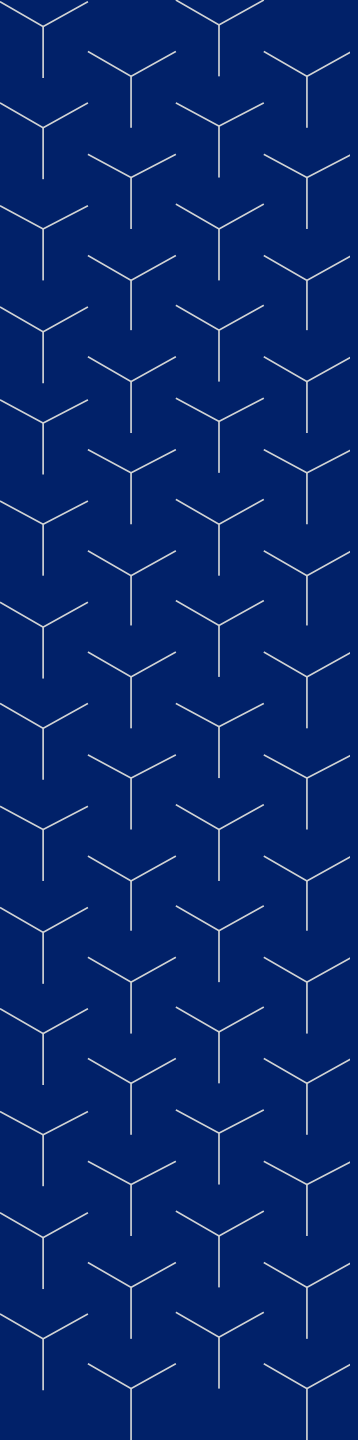
**BULK PRODUCTION IS NOT
MASS PRODUCTION**

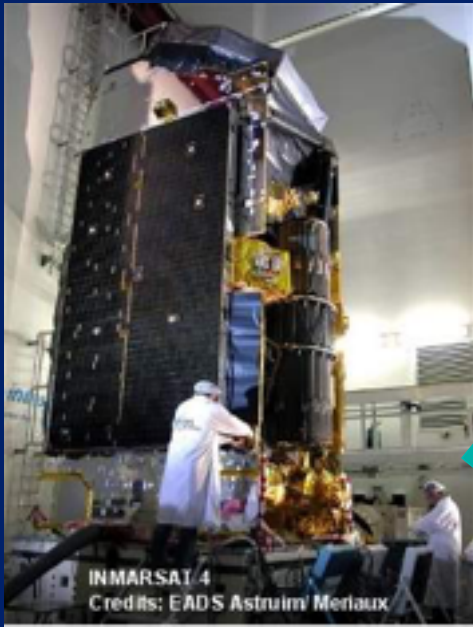
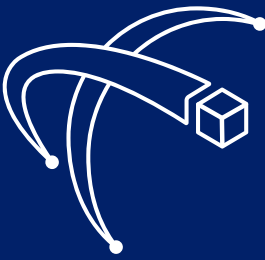
The \$10k Spacecraft



- The \$10k spacecraft has been talked about regularly, but what is needed to achieve this?
 - Careful material and component selection.
 - Design for Manufacture.
 - Design for Test.
 - Volume.
- (Launch cost also needs to come down)





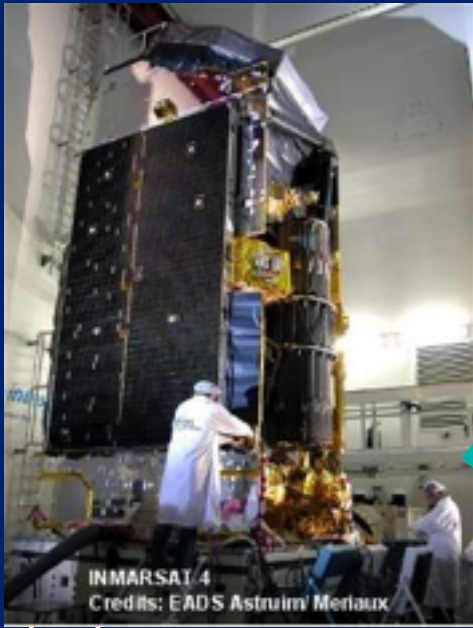


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\$





Ten



Tens

Hundreds





Thousands



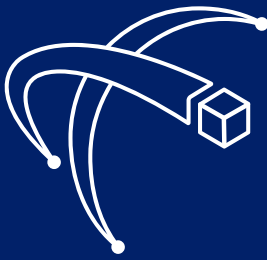
Millions



Billions

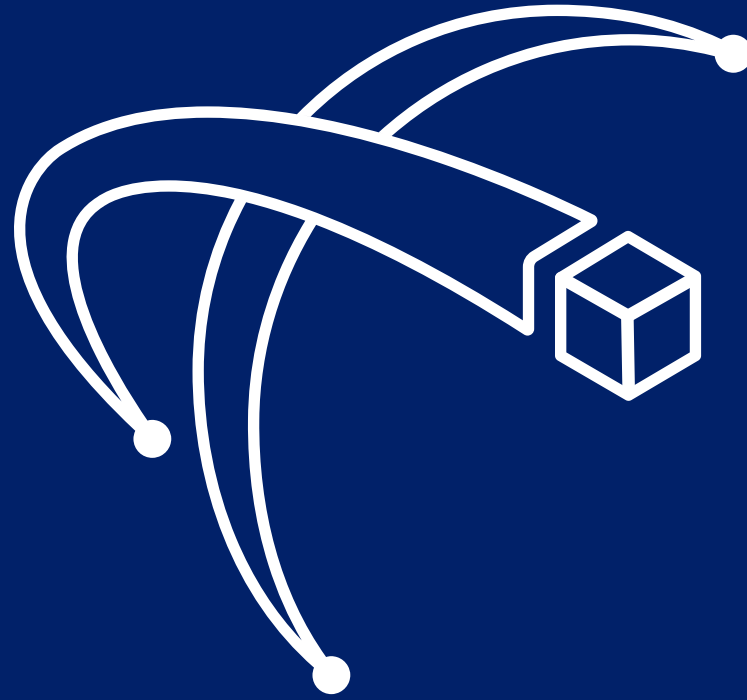


The ONEWEB Example



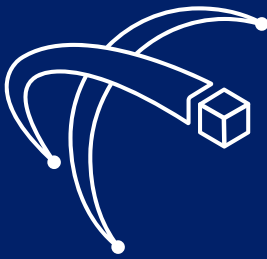
- Targeting \$500k per spacecraft.
- Production quantity of 900 means volume production possible.
- Complex supply chain and production process challenges to achieve price targets.
- Not too dissimilar to CubeSat production approach.





RAMPING UP PRODUCTION

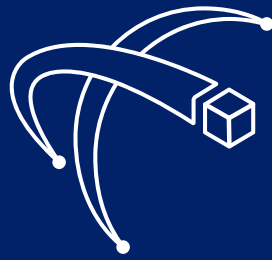
Bulk Manufacture



- For last 4 years been working with automated assembly provider.
- Current product generation has also been through Design for Manufacture cycle.
- Supply chain management is now significant part of our operation.
- 1000 flight assemblies in assembly in January.
- 350 flight units delivered in last two months.



Logistics and Process



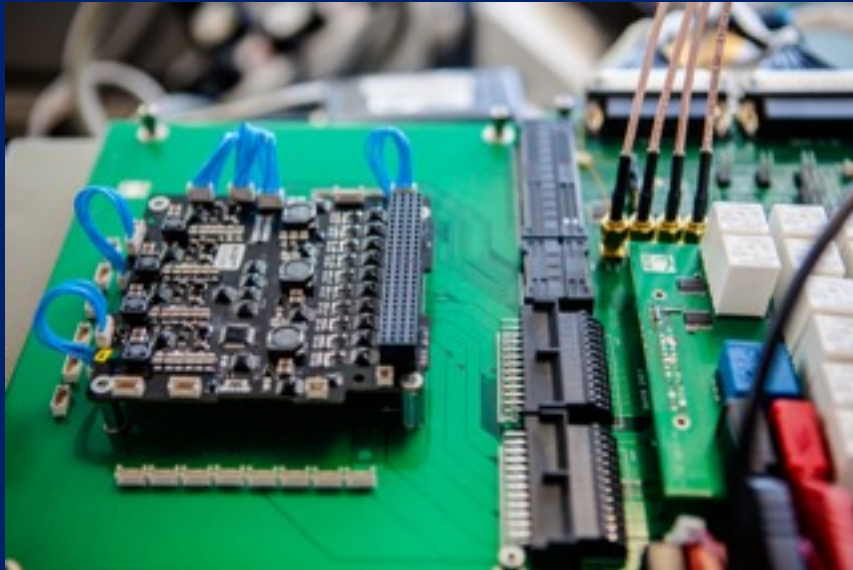
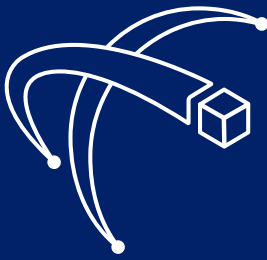
- Materials control, stock management, logistics planning, etc. are key functions.
- New software tools being rolled out including MRP, task management, version control.



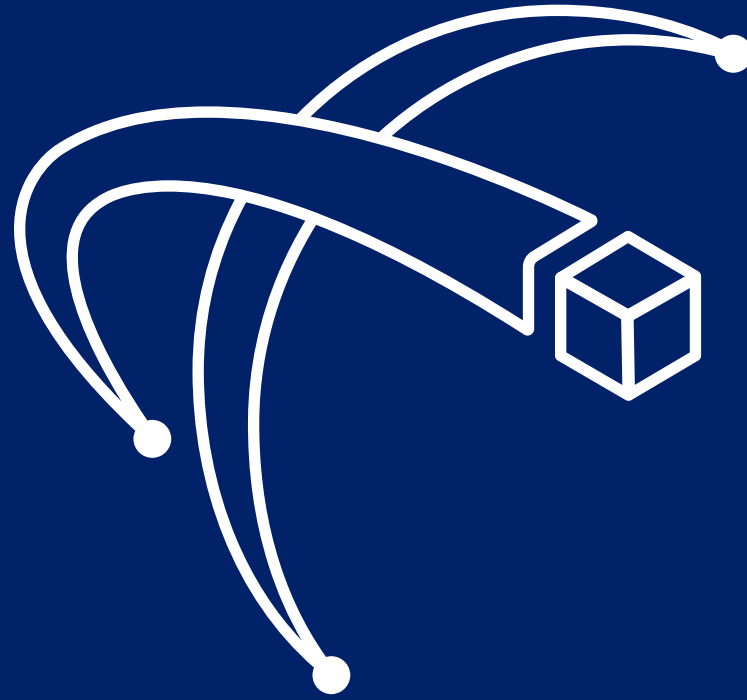
Smaller isn't Simpler



Design for Test

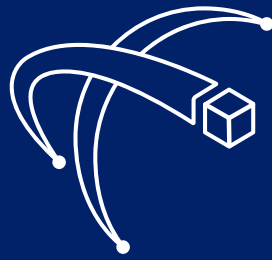


- Equally as important.
- Automated test for subsystems and full platforms.
- Test times drastically reduced.
- Touch time for test engineers and technicians can be minimized.
- Delivery lead-times for standard products can be vastly reduced.
- Batch acceptance processes soon to be introduced.



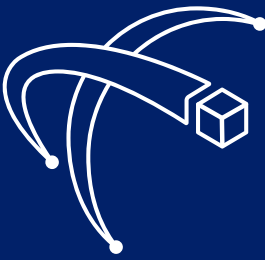
PROCESS FOR PLATFORMS

Design for Integration



- Highly repeatable, standard integration process is critical to reducing cost and delivery schedule.
- This is designed in during the mission system design.
- Systems Engineers also perform FlatSat test phases to ensure software and interface compatibility of subsystems and payloads are validated.

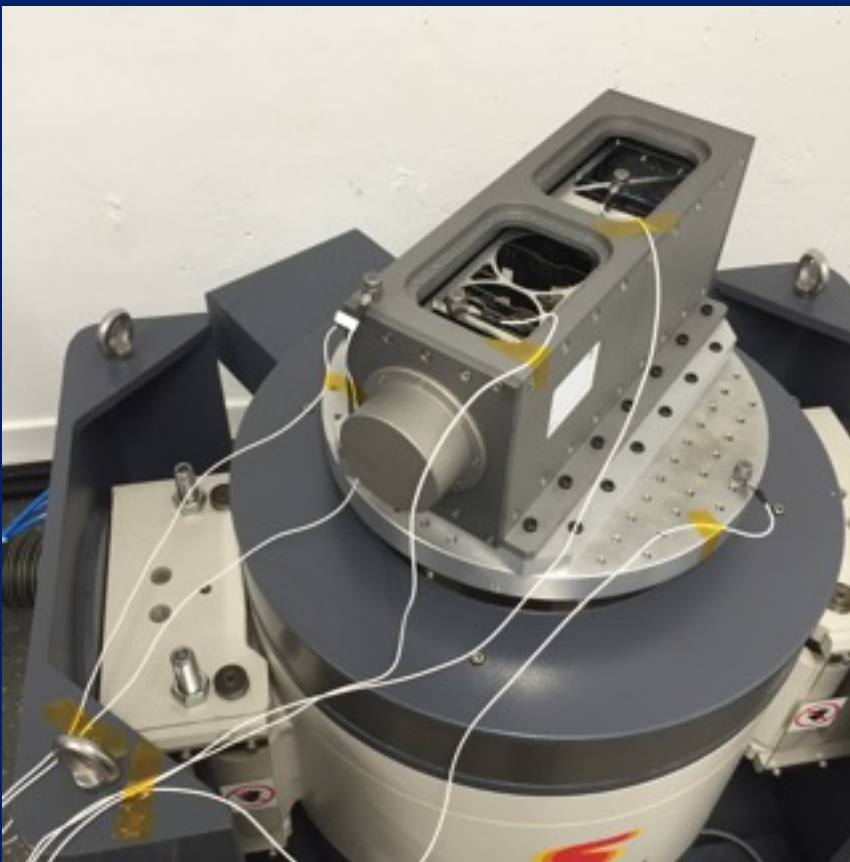
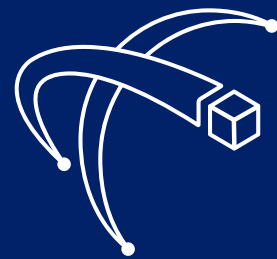
Integration Station



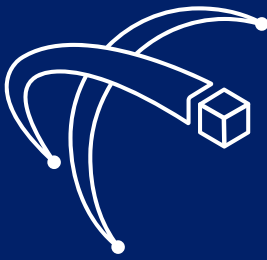
- Integration and test stations for all CubeSats are identical at Clyde Space.
- Identical test equipment, software, tools, layout, etc.
- We now have 12 integration stations in use.
- A spacecraft never leaves its station until it goes for EVT



In-House EVT



- In order to complete the full production process environmental testing must also be considered.
- In addition to thermal testing capability, we have introduced in-house capability to perform vibration and thermal vacuum testing.
- Once completed, the spacecraft is ready to ship to launch. This truly allows the CubeSat production process cycle to be owned completely in-house.



Summary



Batch acceptance testing on subsystems being introduced shortly.



An average of SIX spacecraft per month through our cleanroom this year.



Soon to hit 200 assemblies shipped per month as throughput continues to increase.



Combining space level build quality and automated process is not straightforward and can take time to get right.



The \$10k spacecraft is still a mythical creature, but continued efforts in DfM, DfT will move us closer.