

# Aerospace is flying high again

How **Chart** is leading in aerospace applications

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For the last several years, the aerospace market has been revived with new developments and applications. Launching rockets has become headline news again as technology has led to the use of reusable rockets that lower the cost per launch and make space accessible to everyone. Not too long ago, economics and technology limited space launches only to government entities and their programs. But today, these efforts are being funded by private investors and innovators, spurring development at

a faster pace with multiple companies competing for launches and contracts.

Chart Industries has been a global leader in the cryogenic industry for over 50 years. Today, Chart has a diverse portfolio that includes providing specialized cryogenic equipment and storage tanks for aerospace applications on a global scale. New Prague, Minnesota, Decin (Czech Republic), India and China are all key manufacturing facilities providing consistent Chart quality and design to serve global clients. Chart's global

reach is further amplified by Chart India (VRV S.r.l.) receiving a major commitment from the ISRO (Indian Space Research Organization) for hydrogen tanks.

Cryogenic propellants and oxidizers are cornerstones in rocket technology, allowing for high volume of on-pad storage of liquid oxygen (LOX) and liquid hydrogen (LH<sub>2</sub>). The use of cryogenics in rocket launches and testing continues to expand; and Chart is at the forefront of design and system integrations using this low temperature



technology. 2020 will be another year of significant milestones for global commercial and military aerospace programs. Continued revenue growth, new investments, upgrades, repair, refurbishment and system designs are allowing for new and expanded space technologies and sites across the globe.

The race to launch is reducing the use of onsite erected tanks for these private investors due to long lead times and onsite construction vs. a shorter window of time to get the launch pads ready. Previous manufacturing limitations did not allow for the use of multi-bullet tank arrangements, but now, it is possible to deliver 60,000 to 1,000,000 gallons of overall volume within a single calendar year. Chart's team has expanded to meet the need and has successfully delivered shop-built bulk storage tanks in volumes up to 250,000 gallons (1000 m<sup>3</sup>).

Why so much interest in the race to space?

- Satellites
- Weather tracking/forecasting
- Communication enhancement
- Research
- Defense
- Navigation
- Interplanetary exploration
- Commercial space flights
- 3-D rockets and components, lowered cost of barriers to entry

### Rocket fuel

Reliance on traditional propellants is



© Chart | Liquid nitrogen high pressure tank supply system at a space environment simulation chamber



“Keeping pace with the fast-moving aerospace industry has required building some of the largest single hydrogen bullet-style bulk tanks for Cape Canaveral”

changing in the low-cost launch model. While liquid hydrogen and liquid oxygen remain a staple of upper stage rocket fuels, first stage propellants are starting to be rethought.

All major private aerospace companies have announced they will be using liquefied natural gas (LNG) as a primary propellant, displacing RP-1 on their next generation rockets. The enormous US reserves of natural gas

and additional liquefiers being built have created a unique opportunity for this specific market. The commercial availability of the product provides supply chain resilience for the emerging transition to LNG at launch facilities.

Keeping pace with the fast-moving aerospace industry has required building some of the largest single hydrogen bullet-style bulk tanks for Cape Canaveral, each with 172,000+ gallons of capacity with several unique capabilities, line sizes and flows. In liquid hydrogen alone, Chart's portfolio boasts an impressive 500+ tanks produced globally, ranging in size from 1500 to 172,000 gallons.

Many other cryogenic products fit into the launch needs to permit the use of smaller on-board storage tanks. Subcooled propellants and oxidizers are employed to meet these special needs while utilizing Chart's technology and equipment. Further, special cryogenic needs exist in mobile launch platforms including vacuum jacketed (VJ) piping, couplers, decouplers, umbilicals and flex hoses. All of these provide efficient low heat leak transfer of the various liquids to the rocket prior to launch.

The pressure transfer of the fuel from the storage bullets to the rocket occur through vacuum jacketed cross-country lines that are required to operate at flows up to 5,000 GPMs. Pressure transfer technology eliminates ►



© Chart | (left) LNG Bullet Storage Tanks 3 x 100,000 gallon capacity; Multiple storage units with interconnecting VJ piping manifolds





© Hansa Meyer | Four large hydrogen storage tanks, some of the biggest ever made by Chart, were transported to the end-user via barge along the Minnesota River, and shipped approximately 3000 miles from Minnesota to the final destination



- ▶ the need of pumping systems which sometimes add unneeded operational risk at launch. Chart manufactures this VJ pipe, designed to specific flow and pressure requirements, at various global locations.

Long before a launch occurs, many public and private test facilities operate space simulation test chambers for testing rockets and equipment used on space stations, satellites and even Mars landers. Chart also manufactures the liquid nitrogen systems used in these thermal test chambers and high vacuum systems. Foreseeing and solving these challenges requires an enormous amount of technical expertise in cryogenics, which Chart possesses with decades of experience.

This wealth of experience allows Chart to make great strides in the cryogenic equipment for aerospace. Better solutions for space travel include product integration not only of cryogenic liquid trailers and jumbo cryogenic ground storage tanks, but also of heat exchangers, LNG knock out drums, liquid conditioning systems, subcoolers, deluge systems for acoustical suppression systems and much more.

**Moving the largest aerospace tanks**  
Chart Industries engineered and



manufactured four large liquid hydrogen vacuum jacketed storage tanks to be used as part of the ground storage for propellant fuels.

The end user requested the largest tanks that could be built (172,000+ gallons gross capacity) and still transported to final site. Engineered into the design of these large tanks were the calculations to support the shipment of the tanks, including any material stresses that could be encountered during the move. Since liquid hydrogen molecules can leak through the tiniest pores in welded seams, understanding the journey the tanks would be taking was all part of the planning process.

The tanks were built at Chart's facility located in New Prague, Minnesota, and transported from the factory, over roads to a nearby barge facility on the Minnesota River. The cargo was then floated to the Mississippi River and traveled nearly its entire length (approximately 3000 miles) and then on to the final destination at Cape Canaveral.

Frank Scheibner, President and CEO at Houston-based Hansa Meyer

Global Transport USA which handles the transporting and setting of large storage vessels, said, "Those mega transports were not without challenges. These tanks are up to 186 feet long, 15 feet high and weigh up to 400,000 lbs. Challenges started with moving from Chart's facility to a barge terminal 20 miles away. Roundabouts, railroad crossings and in-town traffic of cities we traveled through all were addressed. We needed the help of the police, bucket truck companies and utilities to either lift or completely disconnect overhead powerlines."

"Once we get to the barge terminal, we have to build a road to get to the barge. The ground has to be prepared and stabilized. Specially designed and built bridge jumpers over 50 feet in length have to be used to load the barge. The tanks have to be trans-loaded to Hansa Meyer's self-propelled trailers to load the barges. Once at the destination we have to remove all the securing and unload the barges, transport the tanks to the site and then set them on pedestals 8 to 10 ft in from the ground."

Foreseeing and solving multiple design and shipping challenges required an enormous amount of technical expertise in cryogenics and logistics. With over 50 years in cryogenics, 500+ liquid hydrogen tanks produced globally and vast LNG experience, Chart Industries has been at the forefront in cryogenic equipment supporting the great strides being made in aerospace. [gw](#)



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## Your Mission. Made Possible with Chart.

Chart is a leading provider of engineered systems and equipment to the aerospace industry. We have been integral in achieving operational success for our customers switching from RP-1 to Liquefied Natural Gas (LNG) propellant. Chart also provides on-pad storage of liquid oxidizers (LOX) and upper stage liquid propellant (LH<sub>2</sub>). Chart has designed, manufactured, tested and assembled advanced cryogenic system equipment for more than half a century. Our team works closely with each customer to ensure that systems are designed properly, function at their peak performance, and minimize risk to operators. Built for long-term integrity, Chart system components and product designs provide the highest level of performance at optimal operating costs.

- ✦ Bulk Storage Capabilities (1500 to 200,000 gallons)
- ✦ Vacuum Insulated Pipe
- ✦ Ambient Pumpless Pressure Building Units
- ✦ Discrete Advanced Engineering Analysis (FEA/CFD/TRIFLEX®)
- ✦ Engine Run Test Tanks
- ✦ Cryogenic Umbilical Hoses
- ✦ Subcooled Liquid Storage Design (to -452°F)
- ✦ And More!

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