

The Geo Quick Ride (GQR) Program – Providing Inexpensive and Frequent Access to Space

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ABSTRACT: This paper examines piggybacking NASA, university, and industry payloads on commercial geosynchronous satellites. NASA's RSDO Office awarded Geo Quick Ride (GQR) study contracts in 1998 to spacecraft manufactures to examine the issues with flying secondary payloads. The study results were very promising. Commercial communication satellites have frequent flights and significant unused resources that could be used to fly secondary payloads. However, manifesting secondary payloads on a commercial revenue-generating satellite is a complex problem to solve. The solution requires multiple simultaneous approaches in order to be successful. There are business, economic, technical, schedule, and organizational issues to be resolved. This paper examines the Geo Quick Ride (GQR) concept, discusses the development issues, and describes how this concept solves many of these issues.

1. INTRODUCTION

The science community needs a low-cost approach to fly remote sensing, space science, and technology validation missions. Typical low-cost flights, like balloons and sounding rockets, have their limitations and may not be appropriate for future missions. Even though the Shuttle has been a workhorse for NASA for many years, it is near or at the limit of its useful lifetime and its low inclination and low altitude orbit may not be appropriate for future space missions.

Commercial communication satellites have frequent flights and significant unused resources that could accommodate secondary payloads. However, manifesting secondary payloads on a commercial satellite is a complex problem. The solution requires simultaneous approaches in order to be successful. There are business, economic, technical, schedule, and organizational issues to be resolved. This paper examines the GQR concept, discusses the development issues, and describes how this concept solves the issues.

2. GQR – PAST AND PRESENT

There are two parts to the GQR story. NASA's initial Request for Information (RFI), surveyed spacecraft manufactures and studied the feasibility of the GQR concept. A more recent RFI studied what it would take to accommodate NASA's GIFTS instrument. The following paragraphs discuss both efforts and provide additional background on the GQR concept.

2.1 *The Initial GQR Studies*

In 1998, NASA's Rapid Satellite Development Office (RSDO) conducted studies to determine if government payloads could take advantage of the unused capacity (mass, power, volume, etc.) on commercial communication satellites. Four spacecraft manufactures responded to the RFI and were interested in the concept. The studies showed that the average geosynchronous communication satellite has approximately 90kg of unused mass and 450W of unused power.

However, neither NASA nor the commercial satellite manufactures were able to fly a GQR payload. Manufactures argued that NASA had to fund the upfront costs to implement the concept. NASA claimed the RFI responses demonstrated a need and manufactures should take the initiative and implement the concept. In reality, the economy was strong and manufactures were not interested in a \$10 million payload. In addition, NASA was unwilling to accept the risk of selecting a mission that implemented the unproven GQR concept.

In the RFI responses, satellite manufactures explained that the communication satellites were being built for an owner/operator and that NASA had to negotiate with them to add a payload to their spacecraft. NASA communicated with several owner/operators, but no action was ever taken.

2.2 Recent GQR Studies

In July of 2003, after NASA's GIFTS mission lost its Navy spacecraft and Air Force launch vehicle, NASA Goddard issued another GQR RFI to find a ride to GEO for the GIFTS instrument. Four spacecraft manufactures and two satellite owner/operators submitted favorable responses. In addition, two additional owner/operators were interested in the GQR concept, but were unable to accommodate the large GIFTS instrument. In the original GQR RFI, vendors were asked to accommodate a small (10-20kg) payload. The GIFTS instrument, however, was very large. It required 200kg of unused mass and 500W of unused power.

Despite the size of GIFTS, vendors were anxious to accommodate it, but in 1998 they were only moderately interested in the concept. What changed? Several things: 1) the economy was stronger in 1998 with each manufacturer developing 5 or more spacecraft a year, compared to the current economic downturn; 2) GIFTS required a large data downlink and the lease of a transponder provided another revenue stream for the owner/operators; 3) the new RFI asked vendors to provide a ground station and this provided another revenue stream for the owner/operators; and 4) the initial studies were for potential payloads and GIFTS was a funded instrument.

The recent RFI responses provided strong support for the GQR concept. The concept provides economic advantage to a struggling US satellite industry and the concept provides an inexpensive method to get Earth Science, Space Science, and technology demonstration payloads to space.

2.3 The FAA and GQR

In the Pan Am Sat (PAS) RFI response, they provided an example of a current GQR payload. The FAA, not NASA, was the first to implement the concept. The FAA awarded Pan Am Sat a contract to accommodate an air traffic control technology demonstration payload (WAAS). Pan Am Sat awarded Orbital the subcontract to manufacture the communication satellite, awarded Lockheed the subcontract to develop the payload, and PAS provided the payload, spacecraft, and mission management.

This is a perfect example of how the GQR concept can take advantage of a commercial opportunity. The government specified the requirements and a commercial organization provided the payload, spacecraft, launch vehicle, and program management.

3. THE ISSUES WITH IMPLEMENTING GQR

There are several issues with implementing the GQR concept. The following paragraphs examine each issue and explain our approach to resolve these issues.

Schedule – Commercial communication satellites are market driven. Owner/operators buy a satellite from a spacecraft manufacturer when the market requires additional communication capabilities. The satellite manufacturing process is routine and requires less than two years to launch a satellite.

The schedule for a NASA missions, in contrast, are development driven and require three or more years to implement. NASA typically will not start developing an expensive science instrument four years before launch if it does not have a definite launch commitment, and industry won't make a commitment until two years before launch. The difference between commercial schedules and NASA schedules contributes to the problem of utilizing the excess resources on commercial satellites.

In the GQR concept, NASA develops a pool of instruments with the characteristics and requirements of each instrument well defined (orbit location, pointing, mass, power, volume, data rate, etc). NASA also maintains a list of upcoming communication satellite missions and matches instruments with launches. The pool of potential GQR payloads will be developed and maintained by NASA issuing regular RFIs to the payload developer community. The list of upcoming commercial missions will also be maintained by issuing RFIs to the spacecraft vendor community. The results of these RFIs will be briefed at industry days, presented at conferences, and maintained on a web site (along with addition GQR documentation including interface documents, environmental specifications, payload development guides, etc.).

Interfaces – The lack of industry-accepted interface standards for payloads is another major issue with flying instruments on commercial satellites. Each vendor has their own power, time, data, and command interface and it would be expensive to design a single instrument to meet the interface requirements of every spacecraft.

In the GQR concept, a standard GQR Electronics Module (GEM) is flown on every mission to interface the payload to the satellite. GEM provides a standard interface to the payload and is configurable to the different spacecraft options. Instrument providers develop their instrument to a standard interface and are not concerned with specific satellites. GEM is based on

the standard Multi-mission Avionics Platform (MAP) architecture, and its components will be available commercially through RSDO's avionics catalog. Figure 3-1 shows how GEM provides a standard interface to one or more payloads and is configured to meet the unique spacecraft requirement.

Risks – Insurance is another issue with flying government payloads on commercial communication satellites. A recent string of communication satellite insurance claims have driven up insurance costs. As a result of these new insurance costs, satellite owner/operators are more cautious about adding un-flown systems to their satellites.

The GEM box can provide two functions. It can interface instruments with standard interfaces to a non-standard spacecraft, but it can also provide the fault tolerance and isolation needed to protect the spacecraft. In addition, GEM will not be new technology. The GEM avionics will be available as pre-environmentally qualified systems. This will mitigate the failure risk and help minimize insurance companies concerns with GQR payloads. The Space Shuttle Hitchhiker Program successfully implemented a similar concept. The Hitchhiker Program provided university and NASA scientists with a standard, pre-qualified, payload carrier to interface their experiments to the Space Shuttle.

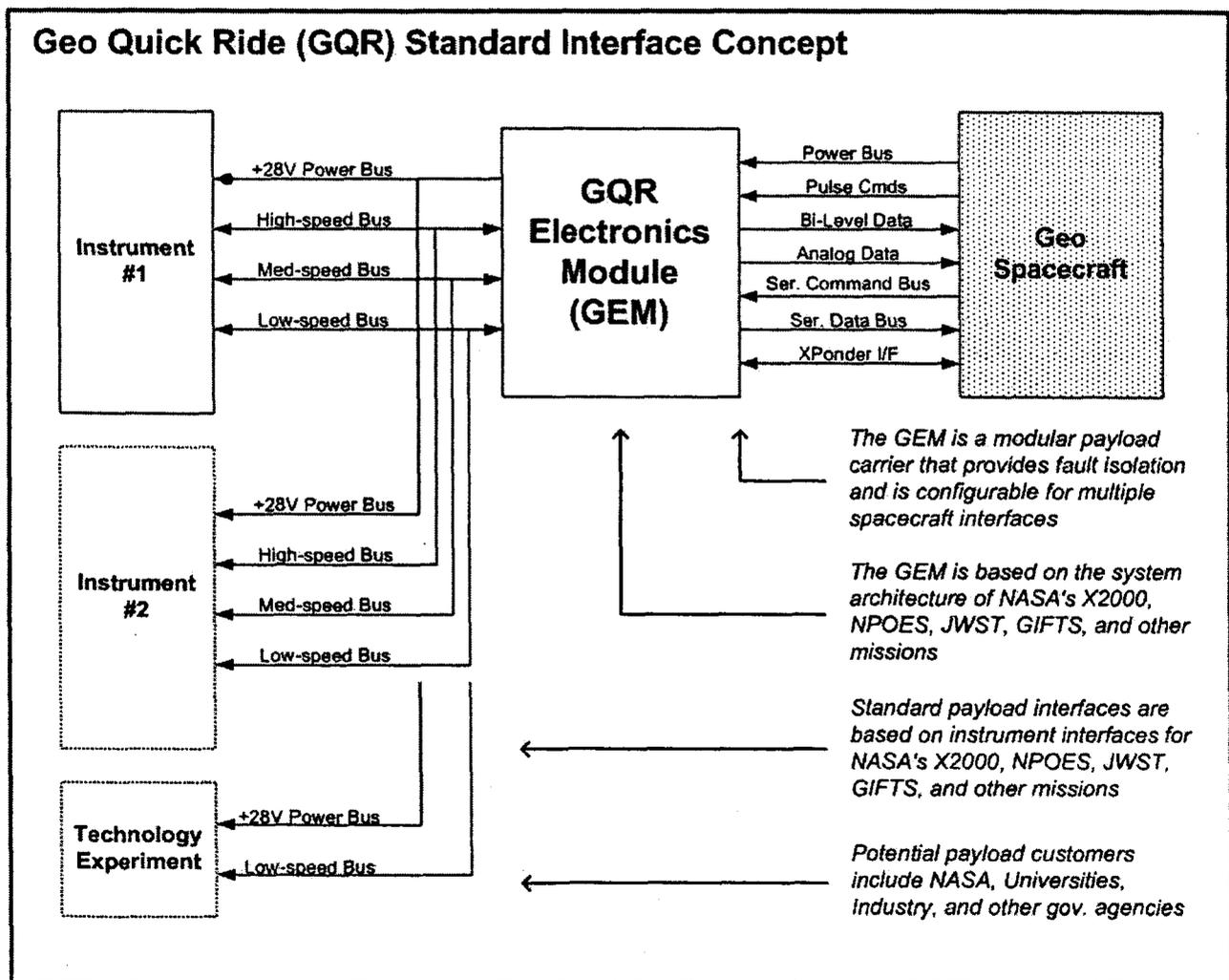


Figure 3-1 – GEM provides a standard interface to payloads and is configurable to a spacecraft.

Financial – Satellite owner/operators make their revenue by leasing transponders and operating ground stations. In the original GQR concept, payload data went through the satellite and the government established their own ground station to acquire the data.

In the recent GQR RFI, we asked vendors to consider leasing a transponder to the payload and provide the ground station services. This extra revenue provided more incentives to industry and should save the government money by not buying a ground station.

Public Relations – A food processing company has an ad “we don’t make the food you eat, we make the food you eat taste better.” If consumers can’t buy their product, then why advertise? They advertise to improve public perception and to improve their stock price. Satellite owner/operators are in a similar position. It is difficult to find an effective marketing campaign or public relations approach. Consumers don’t buy their services, so a multimedia approach is not cost effective. It is difficult for the public to differentiate one owner operator from another. There are a small number of buyers and they are driven by cost not perception.

Owner/operators see the GQR Program as means to present their name to the public. For example, TV News organizations frequently thank NOAA for their satellite images, but if the image was from a commercial satellite, they can claim this image brought to you by vendor xyz. This is the kind of advertising money can’t buy and it makes owner/operators more willing to accommodate secondary payloads.

Fragmented Market – The payload market is fragmented, with payload developers (buyers) coming from different NASA Centers, universities, Federal Funded Research Centers (FFRDC), and other government agencies. In addition, the cost to accommodate a secondary payload (~\$10M) is small compared to the cost of a communication satellite (~\$300M). These two factors make it difficult to get the attention of spacecraft vendors.

The GQR Program focuses on improving the buying power of secondary payload developers by 1) not impacting spacecraft manufacturing; 2) providing standard payload interfaces to enable spacecraft and payload substitution; and 3) reducing the number of buyers by collecting requirements from multiple payloads and matching them with available spacecraft. In addition, the GQR Program will be run out of NASA’s RSDO Office which provides spacecraft to primary payloads. RSDO provides a credibly, cost effective alternative to prevent GQR costs growth.

Chicken and Egg – The VOLCAM proposal to NASA’s EESP Program (1998) and the GeoTRACE proposal to NASA’s NMP Program (1999) both included the GQR concept. NASA Headquarters selected neither mission and one of their reasons was that the GQR concept was too risky because it had not yet been used. Scientists are hesitant to propose a GQR mission because Headquarters has not yet selected a GQR mission.

The GIFTS Mission was going to break the chicken and egg dilemma. The GIFTS Mission was already selected by NASA and in the middle of their implementation phase, but lost its spacecraft and launch vehicle. The mission could not afford their own spacecraft so they accepted the GQR option. Headquarters could not afford a new spacecraft and launch vehicle so they accepted the risk of a GQR mission. However, budget issues with GIFTS caused by the schedule delay of losing their original spacecraft, caused the mission to be canceled in the Spring of 2004.

The GIFTS exposure of the GQR concept has made NASA Headquarters, payload developers, and spacecraft vendors more comfortable with the GQR concept, but the chicken and egg dilemma still exists. Until a payload implements the GQR concept, the perception will always be that it can’t be done.

4. SUPPLY AND DEMAND

Adam Smith argued that each good or service has a “natural price.” If the price is above the natural price, then more resources would be attracted into the trade, and the price would return to its “natural” level. The converse is also true, if the price is below its “natural” level, resources will leave the trade.

Demand is a force that increases the price of a good and supply is a force that reduces the price. When the two forces balance one another, the price would neither rise nor fall, but would be stable. The stable or natural price is the “equilibrium” price. This sort of “equilibrium” exists when the price is just high enough so that the quantity supplied just equals the quantity demanded. The corresponding quantity is the quantity that would be traded in a market equilibrium.

The supply and demand model may not hold true for the secondary payload market. The large government role in payloads, spacecraft, and launch vehicles may introduce inefficiencies to the market, thus making it difficult for the market to reach equilibrium. The GQR concept brings efficiencies back to the secondary payload market by reducing the transaction cost of flying secondary payloads.

Transaction costs are defined as the cost of providing for some good or service through the market rather than having it provided from within a firm. In the secondary payload market, transaction cost is the accommodation cost on a third party satellite versus developing the spacecraft and launch vehicle yourself. There are three elements to transaction costs: 1) the search and information costs; 2) the bargaining and decision costs; and 3) the policing and enforcement costs.

The secondary payload market is comprised of small fragmented buyers that, individually, are unable to impact transaction costs. The GQR concept addresses each element of transaction costs and is able to lower the overall cost of flying secondary payloads. The GQR Program collects data on potential secondary payloads and upcoming launch opportunities, thus saving payload providers the search and information costs. The program awards general (zero dollar) contracts to all potential spacecraft providers, thus reducing the payload provider's bargaining costs. The program competes the delivery order contract for each specific payload and awards a firm-fixed price (FFP) contract, thus reducing the payload providers policing and enforcement costs. The following paragraphs describe some specific GQR supply and demand issues.

4.1 Demand Side: Potential GQR Payloads

Demand is not the same as need. Demand implies the purchasing power to influence the market place. Need without purchasing power will not create effective demand in the marketplace and will not influence the supply side of the model. There is a need for inexpensive access to space, but many of these concepts are unfunded and are therefore unable to influence the supply side of the secondary payload market.

NASA's Earth Science organization (Code Y), Space Science organization (Code S), Biological Science organization (Code U), and Exploration organization (Code T) are actively looking for inexpensive access to space. The GQR Program will work with potential projects early in their development process to help define their concept and find a ride on a commercial spacecraft. The following paragraphs describe general missions looking for rides to GEO.

Code Y and Code S – Many of NASA's call for new missions, include a call for Missions of Opportunity (Announcement of Opportunity (AO) for both Earth Science (ESSP) and Space Science (Discovery, New Frontiers, SMEX, Geospace Sciences, etc.)). These are typically low cost missions that piggy back on another NASA mission. The GQR concept is a good match for these missions.

Recent surveys collected requirements on potential Missions of Opportunity for both Earth Science and Space Science payloads. Nineteen potential Earth Science payloads were defined with an average mass of 24kg and an average power 53W. Six Space Science payloads were defined with an average mass of 5kg and an average power W. Both sets of payloads fit comfortably in the average mass (90kg) and average power (450W) available to a GQR payload.

Code U – NASA's Office of Biological and Physical Research (OBPR) is undertaking a new effort called the Free Flyer Program (FF). The OBPR-FF Program will use dedicated satellite missions and secondary payload missions to understand the biological dangers inherent in long-duration space flight. Astronauts who flew in lengthy past missions have suffered permanent bone and muscle tissue damage. Future crewed exploration missions must be preceded by autonomous vehicles enabling science experiments and technology demonstrations to characterize and devise methods to mitigate the dangers of: 1) long term effects of prolonged weightlessness; 2) galactic cosmic radiation protection/effects; and 3) long-term life support and equipment maintenance.

To meet the goal of a crewed CEV flight in 2014, NASA must conduct biological experiments and develop technology to insure the health of future human explorers. NASA can undertake a significant number of low-cost, fast turnaround experimental missions by flying these as secondary payloads on GQR missions. A recent survey of potential OBPR Free Flyer payloads defined six experiments with mass between 10 and 50 kilograms and power between 2 and 60 watts.

Code T – On January 14, 2004, the President of the United States established a new policy and strategic direction for the U.S. civil space program – establishing human and robotic space exploration as its primary goal, and setting clear and challenging goals and objectives. In response to this charge, NASA created a new Office of Exploration Systems (OExS).

The Exploration Program is developing a wide range of new technologies. In a recent Intramural Call For Proposals (ICP) for Human & Robotic Technology, they are looking for carriers and launch opportunities for in-space validate of new technology. The GQR concept meets the need to inexpensively validate new technology and the GQR concept was proposed to Code T's ICP.

4.2 Supply Side: Secondary Payload Opportunities

Economists treat supply as a relationship between price and the quantity supplied. However, it is not enough that the suppliers possess the good or (the capacity to perform) the service. The suppliers must have the willingness to sell. As stated previously, the cost to accommodate a secondary payload (~\$10M) is small compared to the cost to manufacture a communication satellite (~\$300M). Back in 1998 and 1999 when the economy was strong, spacecraft vendors were not willing to complicate their operations to make a \$10M sale. The economy has changed, and vendors are more willing to accommodate GQR payloads.

In addition to reducing the transaction cost of the payload developers, the GQR Program will work with spacecraft manufacturers and owner/operators to reduce their transaction costs. The GQR Program will work with potential payload customers and provide them with interface, implementation, and environmental documentation. This will save spacecraft vendors the search and information costs. The program will issue standard Request for Orders (RFO) to accommodate pre screened payloads, thus alleviating spacecraft vendors from the cost of bargaining with payload providers.

The following paragraphs describe status of the potential supply side of the GQR payload market.

Commercial Opportunities – The Federal Aviation Administration's Associate Administrator for Commercial Space Transportation (FAA/AST) and the Commercial Space Transportation Advisory Committee (COMSTAC) prepared forecasts of global demand for commercial space launch. The forecasts are available at http://ast.faa.gov/rep_study/forcasts_and_reports.htm

The *COMSTAC 2004 Commercial Geosynchronous Orbit Launch Demand Model*, estimates that the demand for commercial satellites that operate in geosynchronous orbit (GSO) and the resulting commercial launch demand to geosynchronous transfer orbit (GTO). The FAA's *2004 Commercial Space Transportation Forecast for Non- Geosynchronous Orbits*, projects commercial launch demand for satellites to non-geosynchronous orbits (NGSO).

Together, the COMSTAC and FAA estimate that an average of 23.4 commercial space launches worldwide will occur annually from 2004 to 2013. The combined forecasts are similar to last year's forecast of 23.7 launches per year. In the GSO market, satellite demand is 211 satellites, or 21.1 satellites per year, and in the NGSO market satellite demand is 106 satellites, or 10.6 satellites per year.

International Opportunities – Occasionally international opportunities become available and the GQR Program will work with these opportunities and try to manifest GQR payloads. There are limitations and complications when dealing with international flight opportunities, but cost and political factors often make them desirable.

One such opportunity is Korea's Communications, Ocean, and Meteorological Satellite (COMS) launching in 2008. COMS is a competitive procurement, with multiple, international bidders participating in the procurement activity. The Korean Space Agency (KARI) will select a primary contractor by late 2004. COMS is a imaging mission and its pointing, stability, contamination, FOV, and schedule requirements are compatible with many potential GQR payloads. The mass and volume available for a secondary payload depends on who the Koreans select to develop the mission, but several scientists are interested in a flight opportunity on COMS. The GQR Program will continue to work with both potential spacecraft manufacturers and potential payload providers.

5. CONCLUSION

This paper examined the history and issues of the GQR concept and presented solutions for each issue. Each communication satellite launched has unused power, mass, and volume. This excess capacity is valuable, but neither the government nor industry can capitalize on these opportunities. The GQR Program provides a process for NASA, universities, and industry to take advantage of commercial opportunities.

However, the chicken and egg dilemma examined in this paper still exists. Until a payload implements the GQR concept, the perception will always be that it can't be done. NASA Headquarters will not fund an infrastructure program and wait for customers to use it. Headquarters wants a scientist to propose GQR as part their response to an Announcement of Opportunity (AO) and then they will fund the development of the concept. To be effective, the GQR Program should address the requirements of a wide rang of secondary payloads and not optimized to a specific mission.

The purpose of this paper was to show scientists and other secondary payload providers that the GQR concept is viable and to encourage them to take advantage of these commercial opportunities. Scientists should include the GQR concept in their future proposals to NASA and other government organizations. They should join the GQR Users Group, attend future Industry Days, and respond to future RFIs.