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

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ABSTRACT: This paper examines the feasibility of piggybacking NASA, university, and industry payloads on commercial geosynchronous satellites. In 1998, NASA's RSDO Office awarded Geo Quick Ride (GQR) study contracts to spacecraft manufacturers to examine the issues concerning the flying of secondary payloads. The study results were very promising. Commercial communications 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 we conclude that the GQR project, as conceptualized, addresses all of these issues and is a feasible means of providing low-cost, frequent access to space.

#### 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 useful for future space missions.

The USAF's Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) ring can fly up to six secondary payloads by using the excess capacity on launch vehicles. The ESPA Program will be operational in 2006 and may have a backlog of secondary payload missions.

Commercial communications satellites have frequent flights and significant unused resources that could payloads. accommodate secondary 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 we conclude that the GOR project as conceptualized addresses all of these issues and is a feasible means of providing low-cost, frequent access to space.

#### 2. GOR - PAST AND PRESENT

There are two parts to the GQR story. NASA's initial Request For Information (RFI), surveyed spacecraft manufacturers 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 satellites. communications Four spacecraft manufacturers responded to the RFI and were interested in the concept. The studies showed that the average geosynchronous communications satellite has approximately 90kg of unused mass and 450W of unused power. The average FOVs and typical images available from GEO are shown in Figure 2-1 and 2-2. Despite the study results, neither NASA nor the commercial satellite manufacturers were able to fly a GQR payload. Manufacturers argued that NASA had to fund the upfront costs and NASA claimed vendors needed to take the initiative and implement the concept. In reality, the economy was strong and manufacturers did not need a \$10 million payload. In addition, NASA was unwilling to accept the risk of selecting a mission that implemented the unproven GOR concept.

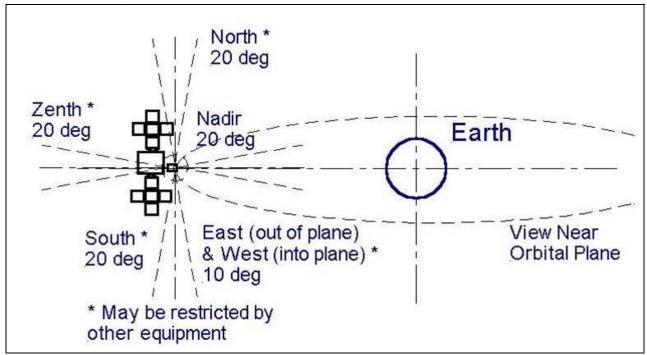


Figure 2-1 – Average Field of View (FOV) for a GQR Payload. Mission specific FOV depends on spacecraft manufacture and the complement of communication payloads (J.T. Riley)

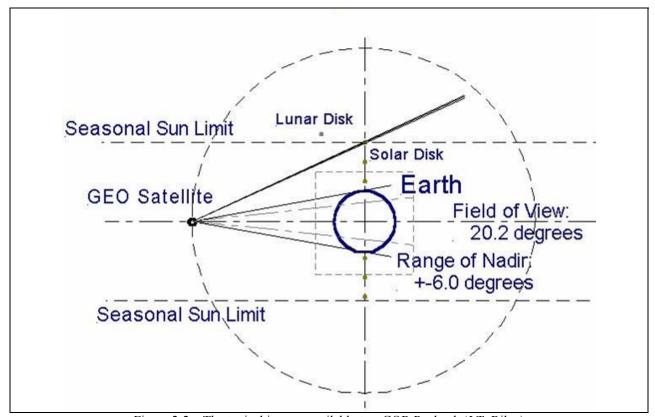


Figure 2-2 – The typical images available to a GQR Payload. (J.T. Riley)

In the RFI responses, satellite manufacturers explained that the communications 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 manufacturers and two satellite owner/operators submitted favorable responses. Moreover, 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, the 2003 RFI responses indicated that 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

The FAA, not NASA, was the first organization to implement the GQR concept. The FAA awarded PanAmSat (a communications satellite owner/operator) a contract to accommodate an air traffic control technology demonstration payload (WAAS). PanAmSat awarded Orbital a subcontract to manufacture the communications satellite, awarded Lockheed the subcontract to develop the payload, and PAS provided the payload, spacecraft, and mission management.

This is a great 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. This section examines each issue and explains our approach to resolve the issues.

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

The schedules for 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, yet 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 well-defined characteristics and requirements (orbit location, pointing, mass, power, volume, data rate, etc). The GQR Program maintains a list of upcoming communications satellite missions. This enables the efficient pairing of instruments with launches. The pool of potential GQR payloads will be developed and maintained by the Program 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 additional 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 modify each individual 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 communications satellites. A recent string of communications satellite

insurance claims have driven up insurance costs. As a result, satellite owner/operators are more cautious about adding untested systems to their satellites.

The GEM box can provide two functions. It can mate 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 company 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.

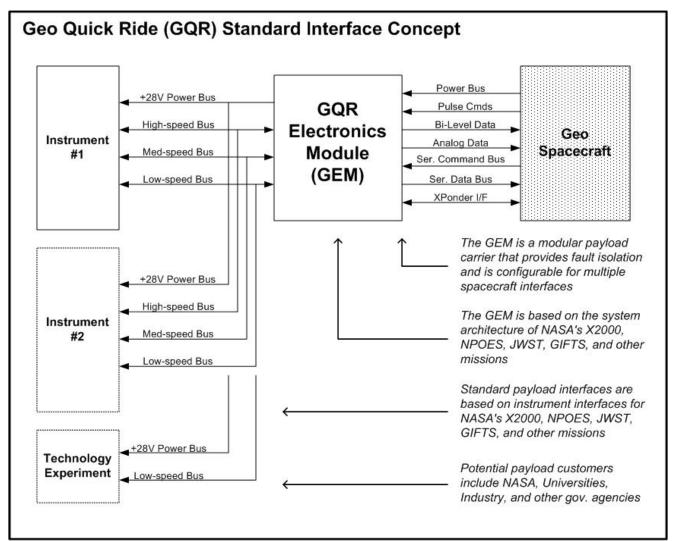


Figure 3-1 – GEM provides a standard interface to payloads and is configurable to a spacecraft.

**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. The extra revenue provides incentives to industry and should save the government the full cost of buying a ground station.

Public Relations - A company which processes food for several major vendors released a series of advertisements that said "we don't make the food you eat, we make the food you eat taste better." This campaign was launched despite the fact that consumers do not purchase their product, their service is provided to other commercial vendors. If consumers can't buy their product, then why advertise? They advertise to improve public perception and to improve their stock 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 a 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 and Development Centers (FFRDC), and other government agencies. In addition, the cost to accommodate a secondary payload (~\$10M) is small compared to the cost of a communications 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 managed by NASA's RSDO Office which provides spacecraft to primary payloads. RSDO provides a credible, cost effective alternative to prevent GQR cost 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 had the potential 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 of the schedule delay of losing their original spacecraft, caused the mission to be cancelled 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, there will always be a perception of excessive risk of an untested concept.

#### 4. SUPPLY AND DEMAND

Economist 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 goods, while 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 significant 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 helps to restore balance in 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, the 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 too insignificant 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.

## 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 (Code Y), Space Science (Code S), Biological Science (Code U), and Exploration (Code T) organizations 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 commercial spacecraft. The following paragraphs describe general missions looking for rides to GEO.

Code Y and Code S – Many of NASA's calls 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 piggyback 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 of 53W. Six Space Science payloads were defined with an average mass of 5kg and an average power 6.5W. 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 Crew Exploration Vehicle (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** – In January 2004, the President established a new policy and strategic direction for NASA – 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.

The Exploration Program is developing a wide range of new technologies. In a recent Intramural Call For Proposals (ICP) for Human & Robotic Technology, Code T is looking for carriers and launch opportunities for in-space validation of new technology. The GQR concept meets the need to inexpensively validate new technology and 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 communications 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 now more willing to accommodate GQR payloads.

In addition to reducing the transaction costs of payload developers, the Program will reduce the transaction costs of spacecraft vendors. The 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.

**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 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, estimates 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. In the GSO market, an average of 21.1 satellites per year, and in the NGSO market, an average of 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 an 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 facing the GQR concept, and presented solutions for each issue. Each communications satellite launched has unused power, mass, and volume. This excess capacity is valuable, but neither the government nor industry has been able to capitalize on these opportunities. The GQR Program provides an efficient, feasible, cost-effective process for NASA, universities, and industry to take advantage of these ample commercial opportunities.

However, the "chicken and egg dilemma" described in this paper still exists. Until a payload implements GQR, the perception of risk and an unproven concept will remain. Headquarters will not fund an infrastructure program and wait for customers to use it. Headquarters wants a scientist to propose GQR as part their science proposal, presenting a clear opportunity to fund the development of the concept.

The purpose of this paper was to demonstrate to scientists and other secondary payload providers the viability of the GQR concept, and to encourage them to take advantage of these commercial opportunities. We strongly encourage potential customers to include the GQR concept in their future proposals to NASA and other government organizations, to join the GQR Users Group, to attend future Industry Days, and to respond to future RFIs.