

***Satellite Telephone
Quality of Service Comparison:
Iridium vs. Globalstar***

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Globalstar and Iridium: A Side-by-Side Performance Comparison

Executive Summary

Satellite phones are not a trivial investment. The cost of the phone, the per-minute charges and the phone's applicability to each end user's needs must be carefully weighed against the user's telecommunications requirements. A short search will show that there is ample evidence of a decline in the cost of handsets and per-minute charges. Fortunately, this trend is expected to continue. Nonetheless, potential customers for satellite phones have had difficulty in obtaining significant comparative data on how each satellite phone system performs. The marketing materials provided by the service operators are important sources of information, yet nothing can really measure up to the ability to test each system side-by-side in a real world environment.

The following white paper is just that, the results of a rigorous testing of the true functionality of the latest equipment and services offered for the Iridium and Globalstar satellite phone systems. Many variables were evaluated and taken into account in this testing and the results demonstrate that there are a number of statistically significant differences between the two systems.

The most glaring distinction between the Iridium and Globalstar satellite phones noted by the more than ten individuals testing the equipment was that of audio quality during voice calls. It was universally observed and demonstrated in sampling after sampling that the Globalstar system had a far superior audio quality compared to the Iridium system. Even under ideal conditions, the Globalstar phone outperformed the Iridium in the audio quality criteria. More importantly, the Iridium phone was rated as falling below mission critical quality on anywhere from 10% to 35% of its calls in the two more challenging test scenarios.

On the data side, both phones suffer from low data rates making web usage and data downloads difficult. Nonetheless, when comparing the phones against each other, the technical advantage that Globalstar has in data speed allowed this system to outperform Iridium. Most importantly, Globalstar achieved a 100% success rate in more than 80 download attempts compared to 70% for Iridium.

All in all, Globalstar beat out Iridium for voice calls in most measurements, most especially in audio quality. On the data side, Globalstar again outperforms Iridium on the majority of criteria in this category.

Introduction to the Evaluation

Despite the well-publicized financial problems, past and present, of Iridium and Globalstar, the fact is that both companies are operating their respective systems and offering services to clients worldwide. For those potential customers looking into the purchase of a satellite telephone, it is fair to ask, "which one will best suit my needs?" There are many criteria involved in answering this question, such as planned usage, handset cost, per-minute charges, quality of service, and each potential user will put different priority on each of these criteria.

One of the characteristics of satellite telephones amenable to quantitative investigation is that of "quality of service". The Satellite Communications Group of Frost & Sullivan, an international market intelligence and growth consulting company, undertook an end user comparison of the Iridium and Globalstar systems in order to determine their relative merits in terms of "quality of service". Measurements taken, including call completion, audio quality, call drop, and data rate, have been statistically evaluated under numerous environments in order to provide an objective assessment of this particular comparative criteria.

The study has been designed primarily to examine the call and data service quality of these two satellite telephones. The methodology assumed a potential customer for a handheld satellite telephone with the need for making voice calls and simple data applications. The tests were designed around the idea of measuring, all else being equal, which satellite telephone system would provide a superior call and data capability.

Figure 1 provides an overview of the equipment and software used in the product comparison.

Figure 1

Overview of the Handsets and Data Packs Used in the Evaluation

<u>Iridium</u>	<u>Globalstar</u>
Handset Model:	Handset Model:
Motorola Satellite Series 9500 Portable Phone	Qualcomm GSP-1600 Tri-mode Portable Phone
Handset Software Version:	Handset Software Version:
INC0620	5.3.1.1.0
Data Kit:	Data Kit:
Data Kit for Motorola 9500 Portable Phone	GDC-1100
Software Version:	Software Version:
World Data Services, 15 June 2001	Data Services v. 1.1

Source: Frost & Sullivan

Stacking Up the Voice Calls

In total, well over 1,200 minutes of airtime were accumulated on the two systems in a series of more than 200 calls. A testing methodology was employed so as to ensure that any deviations measured would be almost certainly due to the satellite phone system. As such, all satellite phone calls were made to fixed lines within the United States. None of the calls used for evaluation purposes were made to overseas locations nor were calls made into cellular networks. The voice calls were also made from two geographically different locations, Texas and California.

The primary measures taken for all voice calls were as follow:

- service availability
- call completion (does the call connect when dialed)
- audio quality (measured on a scale of 1 to 5)
- call duration (the duration of the call in minutes and seconds)
- call drop (does the call cut off unexpectedly)

The testing of the voice call capabilities of the two satellite telephone systems was carried out in two distinct stages. First, both phones were tested side by side under ideal conditions. This implies a completely clear sky free of any obstruction 10 degrees above the horizon. Testing was also conducted far from any possible signal interference that could be generated by airports, industrial zones, or any other such activities.

The results of the testing under ideal conditions showed that in most aspects, the satellite telephones performed relatively similarly. Both experienced almost no service outage and a first attempt call completion rate of 97% for Iridium and 100% for Globalstar was recorded. The first attempt call completion is a measure of the frequency a call was successfully made on the first attempt to dial a phone number. The goal of all calls was to maintain the connection for at least 5 minutes and to extend roughly one third of the calls to 12 minutes in duration. The longer call length was desirable in order to maintain the call connection long enough to confirm that call hand-offs from one satellite to another occurred as the satellites traveled across the sky.

Figure 2 summarizes the findings of voice calls made under ideal conditions.

Figure 2

Comparison of Voice Calls Under Ideal Conditions

Average Call Length:	
Iridium	8 minutes 34 seconds
Globalstar	8 minutes 50 seconds
Percentage of Call Connect on First Attempt:	
Iridium	97%
Globalstar	100%
Average Audio Quality (1 unintelligible to 5 excellent):	
Iridium	3.1
Globalstar	4.0
Average Call Drop Rate:	
Iridium	18.4%
Globalstar	2.6%

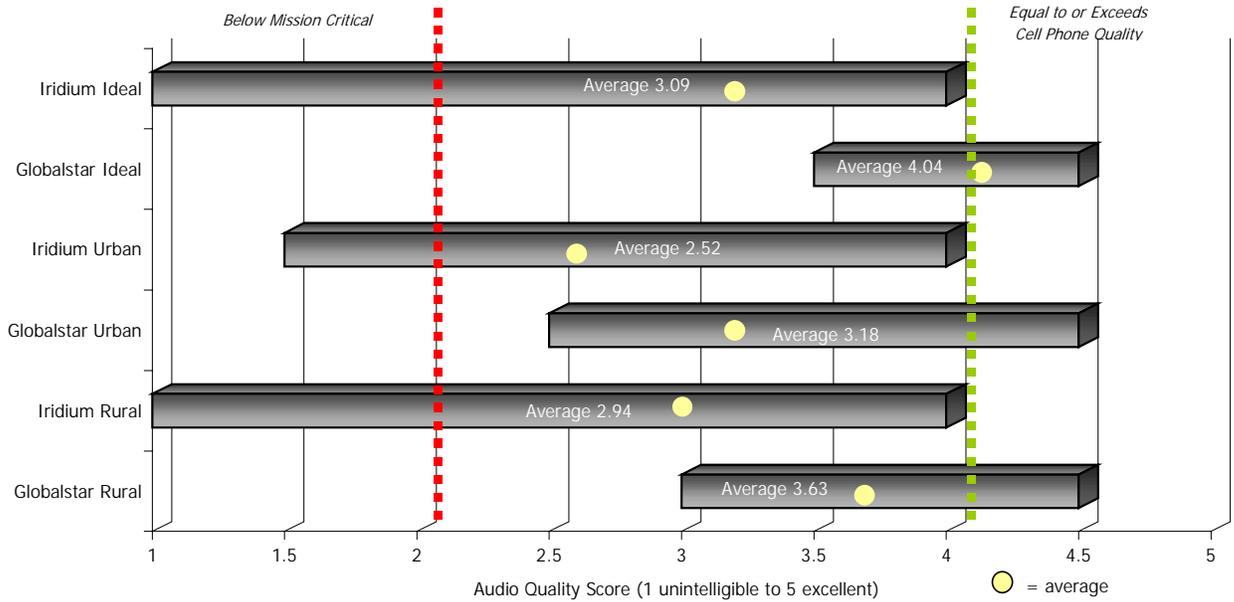
Source: Frost & Sullivan

The Globalstar system had a very low drop rate, measured at 2.6%, under ideal conditions. The Iridium system did not perform quite as well in this measure, recording a drop rate of 18.4% under ideal conditions. The most dramatic difference between the two systems was the assessment of audio quality. While audio quality of the call can be a subjective measure, it was universally noted that the Globalstar audio quality was significantly superior to that of Iridium. The effects of degradation in the audio signal and a noticeable time lag gave the Iridium calls a universally lower scoring in this measure in almost every instance. The effect was most noticeable on the call receiver end of the conversation (i.e., the person receiving a call from someone speaking into a satellite phone). Repeated comments related to the frequent loss of words or parts of words most likely due to the loss of data packets. There was also a distinctive "Iridium drawl" that gave the caller on the satellite phone a slurred voice. Under the ideal scenario, the Iridium scored an average on 3.1 on a scale of 1 (unintelligible) to 5 (excellent) with actual score ranging from a low of 1 to a high of 4.

Conversations over the Globalstar satellite telephone were regularly superior to Iridium and could even be described as approaching that of a good quality cellular phone call. In 23% of the instances under ideal conditions, the Globalstar audio quality could be described as equivalent or better than a cell phone, while Iridium never achieved cell phone quality in any of its ideal calls. This was defined by scoring 4.5 or better in audio quality. Figure 3 shows the scores on audio quality for both phones in different calling environments.

Figure 3

Comparison of Audio Quality for Differing Environments



Source: Frost & Sullivan

The second stage of the research was to undertake extensive testing of the two satellite telephone handsets in significantly more challenging environments. The two other environments were urban and rural. In both cases, the same measures listed above were made. In many ways, the testing took the two satellite telephones to their limits. The methodology was devised so that each satellite telephone would be tested under conditions of increasingly severe signal degradation. The urban testing measured the effect of the proverbial "urban canyon" and the rural testing brought in elements such as foliage cover and rugged landscapes.

The two systems performed as expected under difficult situations: the greater the physical interference with the signal, the greater the rate of calls drops and unobtainable service was noted. It was fairly remarkable that both phone systems were in fact able to perform under circumstances that would not be recommended by the service provider.

In the case of the urban environment, call completion rates were 77% for Iridium and 89% for Globalstar. This compared with 87% and 87% respectively in the rural environment. (These figures represent call completion within 4 attempts; completion rates on first attempt are provided in the charts that follow.) All in all, numerous successful calls were made under situations with rather severe environments. Yet again, the striking difference between the Iridium satellite telephone calls and that of Globalstar was Iridium's distinctly poor audio

quality. The audio quality scale was set up so that any audio quality score of 2 or lower (on a scale of 1 to 5 as described above) would be considered below the minimum needed for any mission critical applications.

Of all calls that were completed (i.e. a call connection was established) in the urban environment, Iridium's audio quality could be considered above mission critical for only 67% of the total completed calls compared to 100% for Globalstar. In the rural environment, Iridium scored above mission critical for 85% of its completed calls compared to 100% for Globalstar.

The other main factor was call drops. Here we noted similar percentages of call drops. A rate of 70.4% in urban areas and 40.7% in rural areas for Iridium and 64.5% in urban areas and 37.0% in rural areas for Globalstar.

Overall, it can be said that signal blockage is signal blockage, no matter which system. If there was sufficient clear sky, both systems would be operable and the main differentiator was audio quality. Under all types of conditions, Globalstar showed time and time again a significant and measurable superiority over the Iridium system in this aspect.

Figures 4 and 5 summarize the findings for use of the two satellite phone systems in rural and urban environments.

FIGURE 4

Comparison of Voice Calls in a Rural Environment

Average Call Length:	
Iridium	5 minutes 03 seconds
Globalstar	5 minutes 51 seconds
Percentage of Call Connect on First Attempt:	
Iridium	71%
Globalstar	84%
Average Audio Quality (1 unintelligible to 5 excellent):	
Iridium	2.9
Globalstar	3.6
Average Call Drop Rate:	
Iridium	40.7%
Globalstar	37.0%

Source: Frost & Sullivan

FIGURE 5

Comparison of Voice Calls in an Urban Environment

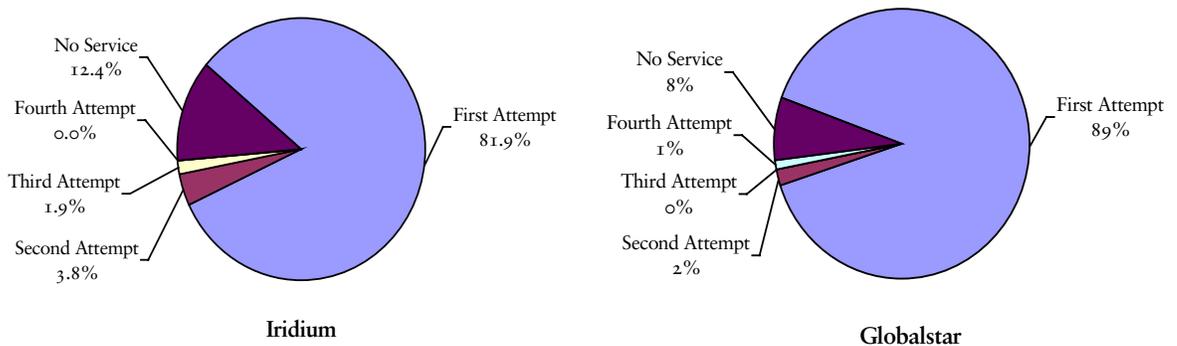
Average Call Length:	
Iridium	3 minutes 35 seconds
Globalstar	4 minutes 14 seconds
Percentage of Call Connect on First Attempt:	
Iridium	74 %
Globalstar	83 %
Average Audio Quality (1 unintelligible to 5 excellent):	
Iridium	2.5
Globalstar	3.2
Average Call Drop Rate:	
Iridium	70.4 %
Globalstar	64.5 %

Source: Frost & Sullivan

Figures 6 and 7 show the comparison of call connection rates and call drop rates for the Iridium and Globalstar phones across calls made in all environments, indicating an advantage for Globalstar in call connection and in call drop rates.

FIGURE 6

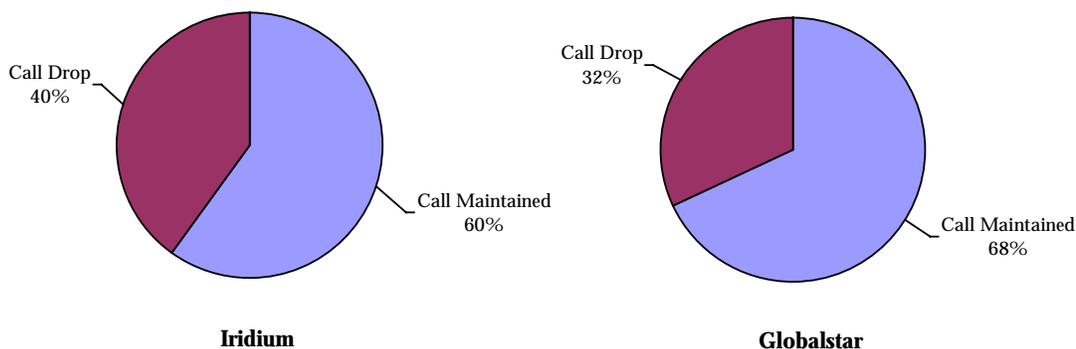
Comparison of Overall Iridium and Globalstar Call Connection Rates for Ideal, Urban and Rural Environments



Source: Frost & Sullivan

Figure 7

Comparison of Overall Iridium and Globalstar Call Drop Rates for Ideal, Urban and Rural Environments



Source: Frost & Sullivan

The Bits and Bytes of Data Calls

The typical application envisaged for this part of the investigation would be the use of the Globalstar or Iridium handsets connected to a laptop computer for e-mail access and simple data downloads. Often, these applications make use of an http-based Internet browser. This posed a problem for our testing, since there is no simple methodology to easily compare in a quantitative sense the browsing of web pages on the two satellite telephone systems. Issues such as caching, spoofing, web page architecture, lost packets, and busy servers make it difficult to set up an analysis such that any potential problems can be isolated to the satellite system end of the network. If it is unsure where the delays are introduced, then it is difficult to make a fair quantitative assessment.

For this reason, the data service part of the experiment was divided into two segments. First, in order to enable quantitative measures, the phones were tested using file transfer protocol downloads (ftp) from a server located on a high-speed connection to the Internet. Two files were chosen and multiple downloads were made in order to determine the actual data rates. The second part of the research was a qualitative assessment of web browsing on both systems. These results are presented in the following section.

Figure 8

Overview of Data FTP Details

Information on Data Test	
Site Used	ftp.esri.com
Client Used	WS_FTP LE32
Highly Compressible File:	aaa_win.apr
File Size	151704 bytes
Potential Compression Ratio	1 : 5.7
Minimally Compressible File:	appatch_digu.tar.Z
File Size	154290 bytes
Potential Compression Ratio	1 : 1.1
Dial-Up Service Used	56K UUNet connection in Millbrae, CA

Source: Frost & Sullivan

In terms of data downloads, each file was downloaded 80 times which translates to more than 20 MB downloaded over the combined systems. This was done equally over the packet and dial-up modes offered by each service provider. Packet mode is where Globalstar or Iridium provide access to the Internet through their respective gateways and dial-up mode is where an independent Internet service provider (ISP) is used to provide Internet access (essentially a dial-up connection via satellite).

The potential compressibility of the files is important because Iridium employs a proprietary data compression technology to improve its data rates when using its packet service. The software automatically compresses files before they pass over the satellite network. Of course, certain files are more amenable to compression than others. Hence, the two files chosen for this research have very different potential compression ratios and, as will be seen in the data below, this leads to a number of important findings.

Figure 9 and Figure 10 provide a breakout of the data rates and download times for the highly and minimally compressible files in both packet and dial-up scenarios. Additionally, the percentage of successful downloads is given.

Figure 9

Comparison of Data Downloads using Packet Services

Average Data Rate for Highly Compressible Files:

Iridium	7.46 Kbps
Globalstar	7.62 Kbps

Average Download Time for Highly Compressible Files:

Iridium	2.8 minutes
Globalstar	2.7 minutes

Average Data Rate for Minimally Compressible Files::

Iridium	2.28 Kbps
Globalstar	6.88 Kbps

Average Download Time for Minimally Compressible Files:

Iridium	9.1 minutes
Globalstar	3.0 minutes

Percentage of Successful Download Attempts:

Iridium	88%
Globalstar	100%

Source: Frost & Sullivan

Figure 10

Comparison of Data Downloads using Dial-Up Services

Average Data Rate for Highly Compressible Files:	
Iridium	2.19 Kbps
Globalstar	6.31 Kbps
Average Download Time for Highly Compressible Files:	
Iridium	9.4 minutes
Globalstar	3.2 minutes
Average Data Rate for Minimally Compressible Files::	
Iridium	2.21 Kbps
Globalstar	6.02 Kbps
Average Download Time for Minimally Compressible Files:	
Iridium	9.4 minutes
Globalstar	3.5 minutes
Percentage of Successful Download Attempts:	
Iridium	70%
Globalstar	100%

Source: Frost & Sullivan

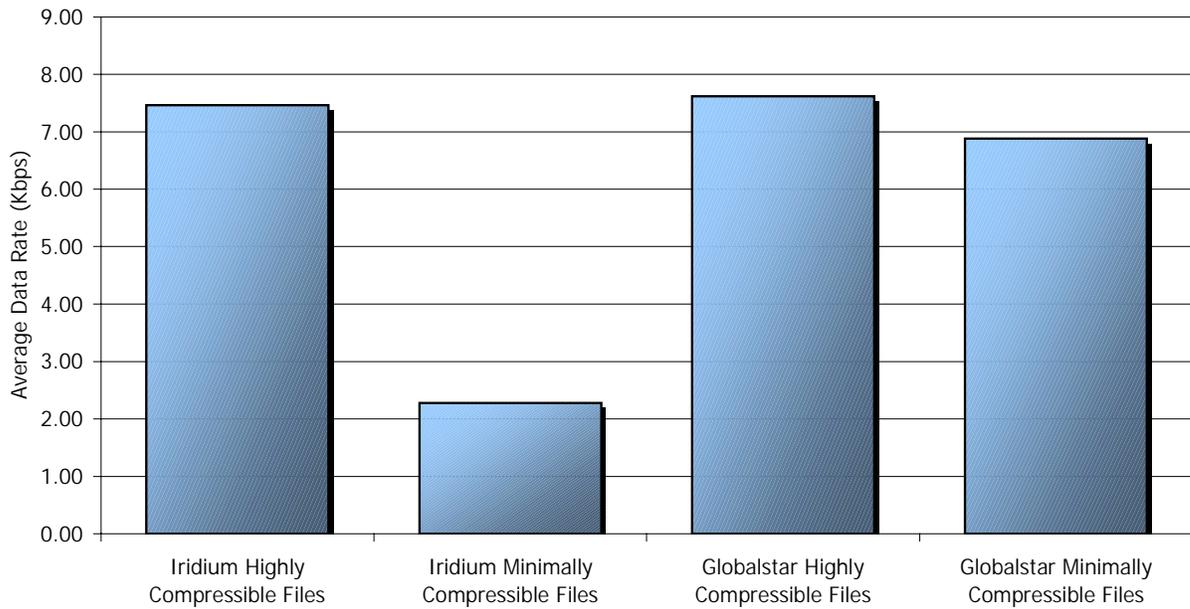
It must be noted that compared to data rates most end users have grown accustomed to in the business and home environments, the two systems are quite slow. This is not surprising given that the two systems were both designed to primarily serve a market for voice calls. Nonetheless, the research demonstrates that Iridium is only comparable to Globalstar in the single category of downloading highly compressible files while using their packet data service. This is due to Iridium's above mentioned use of data compression technology. **In every other measure, Globalstar is significantly superior to Iridium.**

While both systems are looking to improve data rates, any potential heavy data users would find unacceptable the 2.28 to 7.62 Kbps data rates of either of the satellite telephone systems. Yet, if an end user's requirement is the download of files or e-mails limited to a few 100 kilobytes, then **the side-by-side testing shows that the Globalstar system offers a relatively superior data rate compared to the Iridium system under all conditions.** This is not unexpected, given the basic technical differences that are inherent in the design of each system. It also indicates that while Iridium can (and does) obtain up to 8 Kbps, the typical data rate will be much lower since most files used today, especially those on web pages, are already compressed to an certain extent. Iridium's compression technology will only be beneficial in a minority of instances.

Figures 11, 12, 13 & 14 provide a graphical illustration of the comparative data rates and download times for the various scenarios studied.

Figure 11

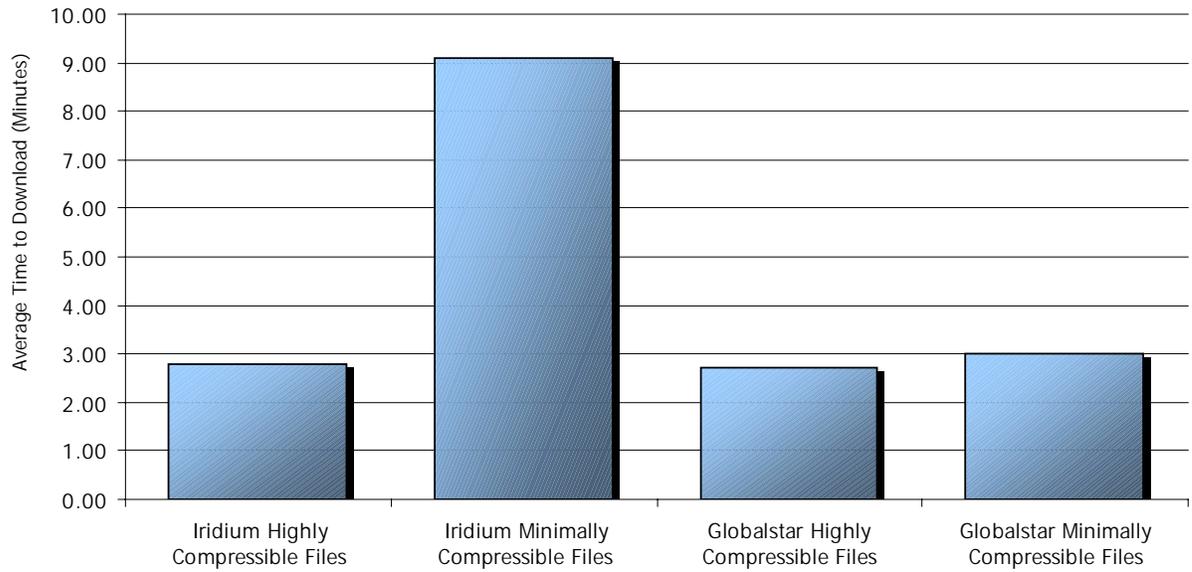
Average Data Rates for Packet Data Mode



Source: Frost & Sullivan

Figure 12

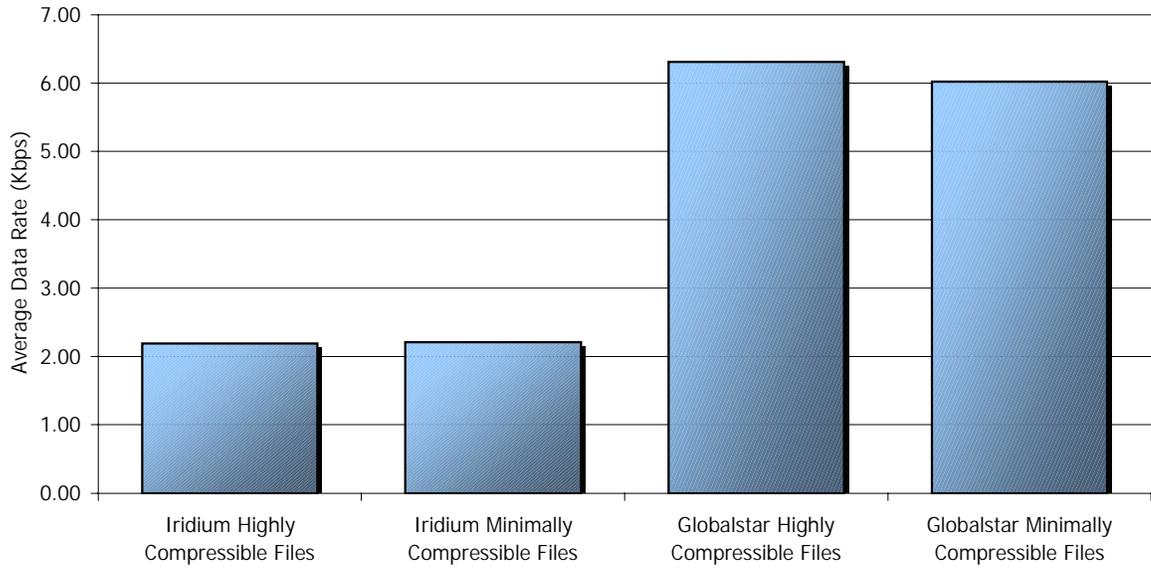
Average Download Time for Packet Data Mode



Source: Frost & Sullivan

Figure 13

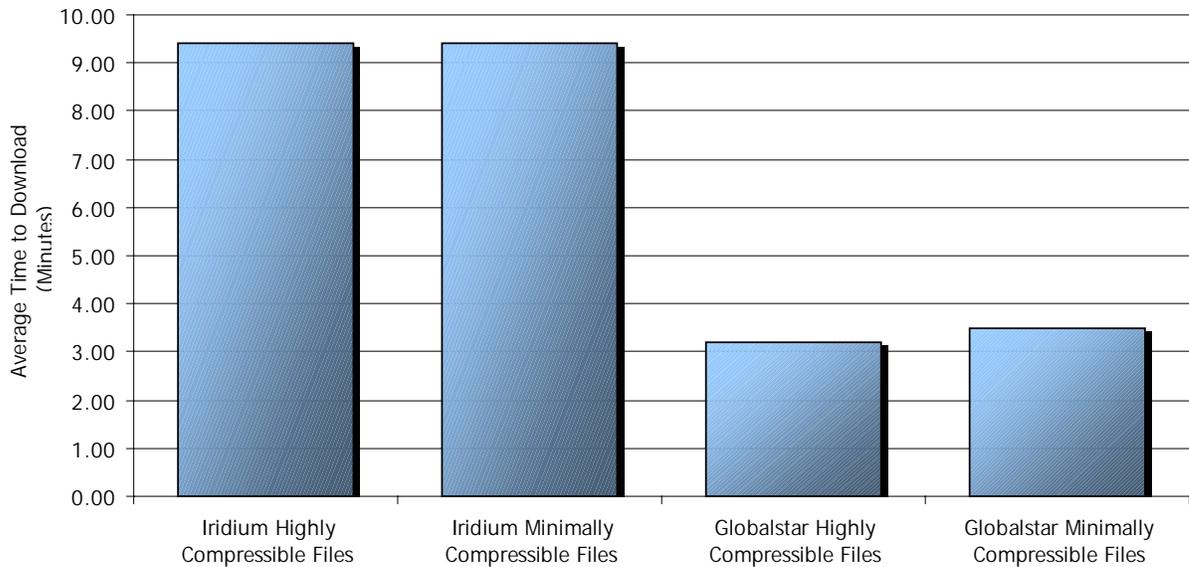
Average Data Rates for Dial-Up Data Mode



Source: Frost & Sullivan

Figure 14

Average Download Time for Dial-Up Data Mode

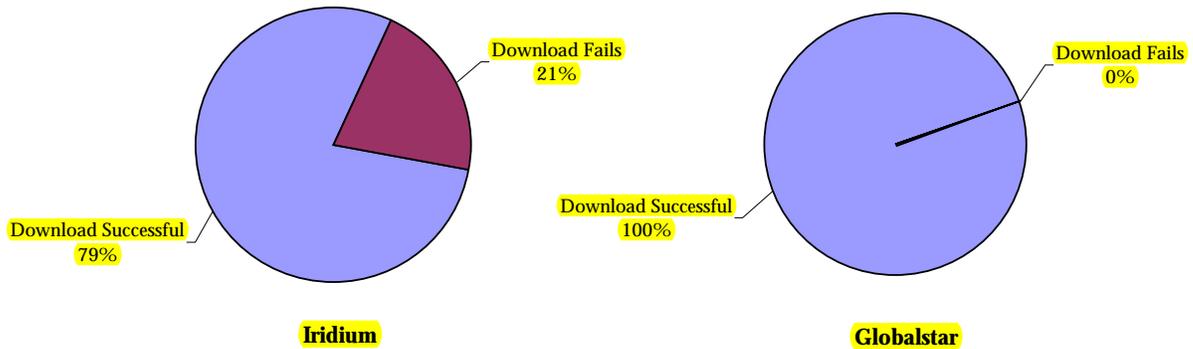


Source: Frost & Sullivan

The final research point of interest to present is the rate of successful downloads. A significant number of Iridium downloads suffered from lost connections, stalls and spoofing problems that led to failed downloads. However, as can be seen in Figure 15 below, Globalstar accumulated a remarkable 100% success rate. This success rate covers both packet and dial-up scenarios and accounts for more than 80 attempted downloads. On the other hand, Iridium had a download success rate of 70% for the dial-up scenario and 88% for the packet scenario, giving an average success rate of 79%

Figure 15

Data Download Success Rates for Dial-Up and Packet Scenarios



Source: Frost & Sullivan

The Web and The Satellite Phone

As mentioned above, the second part of this phase of the research was an investigation of applicability of satellite phone systems to web browsing. This was done simply by accessing a number of different web sites and surfing through each site. A variety of sites were chosen from "light" sites such as www.Google.com to heavy sites such as "www.NBC.com." In addition, web pages in the United States, Japan and Australia were browsed in order to seek a comparison between sites directly linked to the U.S. backbone (to which both satellite telephone gateways are also connected) and those remote from the U.S. backbone.

Both Globalstar and Iridium make ample warning to the end user that they should not expect connections speeds similar to those we have grown accustomed to in our offices and our homes. Even being fully armed with these warnings, web browsing is neither a fun or pleasant experience when using satellite telephones. To speed the "surfing" along, images and other multimedia downloads were turned off in the browser. Yet, it was quickly realized that significant content is lost when this option is implemented. And as web design advances in the future, it can be expected that there will be less and less simple html text to view. As soon as the images were reinstated, the time to download was greatly multiplied on both systems.

This said, how does Globalstar stack up to Iridium in this particular element of the review? **It is clear that the relatively greater data speed of the Globalstar system makes web browsing possible, albeit at a rather slow rate. The much lower data rate for the Iridium system makes**

web browsing a very unpleasant task. Add to this the relatively high number of connection drops and stalled downloads, and web browsing becomes a more or less impractical option with the Iridium system.

Fortunately, it is not expected that web browsing will be a major requirement for an end user considering the purchase of a satellite telephone. Access to e-mail and ftp are foreseen to be more typical data applications and as the results above indicate, the Globalstar system is superior to Iridium in most measures within this research.

For more detailed information on the evaluation procedures utilized, the Satellite Communications Group of Frost & Sullivan can be contacted through Juliette Salvati, Program Leader, jsalvati@frost.com

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