The Digital Advanced Rural Testbed (DART) project was established by the UK Technology Strategy Board (TSB) to develop enhanced broadband networks in selected rural areas so that third-parties could test new business models, applications and advanced services.

Several leading academic and broadcast industry partners came together to create the DART project: Lancaster University, 21media, University of Aberdeen, H3B Media and Avanti Communications. Avanti delivered content and services to the testbed via its HYLAS 1 satellite, while other partners promoted the use of the system.

A number of third-party companies were given the opportunity to use the DART project’s advanced network to test new business models, experimental applications and advanced services before launching them commercially. Services that could be trialled included video-on-demand, videoconferencing, gaming and large file distribution, as well as other, more novel, services.

The project supplied specialist reception equipment to a testbed of rural customers across the UK. This equipment provided partners with comprehensive delivery and consumption data, as well as enabling them to test potential payment methods. Features of the technology included multicasting, content caching, adaptive variable bandwidth and the ability to take micropayments.

The project was supported by partnership funding in the form of an award from the Research Councils UK’s Digital Economy programme to the dot.rural Digital Economy Hub (EP/G066051/1).
The first aim of the project was to develop technological advances in the way communications infrastructure is engineered. The second was to ensure the resulting enhanced broadband service led to greater inclusion of rural communities and businesses in the digital economy, as well as better responding to their needs. DART supported these aims by:

- Building a testbed to support advanced infrastructure and key "technology enablers"
- Support experimentation with new business models for next-generation access
- Allowed third-parties (content providers) to experiment with new network infrastructure and service enablers
- To pilot new digital applications with users in remote and rural communities

DART allowed network operators, application developers and content providers to answer questions such as:

- How can I watch high-quality on-demand and online TV using satellite broadband?
- How do I create digital audio-visual content and make it accessible to everyone?
- I have developed a new application, how do I test it with rural users?
The DART Project implemented four key “technology enablers” likely to play a significant role in next-generation networks. Content providers were invited to design systems to exploit these key technology enablers to test them with real users in the testbed areas. The four enablers were:

- **Multicasting**
  The distribution of data to multiple receivers and end-users.

- **Caching of multimedia content**
  Offering high-speed access to online video content.

- **Dynamic bandwidth & Variation of quality of service (QoS)**
  The ability to select changes in the level of bandwidth and quality of service to match the customer’s requirements at any particular time.

Although micropayments were not a technology enabler as such, the ability to collect micropayments from customers for on-demand quality of service changes, such as temporary increases in bandwidth to cater for peak requirements, was a key element of the dynamic bandwidth trial.

DART enabled application and content providers to experiment with innovative network technologies, giving them the opportunity to tailor and sell their services and products in novel and innovative ways, rather than delivering basic broadband connections.

The experience they gained from this was designed to stimulate more informed deployment of next-generation networks and the applications that content providers will subsequently choose to implement.
The internet protocol television (IPTV) trial over the DART testbed enabled the satellite network operator to provide IPTV to its satellite broadband customers who live in remote areas.

Consumption of video over IP has been growing rapidly and is considered to be the main factor contributing to consumer bandwidth use. This puts users in remote locations who are reliant on satellite bandwidth at a disadvantage, due to the cost associated with consuming large amounts of bandwidth over satellite.

Video consumption also creates an issue for content providers, as they are relying more and more on CDNs (content delivery networks) to push the content to the nearest network node or to the edge of the network so that they can reduce congestion at their central locations and distribute the load across the network.

Distribution of the content to the edge of the network is helpful for customers served by ADSL/DSL, but does not help customers served by satellite broadband. This trial also experimented with securely pushing the content cache to the user’s premises, which is similar to edge-casting the content to CDN, but here the cache is located at the user’s home broadband router.
The trial explored the technical and business viability of delivering popular content from prominent providers such as BBC in the UK, coupled with rich-media local content via IPTV, to users in remote areas served primarily by satellite broadband with limited bandwidth.

The development and implementation phase involved designing, developing and testing the “multicasting” and “caching” technology enablers for use over satellite. A common interface was specified and equipment installed to allow users to cache the digital content (TV, films, digital media) and provide a user interface to access this content.

The trial setup included:

- Sending invitations to potential trials users
- Supplying participants with client premises equipment (CPE), including manuals to help them connect the CPE to the satellite receiver
- Using multicast and caching to transmit and cache the content (distributed edge cache)
- Engaging with users and receiving feedback on improving the services
- Providing technical and non-technical support
Movies were acquired from the British Internet Broadcasting Company (BiBC), with local content from Lancashire One. A selection of interesting content was always available for the user. Usage was monitored by equipment at both the server side and the client side. Information acquired was used for system maintenance and troubleshooting, as well as in the evaluation process.

Primary feedback consisted of questions to quantify the user experience during the installation process, including ease of use and generic information about the user. Secondary feedback consisted of questions to assess the commercial viability of the system and to determine what kind of billing model would be acceptable to customers.

As the graphs show, usage increased as the trial went on, with peak usage during the holiday season.

<table>
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Usage increased considerably during the Christmas period and shortly afterwards, peaking at over 12,000 minutes viewed in early January 2013.
The trial revealed that:

- Most users in the pilot are mature and would normally be influential in the household when it comes to expenditure on entertainment. There was an equal balance of gender, with participants either employed or self-employed. The time they spend watching content was therefore limited and caching proved an attractive option.
- User response to using the system was positive.
- After a couple of months the users were more confident in using the system.
- 58.66% of usage is on common devices such as PCs and Macs, with 41.34% of usage on other connected devices such as iPads, tablets and smartphones.

Those involved in the pilot were of appropriate age and represented both genders equally, having the capacity to influence the entertainment spend within the household. The responses also indicated that the users were mostly employed or self-employed and wanted to spend their leisure time in the most fulfilling way.

Users felt confident using the video player and were generally happy with the installation and customer service provided. An important aspect that came to light in the survey was the increased number of connected devices being used to view content.

Most users providing feedback are willing to pay this service, but were not happy to pay for any additional services such as DLAN/Media Server.
Robert lives with his young family in a village just outside Llandovery in Wales. Although the village is not extremely remote, it is located in a valley surrounded by hills, and he has experienced a lot of problems receiving a broadband signal.

Robert says: “Even though we are only about four miles from the exchange, we receive a really crumby signal. We rarely have more than half a megabyte for any length of time, so we can’t do much with the broadband here. The Welsh Government promised they would fund a radio system, but that fell through and I just felt totally stranded.

“Being part of the trial was great. I mainly use the system for entertainment, although I also do some web design. Over the years I’ve been so disappointed with the sporadic broadband that I haven’t been able to develop my internet services from here. Even simple things that other people take for granted, such as browsing or watching iPlayer, were too slow.

“There has been such an improvement since I joined the trial and the family can now watch iPlayer and browse the internet more quickly and efficiently.

“We had no hotspots in the local area, but now our house is a hotspot, and my son loves it.”
The community IPTV trial in the village of Wray, Lancashire experimented with pushing content closer to users than is possible across traditional content delivery networks. The satellite broadband network was used to multicast content to a cache located in the community centre at the heart of the village, from where it could be accessed by residents of Wray and the surrounding area using a WiFi mesh network.

As with the Scottish trial, the main aim was to test the technical and business viability of providing popular content from both national providers such as the BBC and local providers over IPTV. The trial tested the “multicasting” and “caching” technology enablers, using the interface that was agreed in the Common Work Package between the consortium members.

Setup included the following steps:

- Installation of satellite broadband equipment and local cache node within the community centre
- Selection of users from the community network to take part in the trial
- Distribution of invitation emails to the selected group of users
- Supplying the users with instructions on how to access the web interface to the community cache, and providing details of the content available
- Using the multicast and caching enablers to transmit and cache the content acquired from content providers to the community cache
- Engaging with the users and receiving feedback on improving the services
- Providing technical and non-technical support to the users
Users were selected from a well-established community broadband network and have had previous involvement in trials and research. Movies were acquired from BiBC and local content from Lancashire One.

Usage was monitored by equipment at both the server side and the client side, and the statistical data collected was used for system maintenance and troubleshooting, as well as in the evaluation process. Evaluation also relied on direct user feedback, consisting of questions that would quantify the experience of the user – asking questions that would help to establish the viability of such a service as a commercial proposition and the type of charging model that would be acceptable to the users.

Use of the system increased steadily over the period of the trial. It is clear that users understood the benefits and would be prepared to pay for the service. Further conversations with community users showed that they also considered the technology to be appropriate for a range of community-style environments – including hotels, holiday camps and caravan sites.

It is important to recognise that the success of the system is hugely dependent on the content available, and whereas the users welcomed the opportunity to influence the choice of content (a feature implemented by Avanti during the trial phase) they believed that content from the major UK broadcasters would have had to significantly greater usage. This is highly encouraging, suggesting that there is a promising business case for the distribution of content to communities via satellite.
The DART Flexible Internet Bandwidth trial allowed users to make “indicative payments” to increase bandwidth allocation of their internet connection. This enabled the service speed to be increased by a factor of 4 for a period of one hour, for a nominal charge of £1 per hour (although no money was taken). The trial began in March 2013 and continued until the end of May 2013.

This used two technology enablers: variation of QoS and dynamic bandwidth. Although not a technology enabler as such, the trial also introduced micropayments. It involved changes to both the way resources were managed (adapting resource management and service level agreement mechanisms) and how they were charged (accounting for each time the service was used).

Examples of applications that could benefit from this offering include:

- Enabling small businesses to increase their internet speed for specific bandwidth-hungry tasks (such as uploading a large graphics/video file), with itemised billing
- Enabling home users to download digital content quickly
- Enabling home workers to upload large data files
- Supporting high-bandwidth applications (such as high-quality conferencing).

It could also offer benefits to application developers (and hence users) by enabling a broader range of services than available through their standard SLA.
The trial sought to confirm the technical viability of delivering and charging for a flexible bandwidth service. Users were invited to provide feedback on their expectations, experience and willingness to pay for a commercial service.

Three additional system components were added for this trial:

- A web interface that allowed users to select a higher level of service for the following hour
- An interface to the service level agreement (SLA) management of the network, temporarily replacing the current SLA parameters with a higher set of parameters. The user then experiences the higher performance
- An interface to the subscriber database with billing functions so the user could be charged

Users were selected who had either no broadband service or a limited cable broadband service. Each user was provided with a satellite terminal, enabled with the standard SLA. The users were also provided with accounts on the billing system and given instruction on how to use the flexible internet bandwidth service.

At the end of each calendar month each user was provided with indicative bills for the capacity they had consumed (no payment was taken).

Evaluation of the trial used three methods:

- Questionnaires estimated the value and interest in the service. Users were also invited to comment on their experience of using the standard service
- Feedback was requested based on the billing-for-usage offering. Users were asked to quantify their willingness to pay for this type of service
- Finally, selected users were interviewed to assess their experience
A user community has been created and supplied with a standard satellite service. Pilot feedback indicated that a number of improvements were needed to the user interface to ensure that users understood and could use the service being offered. These included the ability to extend the period of elevated service level agreement.

One of the challenges in delivering next-generation services to rural users is the cost-effective provision of headline speeds and throughput. The Flexible Internet Bandwidth testbed required development of user interfaces, changes to the service platform and support for micropayments. The trial has successfully explored a potential shift from QoS provision with a basic SLA to one in which the service can be dynamically varied according to the needs of the user.

This change will enable operators to tailor and sell services and products that go beyond simply delivering basic broadband connections. It has the ability to increase the size of both the market (variable QoS with a more acceptable pay-for-use pricing structure) and the margin (revenue from sale of additional capacity), while offering the user a service that can meet their needs without them resorting to regular payments for a higher level of service.

The new service has provided a platform that offers a low-cost opportunity for businesses to experiment (in a safe and collaborative environment) with flexible use of satellite broadband. These new service features may be incorporated into the Avanti standard product offering and rolled-out across Europe, the Middle East and Africa via Avanti’s channel partners.
Few people are more conscious of the lack of cable and DSL infrastructure in remote locations than those who work in the creative industries. Clients are increasingly demanding work be sent to them via the internet, and those who have to rely on the postal service to deliver portable media to their clients are at a distinct disadvantage.

David was drawn to the beautiful landscapes of the Scottish islands, with their stunning gorse hills and meadows of purple heather. But being totally immersed in nature came at the cost of a relationship with the online world that is considerably less harmonious.

David was frequently forced to climb nearby mountains and wave his iPhone in the air in the hope of snaring a signal, or else jumping into his car and driving in search of the nearest cellular hotspot.

David’s only option was satellite broadband, which can reach even the remotest areas that fall beneath the satellite’s footprint. However, as a videographer with large bandwidth requirements for transferring HD video files, the cost of always-on constant high bandwidth was proving prohibitive.

The dynamic bandwidth enabler available during the trial helped solve this problem for David. With this technology, he was able to order a low-cost, standard-bandwidth service on an always-on basis, but by activating the ‘boost button’ he could pay just £1 an hour for a 400% increase in bandwidth.

By using such a flexible system, creatives and businesses based in rural areas can compete with rival firms in urban areas, while continuing to enjoy the advantages of living in a stunning natural landscape.
The Welsh Marches town of Shrewsbury is one of England’s most beautiful places to live, with some 660 listed buildings. People who live there are particularly fond of the Elizabethan Old Market Hall. Originally a drapery, it has been both a courthouse and a jail for those waiting to be hanged in the town square.

A full restoration of the building began in the 1990s, and in 2004 it reopened as a cinema, run by the same council that runs the nearby Theatre Severn. Being able to stream events and performances from the theatre to the cinema was something the management team had always wanted to do.

The managers of the cinema also wanted to go completely digital, but restrictions on how they could alter the Grade I listed building meant that they could not rewire the cinema or add any fixtures to the outer walls.

Using the technology provided in the DART trials, they realised that not only was technology available to help achieve their aim of full digitalisation, but that they had access to satellite professionals who could guide them through the process, while being sensitive to the structure of the building.
The Shrewsbury cinema trial involves the distribution of digital assets (movies) to the Old Market Hall Cinema using the satellite network and the DART “multicasting” enabler.

Conventional movie distribution is an expensive business, where multiple prints of the same content need to be produced to supply multiple cinemas. However, the issue of expense can be easily overcome by using multicast technology, which at its core is a one-to-many system. This has the twin advantages of being both cost-efficient and effective in reducing piracy.

The system does have its drawbacks, including the requirement for a fast connection speed, the issue of streaming versus caching, DRM and other security considerations.

In assessing the performance and cost-effectiveness of film distribution to cinemas via satellite, DART needed to address:

- Design, development and implementation of multicasting and caching, as well as the variable QoS and dynamic bandwidth enablers
- Testing of DART enablers with multicast V-LAN, as well as the satellite network
- Installation of caching equipment at the client’s premises
- Acquisition and transmission of digital assets to the cinema complex
Commercial cinema operators were reluctant to take part in an experimental testbed, as each movie distributed to them is directly related to their revenue, and their revenue models are confidential in nature.

However, H3B’s familiarity with the digitalisation desires of the Old Market Hall, Shrewsbury led to an initial meeting and a subsequent agreement to participate in a trial. The cinema management was willing to provide DART with financial information, which enabled the trial to gather more data about the advantages of using satellite for movie distribution.

As a Grade I Listed building and a Scheduled Ancient Monument, English Heritage rules prohibit satellite antennas being installed on the building. However, we will be able to install an antenna on a neighbouring building and connect using two drums of cabling.

Using the DART multicasting and cashing enabler, the content was delivered via satellite directly to the cinema, removing the need for transportation and delivery of DVDs or BluRay discs, saving on costs and delivering the content in a more secure and environmentally friendly manner.
The Old Market Hall identified a value-added opportunity in the distribution of live events. A comparison of recorded versus live events at the cinema revealed average attendance of around 64% for recorded against a much higher 86% for live events. With live events generating two-to-three times more revenue than recorded events, this gives an increase of some 270% to 400%.

Feedback from the Old Market Hall Cinema has been extremely positive. Grant Wilson, technical manager at the cinema said: “The live content we use the satellite link for is heavily promoted, and we would anticipate that with the additional promotion we should exceed that 86% attendance figure.”

This is a clear indication of the increased income that can be generated from using Avanti’s bidirectional satellite service.

“We anticipate that the ability to stream alternative content via the satellite system will make a significant contribution to the on-going viability of the Old Market Hall,” said Grant Wilson.

The trial added real value to the cinema. Without the DART system installed, it could now offer a popular new service not possible with traditional cinema equipment.

The technological and financial gains obtained have proved so popular with the Old Market Hall that they plan to continue using the DART system beyond the project trial period, propelling the cinema into the digital age.
Ian, a music producer with a recording studio on the remote Isle of Jura in the Inner Hebrides of Scotland, was fortunate enough to have access to broadband already. But the speed was limited and incapable of supporting the data he needed to upload and download.

During the DART trial, he was given access to a satellite flexible internet bandwidth terminal to use alongside his existing broadband service, enabling faster transmission of large files. During the trial, he typically used six boost sessions a month, with an average download of 205MB and upload of 80MB of data per session.

With this FIB enabler, he no longer needed to lose a full day travelling to the mainland to access high-speed broadband, a necessity that was becoming unsustainable from a business perspective.

The trial equipment enabled him to work more closely with colleagues in the music industry, increasing his ability to collaborate on creative projects.
Avanti Communications
Avanti Communications sells satellite data communications services to telecoms companies, which use them to supply enterprise, institutional and consumer users.

Lancaster University
Lancaster University is ranked in the top one percent of universities in the world and is listed at 145 in the Times Higher Education international table.

21media
21media offers state of the art products and services in the fields of IPTV, multimedia and networking systems.

University of Aberdeen
As the ‘global university of the north’, the University of Aberdeen has sent pioneers and ideas outward to every part of the world. It is an ambitious, research-driven university with a global outlook.

H3B Media
H3B Media is a technology-led innovative print and digital publishing and marketing company with offices in Europe, the USA and Latin America.
In today’s knowledge economy there are two major factors that influence the social and economic progress of a society: innovation and collaboration. Innovation is the backbone of progress, with new technology used to meet the requirements of both new and existing markets. Collaboration is when two or more organisations or individuals work together to realise shared goals and objectives.

The DART project has offered an innovative approach, with the various partners (both commercial and non-commercial) and external organisations collaborating to achieve the common goals of running trials and testing business ideas such as IPTV, community caches, digital asset distribution and flexible internet bandwidth. During the project we have seen innovation and collaboration go hand-in-hand.

Innovation within DART stems from the implementation of the DART enablers (multicasting, caching, variation of QoS and dynamic bandwidth) over the satellite broadband network, as well as truly creating a next-generation network. Multicasting and caching increase the bandwidth efficiency for the network operator and end users, while variations in quality of service and dynamic bandwidth provide the flexibility for users and application developers to tweak network parameters and receive more bandwidth when required.

In terms of collaboration, we saw organisations as diverse as Shrewsbury’s Old Market Hall cinema operator, a music producer from a remote parts of Aberdeenshire, local content provider Lancashire One, remote users from Cumbria and Scotland, remote communities such as rural Wray village, software developer 21media, media and marketing company H3B Media, satellite network operator Avanti and academic institutions Lancaster University and the University of Aberdeen, all coming together and to use and promote the testbed. Working with each other, they were able to supply applications and technology to provide an enhanced user experience.

NOTE: to preserve confidentiality, name in the three user’s stories have been changed.