21 Net

Broadband to Trains

AGENDA

•Original ARTES project (2004-2006) in which we demonstrated first implementation of high speed internet over satellite on a high speed train (Renfe), and then a commercial trial (Thalys);

•followed by a review of the developments we have undertaken since then focusing on our implementation on the Italian second railway operator NTV;

•and lastly a summary of the challenges ahead to improve performance (VPNs, improved modems), bandwidth and antennas





Original ARTES Broadband to Trains Project

Event	Date	Month	Original Plan
Kick Off	9 Feb 2004	0	0
BDR	31 Mar 2004	2	1
PSV	4 Nov 2004	9	6
SDA	18 Apr 2005	14	7
FR	6 Feb 2006	24	15

2



Technical Trials in

Business Entertainment E-mail Broadband Internet Access on Irains

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High Speed Internet for High Speed Trains 21Net + Renfe AVE

21 Net

21 Net

Rente Control Coach





25,000 Volt Cable!

World Firsts

We believe that 21Net / Renfe's pilot trials represent:

World's first demonstration of high speed internet access from a high speed train

World's first demonstration of bi-directional Ku band satellite communication to and from a train Receive Data Rate: 4 mbps Transmit Date Rate: 2 mbps



Commercial Pilot on

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Business Entertainment E-mail Broadband Internet Access on trains

High Speed Internet for High Speed Trains 21Net + Thalys Commercial Service -





9

Video produced by European Space Agency



System Architecture



21Net is using Hispasat 1D satellite, that has very good coverage for Spain and Central Europe - > 52dB (green contour). Satellite Operator Approval already granted. For Renfe tests, we used 4mbps receive, 2mbps transmit; For Thalys Pilot, we used 2mbps receive, 0.5mbps transmit



Satellite Ground Station Arganda, Spain

12

Satellite Communication System

- Used DVBS for forward link
- SCPC for return link
- Vipersat Satellite Modems on Train and
- in Hub (picture)





Satellite Antenna

- Modified version of 80cm diameter maritime antenna
- Modifications:
 - Lower to fit within height profile (72cm)
 - Stronger
 - Modified Acquisition and Tracking Software





Radome

- Specially designed for train environment
- Much stronger than maritime radome





Commercial Developments since 2004-2006 Broadband to Trains ARTES project



April 2013

21Net Customer: Thalys (Amsterdam, Brussels, Paris, Cologne)

- 26 High Speed TGV trains
- 8 million passenger journeys per year

- THALYS
- "ThalysNet" Service started May 2008 : almost 3 million users
- Internet on board very popular: Free in Business (up to 40% usage) and EconFlex(12%)





Indian Rail



- Successful trial in January 2009 on Mumbai -Ahmedabad Shatabdi Express
- First contract for Internet on Board 3 Rajdhani trains between Delhi and Calcutta



Net

INDIAN

First WiFi service: Delhi - Kolkata Rajdhani 7/3/2013

QuickTime[™] and a H.264 decompressor are needed to see this picture.





Indian Railways

- 8,000 Trains
- 8 million passenger journeys per year DAY !
- Want to give free Wi-Fi on top trains (Rajdhani, Shatabdi)

TIN CE

• Budget approved for equipping 50 more trains in 2013 budget

20



The Main Rack





NTV, Italy

- 25 High Speed Alstom AGV trains
- Europe's most modern train: Telematics a key feature
- > 10 million passenger journeys per year
- ".italo live" Service started May 2012





Working with NTV to create .italoolive 19



Smart Cinema

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Cinema car

- Full length movies, and trailers, in special Cinema Car
- 8 overhead high resolution screens
- Every seat equipped with headphone jack, volume and channel selector
- Supports multiple languages

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Internet gratuito e portale di bordo Free Internet and on board portal



3 Area Break in carrozza Break Area in coach



7 Responsabile treno in carrozza Train Manager in coach



8 Fasciatolo in carrozza Baby changing table in coach

2012 04 19



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Multimedia Portal

- Touchscreens & Rich Content Portal
- Live TV

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- Video on Demand
- Newspapers, Books, News, Weather, Travel

Italolive



April 2013





- Sky TG24 24 Hour news channel
- Can add additional channels in the future



IPTV available on all devices:

- Laptops
- Tablets
- Smartphones







- Dynamic Multi / Unicast technology over shared satellite link means IPTV plays continuously as train travels at 300 km/hr despite obstructions, bridges and tunnels*
 - *except the very long tunnel between Florence and Bologna
- Very popular on board





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Satellite Antenna integrated into roof

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esa

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Rome

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April 2013

 Rooftop section designed and built by 21Net tightly integrated into design of Alstom AGV train





Another key technology: Gigabit Backbone 2012 03 13





System Complexity - Thalys v NTV



		Switches	Antenna	SIMs		Unit	Points	
Cinema Audio Amplifiers	Cinema Screens Software	Access Control Gateway	Accelerator	Mobile Access Router	Content Server	Media Streamers	Ethernet Switches	9 inch Firmware
Audio Wiring	Cinema Player Software	ACG Software	ACC Software	MAR Software	Video On Demand Software	IPTV Software	9 inch Portal Software	Club Wiring
Cinema At Seat Audio				Laptop Portal Software				Club Arms and Consoles

NTV is a Much More Complex system than Thalys

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36



Lessons Learnt from launch issues



- Time spent in detailed system design, quality assurance and stress testing always time well spent
 - Expect some teething troubles: Overcome them by -
 - Measuring real metrics of the passenger experience
 - Continuous rapid improvement

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Users



• The 21Net services on both NTV and Thalys are very popular with up to 4,000 users a day on each service.





21Net Strategy 2013

Develop:

New technologies to increase bandwidth by an order of magnitude from single digit mbps to 10s of mbps over BOTH

Sat (Ka) and

Cell (LTE)

and Combo business models with useful contributions from

train operators (eg for free services in first class), telcos for WiFi or 3G/4G, IPTV,

advertising, content providers, promotions





Usage Statistics

CONFIDENTIAL	Thalys	NTV	
Passengers / Year	7m	8m (est current run rate)	
Trains in Service (Dec 12)	26	21	
Capacity per train	350	440	
Business Model	Free in CF1, and part of CF2 ("CF2 Flex" fare)	Free throughout the train	
Max Data Rate per train in service (mbps)	4 down / 0.5 up	8 down / 0.5 up	
Total Data Rate for fleet over Satellite link (mbps)	11.3 down / 2.8 up	16 down / 3 up (includes 3.6 mbps of IPTV or downlink)	
esa ARTES Workshop 40	21Net	Rome April 2013	

Usage statistics (NTV)

On a typical busy day, we see a total of 4,000 users with a peak of 1,400 simultaneous connections across 12 trains running at the same time



NTV network	Down	Up
Total Bytes transmitted in one day	121 GBytes	15 GBytes
Average Bytes per User session	30 MBytes	3.7 MBytes
Av. data rate per user session (= 100 minutes)	40 kbps	5 kbps
Typical Total Data Rate from datacentre (16 hour day)	20 mbps	2.5 mbps
Of which, over satellite peak (excluding IPTV)	12 mbps	3 mbps
Satellite bandwidth average (excluding IPTV)	9 mbps	2 mbps



Utilisation of Satellite Link

On NTV, downlink data rate is 10 - 16 mbps during the active time of day, of which 3.6 mbps is IPTV

Uplink data rate is 2 - 3 mbps

Data applies to current fleet of 21 trains, of which 12 maximum active at same time.







Economics of satellite connectivity

- In 21Net's system, data connectivity to moving trains is provided by Cellular networks when available, and by Satellite when not.
- Typically data capable cellular connectivity (UMTS or better) is now available within cities and suburban areas, though usable bandwidth depends on total usage of each base station. Typical data rates of 3 mbps with 3G networks. Higher rates can be achieved with HSPDA+, and are expected with 4G / LTE, but these network technologies are still rather scarce.
- In most large European countries, there is little or no 3G in the countryside. Consequently the coverage along high speed train routes can be ~ 50 %







Economics of satellite connectivity The cost of a Gigabyte of data to a moving train is significantly higher

The cost of a Gigabyte of data to a moving train is significantly higher over satellite than over cellular

▶ However the advantage of providing 95+% Internet availability over a whole journey rather than 50 - 75%, justifies the cost provided that the total cost to the train operator is commensurate to the passenger benefit.

This cost is essentially fixed at a modest amount per passenger journey although users' appetite for mobile data is increasing at a significant rate: 60% pa according to Cisco (http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white paper c11-481360.pdf)

Therefore 21Net is looking to significantly increase its satellite (and cellular) connectivity bandwidth over the next few years without a major increase in the total cost.

This ought to be achievable with a migration from Ku to Ka-band or a realignment of Ku-band pricing in line with Ka-band more competitive

21Net Connectivity Roadmap

- To achieve sensible opex for satellite connectivity requires a high gain antenna (eg G/T = 17 dB/K), dynamic bandwidth assignment and state of the art coding schemes (DVB-S2, ACM) to give high spectral efficiency.
- We expect to move from single digit mbps to double digit mbps data rates over satellite, and also
- over cellular using LTE when available, + multiple SIMs and optimised antennas to get maximum performance for 3G networks
- and by implementing a second generation Mobile Access Router ("MAR2") that aggregates (viz combines) connectivity from satellite and cellular links





Challenges



- VPNs Sometimes problems with VPNs over satellite links
- Improved modems and spectral efficiency
- Bandwidth (4 -> 40 mbps; Ku -> Ka)
- Antennas

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Modem Developments for COTM

2.3 ACM in the Return



ClearSky Widespread Fade Hub Side Fade

> Frequency Hopping based on remote's link condition

hispasat 기

 IRG MODCOD changes based on wider fade condition

Ka-band Antenna



 For satellite connectivity, 21Net is developing a Ka version of its 30RR antenna that could be retrofitted to existing trains (eg NTV, Thalys)

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51



Phasor Antenna

 21Net is working with sister company, Phasor Solutions, on a new, completely flat, electronically steered phased array antenna which will be especially important for trains without much head-room (eg UK trains, SNCF Duplex). This should be introduced in 2014 / 2015





Leading the way in Broadband and Multimedia on board Trains

21 Net

Thank You

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