



TV Transmitter Upgrade/Recycle:

**Enhanced performance at
reduced CAPEX expenses!**

By

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WHITE PAPER

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Introduction

The TeamCast Transmitter (TX) upgrade program provides a low cost, but very effective, solution for Broadcasters to meet the new Government requirements imposed recently worldwide.

In 2016, The European Union reached an agreement on opening up the 700MHz band to mobile services by 2020. As a result, European Broadcasters have been required to relocate their allotted channels to new frequencies. This process, known as **700MHz clearance**, is very challenging for Broadcasters who need to implement costly changes to their infrastructures that are sometimes older than 15 years.

In the US, most TV stations are also required to relocate to new channel assignments according to the FCC's 39-month transition schedule (**US Repack**). This is also a very challenging program with heavy CAPEX investment on TV station sites developments.

In parallel, with the achievements of the second generation of Terrestrial Digital TV technologies (DVB-T2 and ATSC 3.0), Broadcasters are willing to facilitate a smooth **transition from first generation to second generation of DTV standards** while they are upgrading their infrastructure.

It's in this context of mandated frequency relocation that will require transmission infrastructure improvements; TeamCast has developed a very innovative and unique solution for Broadcasters. This solution permits Broadcasters to reduce CAPEX expenditures significantly by upgrading their existing transmitters, versus complete replacement.

The objective of this document is to illustrate the **transmitter upgrade** concept based on concrete case-studies and to explain the solution as proposed by TeamCast based on **TWISTER** and **VORTEX** exciter products. TeamCast is capitalizing on more than 15 years' background in implementing terrestrial Digital TV solutions and 5 years' experience in assisting Broadcasters to upgrade/recycle some of their transmitters. Through this document, TeamCast is pleased to share its own market and technology vision, concerning the existing TX upgrade opportunities worldwide.

TX Upgrade solution genesis

Initial requirements

Back in 2013, TDF, the main French Terrestrial DTV Broadcasters, expressed the need for having a straightforward solution to upgrade some of their DVB-T transmitters. Indeed, some of their transmitters were becoming more and more critical to maintain, mainly because the exciter was approaching its end-of-life cycle. With a continuing lack of support from the original manufacturer for the Exciter (“end-of-life”/“end-of-support”), and with the TX power amplifier stage still in very good operating condition, Broadcasters were faced with a decision. Rather than purchasing complete new transmitters, which represented a more costly investment for the company, the goal was to explore the possibility for partially upgrading the transmitter Exciter at a lower CAPEX investment. The requirements could be summarized as follows:

- ▶ Replacement of the existing and obsolete exciter with a new product
- ▶ Integration within the existing TX environment (THOMSON and SAGEM TX)
- ▶ Support of both DVB-T and DVB-T2 on the same platform
- ▶ Take benefits of the latest state-of-the-art Digital Adaptive techniques to achieve better RF signal performances in terms of MER
- ▶ Redundant architecture: Dual-Drive and 1+1
- ▶ Capability for remote monitoring and control

From OEM modulator to ready-to-integrate exciter

Since its creation in 2003, TeamCast has been focused on designing and providing OEM high-end digital modulators, examples are: MT2 and G4C products addressing DVB-T and DVB-T2 application. In order to meet the TDF expressed demand, TeamCast began development on a new state of the art exciter design. This new development project was termed, TWISTER. Twister integrated specific new features dedicated to controlling the PA stages in addition to our latest developed modulation core and our exclusive Digital Adaptive Precorrection (DAP) algorithm.



Figure 1: From OEM to exciter system designs

These new functionalities include:

- ▶ Forward and Reflected power measurement capability
- ▶ Protection mechanism for high VSWR (Voltage Standing Wave Ratio)
- ▶ Automatic Gain Control (AGC)
- ▶ Power-up switch ON/OFF control and cycle

Once the TWISTER product was finalized, TeamCast concentrated its efforts on designing a fully auto-negotiated 1+1 TWISTER system in order to address needs for 1+1 and Dual-Drive transmitter configuration.

🚩 *Great first success story at TDF!*

TeamCast delivered several tens of TWISTER units to upgrade both Thales Ultimate 1200W (Dual-Drive) and SAGEM 500W TX (1+1). On top of the expected added-value with the new exciter, TDF was very impressed by the RF performances achieved with the TWISTER solution. As an example, MER could be increased in the range of +4 to +5dB at some sites, that brought much better service coverage and also more quality to feed daisy-chained Gap-fillers fed from those TX sites (see here after an extract from TeamCast News 2015).

Sustainability of the French DTT transmitter network with Twister



Gaëlle Kaminsky



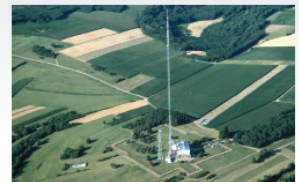
The Digital Terrestrial Television (DTT) platform has been deployed in France since 2005. Eight programme multiplexes are broadcast via 9,000 service outlets, offering a mix of standard definition (MPEG-2) and high definition (MPEG-4) services. However, DTT in France is set to evolve significantly by 2020 with the generalization of MPEG-4 encoding in 2016, the release of frequencies in the 700 MHz band for the benefit of telecom services (thus reducing the number of multiplexes to six), and the preparations for ultra high definition TV (UHDTV) using the DVB-T2 standard.

In this context, with an ageing transmitter base, with the oldest equipment over 10 years old, TDF began discussions on the modernization

of part of its network which could meet the needs of this road-map of evolution. They have chosen therefore to start by modernising those network transmitters which were the first ones deployed by TDF at the beginning of DTT. Rather than replace them, they have chosen to re-equip them with a modern modulator/exciter, which gives them the features of today's state-of-the-art transmitters.

The implementation of Twister in a pilot trial of a dozen transmitters confirmed the performance gains for the transmitters in terms of signal quality (increased MER), reliability (increased efficiency of the power amplifiers) and improved diagnostics (a feature of the remote monitoring functions of Twister).

«Thanks to the partnership with TeamCast, we have identified Twister as an optimal solution - both technically and economically - to sustain a section of our transmitter network for the upcoming evolutions of the terrestrial DTT platform in France, including the transition to the DVB-T2 standard,» says Gaëlle Kaminsky, Head of the DTT programme at TDF.



Since this first key project achievement in France, TWISTER has already been deployed at different sites worldwide, such as in Myanmar, Finland, Maldives, Indonesia, Korea, UK, Spain, Taiwan, etc.

The TWISTER initiative has been recognized as a very unique offering on the market, bringing new possibilities for Broadcasters to optimize and to monetize their Terrestrial Digital TV infrastructure.

Typical Business Cases

From its introduction on the market in 2013, the TWISTER innovative solution has gathered multiple interests from Terrestrial Broadcasters worldwide and different business cases have been identified as illustrated here after.

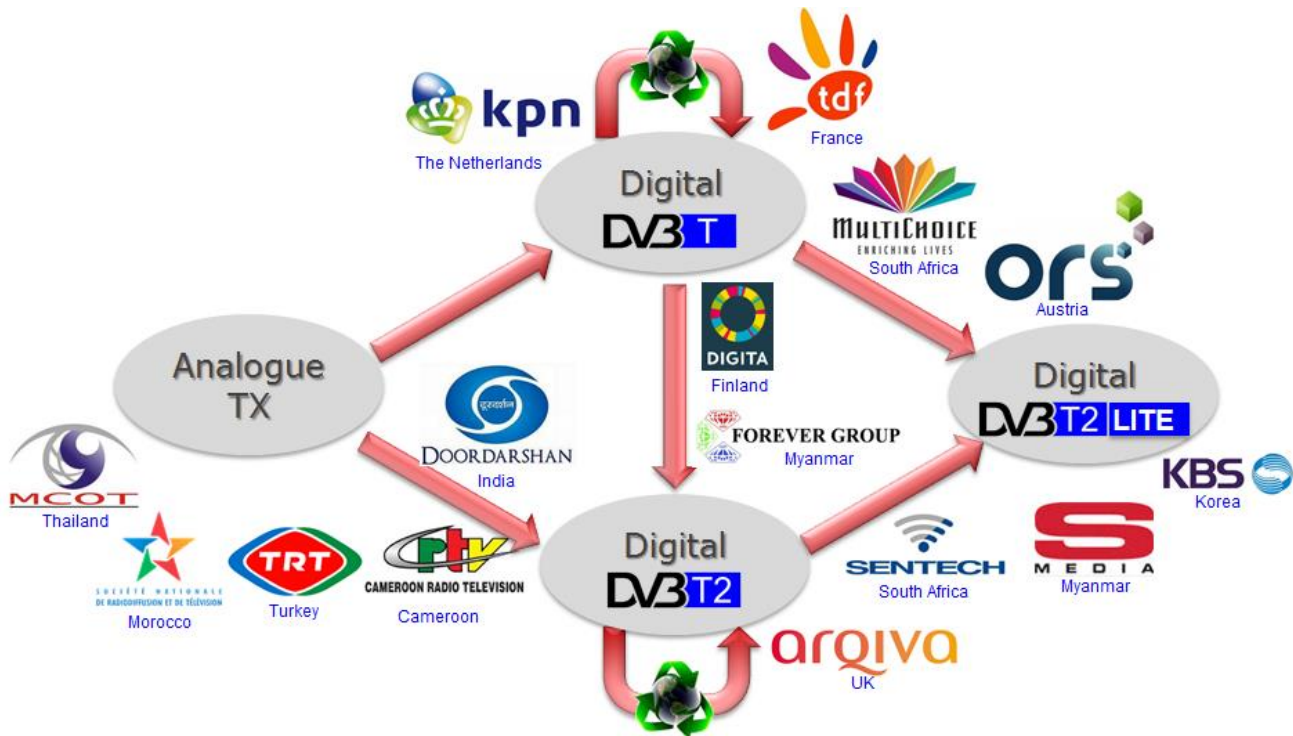


Figure 2: Business Cases with TWISTER upgrade

Indeed, there are many reasons for upgrading existing transmitters which could be summarized in two categories:

Upgrading transmitter for standard migration

Broadcasters migrating from Analogue to Digital, or from first generation of Digital Standard (DVB-T), to second generation of Digital standard (DVB-T2), can install the TWISTER exciter solution. The main benefit of TWISTER is the support of both DVB-T and DVB-T2 (including DVB-T2 Lite) within the same firmware. The changeover between standard is therefore quick and straightforward and does not require neither hardware nor software change.

For the US market, TeamCast initiated a specific development project dubbed, VORTEX. The VORTEX exciter, which is very similar to TWISTER, is also capable to support both ATSC 1.0 and ATSC 3.0 standards on the same hardware. This dual standard mode flexibility enables broadcasters to future proof their transmission systems at a much lower CAPEX exposure.

Upgrading transmitter for “refreshing” and improved performances

Several Broadcasters have elected TWISTER in order to improve existing transmitter performances and capabilities. These DVB-T transmitters were deployed more than 10-15 years ago and therefore suffer from lack of management capabilities and very low performance figures.

These Broadcasters are usually under contract (Service Level Agreement) with their customers. These contracts require some obligation to ensure minimum level of performances in term of service coverage, Quality Of Service, etc. and also minimum of MER expected at the transmitter. Over the last few years, we have seen some increase for this “contractual MER”, for instance from 33dB to

37dB and applicable on the same transmitter which can become critical depending on the original exciter performances and capabilities. Without concern for age of system, this could require a change in the original exciter due to obsolescence, now the need for new equipment is contractually required.

TWISTER provides the capabilities to run latest state-of-the-art Digital Adaptive Precorrection in order to achieve top class of RF signal performances in terms of MER and IMD Shoulders. The gain in MER can be used for better service coverage but can be also converted into gain of efficiency for a reduced OPEX costs (please refer to the GAP® White Paper).

Upgrading transmitters within total TX site renewal plan

The TWISTER could also come as a complementary scenario to complete new transmitter site renewal plan.

Let's take the example of a Broadcaster who delivers and ensures a broadcast service (i.e. signal content distribution over a terrestrial DTV network) to its customers (TV channel or content providers). Let's imagine now that the terrestrial DTV infrastructure needs to be upgraded (for different reasons as previously mentioned: standard migration, frequency repacking, renew of transmitters, etc.).

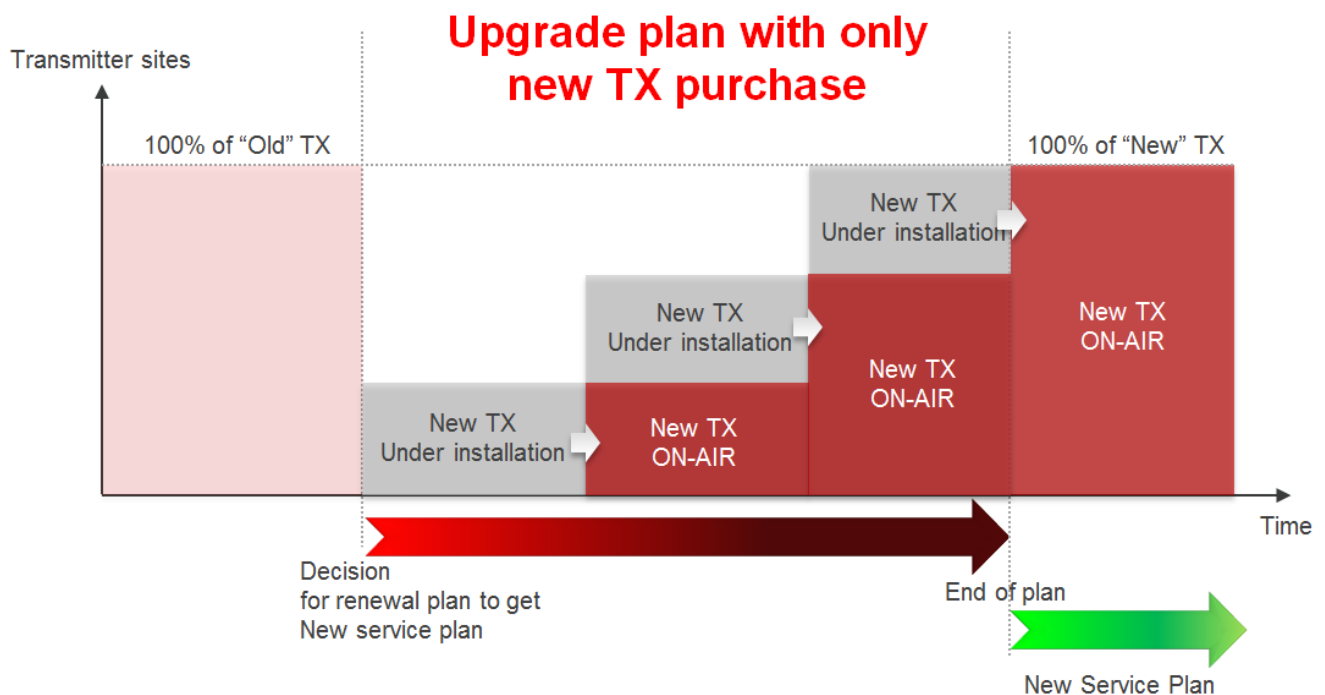


Figure 3: Upgrade plan – New TX only

The above figure illustrates the case where the old transmitters are gradually replaced by new transmitters (here according to three phases). The new service plan can only start after the renewal plan is fully completed. Depending on the number of transmitters, this can take several years. Imagine a transition from DVB-T to DVB-T2, the time required to install the new transmitters is directly affecting the date to start the new service plan.

TWISTER brings the possibility for the Broadcaster to drastically reduce the delay before starting the new service plan. The figure here after highlights the upgrade of some of (or the total of) the old

transmitters with TWISTER in parallel of the installation of new transmitters. Compared with new transmitter installation, the TWISTER upgrade is much quicker and easy to implement and also represents a much lower CAPEX investment cost. After being upgraded with TWISTER, the old transmitters can remain ON-AIR bringing the compliancy to the new service plan requirements (for instance with new standard capability or with new RF signal performances requirements, etc.) as expected by the Broadcaster's customer.

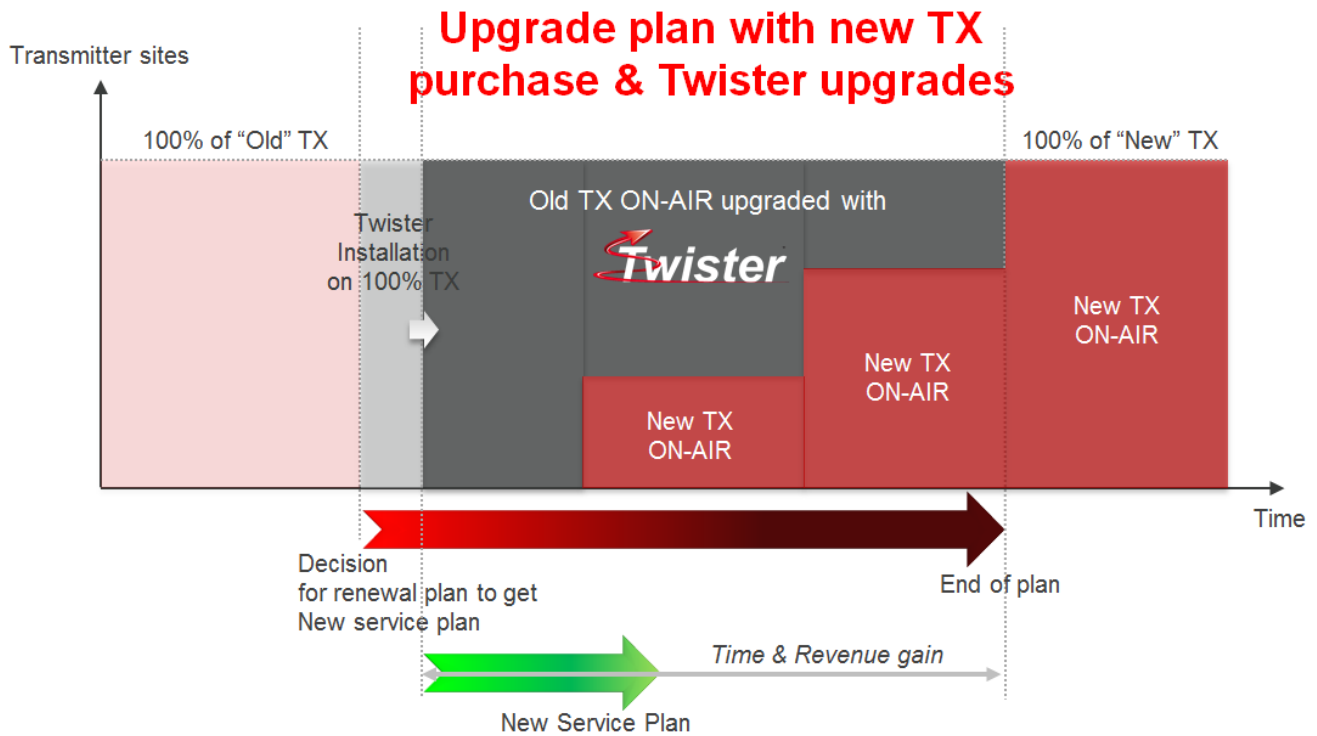


Figure 4: Upgrade plan with old TX upgrade with TWISTER

The illustration introduces a new phase for the installation of the TWISTER. After this installation milestone, the new service plan can be activated in a significantly reduced time frame, compared with the previous scenario. Of course, this scenario can be adjusted in terms of the number of TX's to be upgraded before being exchanged and should be carefully simulated at both the technical level and the business level.

Note that this scenario also allows the Broadcaster to take more time to install new transmitters and thus extend its investment plan over time.

Global Concept of TX upgrade

The concept of TX upgrade is closely related to the characterization of the transmitter life cycle as here after illustrated.

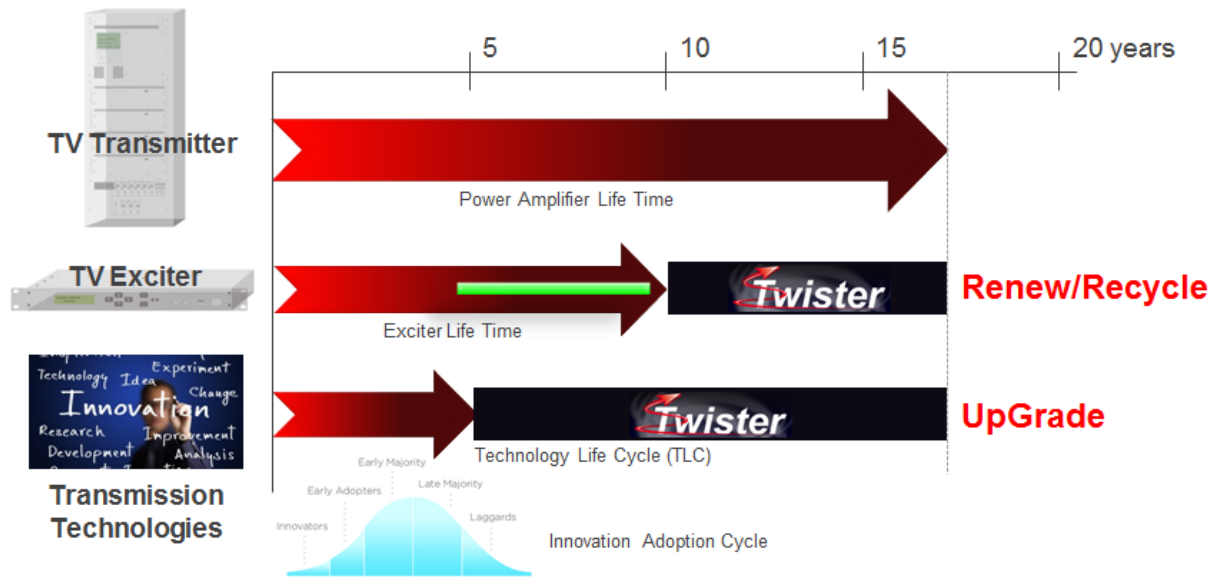


Figure 5: Transmitter life time

The TV transmitter consists of several subparts including the exciter and the PA stages.

It has been observed that the PA stages life time can be much longer than the TX replacement period planned by some Broadcasters (for instance between 7 and 10 years in most cases). In particular, the early high power DVB-T transmitters, installed in the 1998-2000 period are still in operation in Europe.

On the other hand, the exciter becomes obsolete in a shorter time period and for different reasons such as manufacturing obsolescence, not supporting latest generation of Digital Standard (such as DVB-T2), lack of management capabilities (no WEB GUI or limited access to monitoring figures remotely) and low performances in term of Digital Precorrection. It is estimated that the exciter becomes obsolete or not up-to-date in a time period between 5 to 8 years.

From the observation of the life time cycle difference between the PA stage and the exciter, TeamCast has decided to address this demand from Broadcasters to partially upgrade, renew or recycle their existing Transmitters by exchanging the exciter part with TWISTER.

TWISTER has been designed to easily upgrade TV transmitters very economically: the main parts will be re-used (power amplifier, power supply, ASI switch, filters...). The only part that needs replacement is the exciter.

Upgrading with TWISTER is done easily thanks to the features proposed by the product.

TWISTER embeds an Automatic Gain Control mechanism (AGC) as shown in the following figure. This feature allows the transmitter to provide a very stable output power. A protection mechanism allows the user to prevent any overshoot at the safe power amplifier input stage in case of a large power decreases.

Twister & Vortex Exciters by TeamCast

TWISTER consists of a stand-alone and high-end rack digital exciter addressing DVB-T/T2, DTMB (China) and ISDB-T markets.

In addition to the RF waveform generation, TWISTER features several key functionalities such as built-in Automatic Gain Control (AGC), embedded monitoring (SNR, Shoulder levels, forwarded & reflected power levels) as well as comprehensive WEB GUI control, to ease integration process and to drive the Power Amplifier stage in the most efficient way. TWISTER Digital Adaptive Precorrection circuits, powered by TeamCast GAP® - Green Adaptive Processing - algorithm, permitting transmitters to operate very close to their saturation limit, with unequalled RF signal performances and allowing significant gain in transmitter Power Efficiency.

TWISTER has been on one hand selected by several Transmitter manufacturers to be integrated within their own design and, on the other hand, has also been chosen by Broadcasters to upgrade some of their existing transmitters. Such integration has already been qualified with several transmitter brands and models such as Rohde & Schwarz, Thomson, NEC, Electrosys, Harris (today Gatesair), ABE, Elti, IMP, etc.



Figure 6: TWISTER II rack exciter

One key advantage of TWISTER is the capability to operate either in DVB-T or in DVB-T2 with the same firmware. This authorizes a straightforward and smooth transition from 1st generation to 2nd generation of DVB-T technology and in the best conditions of CAPEX costs.

TWISTER brings several key benefits such as:

- ▶ Top class of RF signal performances
- ▶ Worldwide leading and field-proven DVB-T2 technology
- ▶ Up to 7 IP ports for Data & Control
- ▶ Straightforward integration within transmitter
- ▶ Ready-to-drive Power Amplifier Stages
- ▶ Cutting Edge Digital Adaptive Precorrection algorithm (GAP®)
- ▶ N+1 management using GPI and Interlock inputs

VORTEX exciter is very similar to TWISTER but is dedicated to ATSC market, featuring both ATSC 1.0 and ATSC 3.0 standard on the same platform.



Figure 7: VORTEX II rack exciter for ATSC 1.0/3.0 market



Gaining TX performances & efficiency with TWISTER

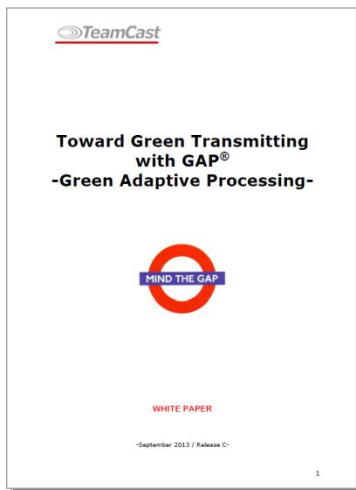
RF performances "high-jump" with TWISTER

Over the last years, TeamCast has supported many Broadcasters for upgrading some of their transmitters. In each occurrence, the new performances with TWISTER compared with the initial exciter, always shows improvements. Improvement ranges are very variable and are depending on various criteria, such as the transmitter model, PA technology and architecture, operating frequency, standard, etc.

The table hereafter gives some illustration of figures.

Note that TWISTER allows broadcasters to balance the performance gain, between the IMD Shoulder and MER.

More dB with GAP® cutting-edge algorithm



After having upgraded existing transmitters with TWISTER, the Broadcaster can take advantage of the latest state-of-the-art Digital Adaptive Precorrection mechanism powered up by GAP® technology. GAP® is a unique and very innovative technology designed by TeamCast that could bring additional performances in term of MER and IMD Shoulder.

The concept of GAP® and a concrete example is illustrated in the dedicated white paper. This white paper is based on a real project implemented in UK for ARQIVA. Indeed ARQIVA has developed a complete business case to upgrade their existing high power transmitter, by renewing the exciter part and with a depreciation of the exciter CAPEX cost based on a OPEX cost saving.


TX Output Power	1000W	1000W
Drain Voltage (V_MOS)	50V	43V
MER_Out (DAP off)	30,2dB	28,4dB
MER_Out (DAP ON)	35,6dB	34,2dB
MER_Out (DAP + GAP®) 	37dB	35,5dB
Electrical Power Supply (Σ currents * Voltage)	3700W	3125W (575W power saved)
Power Efficiency	27%	32%
OPEX Cost Saving per year (assuming 0.25€/kWh)		2000€ per year per TX

Figure 8: Illustration of gain of performances with GAP®

Technical integration of TWISTER within TX environment

The integration of TWISTER within TX environment depends of the TX type and brand. This is normally studied onsite by TeamCast engineers and in collaboration with the Broadcaster, during preliminary integration phases. The integration of TWISTER can be illustrated as follows:

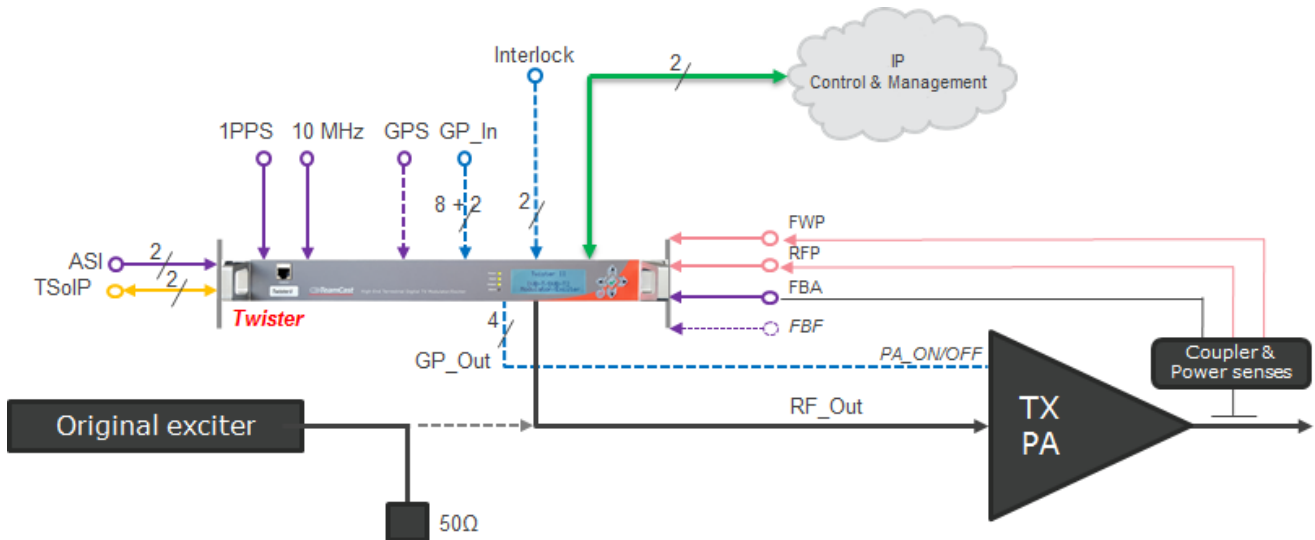


Figure 9: Integration bloc diagram

The concept consists of integrating TWISTER within the existing TX with the different interface connections required for:

- ▶ Input interfaces: TS over ASI and/or TS over IP format.
- ▶ RF Output: to drive the PA stage. Adjustable from 0dBm up to +14dBm.
- ▶ RF feedback samples: to operate the precorrection, the power measurements and the AGC. An external coupler is expected for those signals.
- ▶ Clock and 1PPS: TWISTER features onboard GPS. It can also be synchronized from external 10 MHz and 1PPS signals for SFN operating.
- ▶ Control & Management: performed from IP interface (for local and remote control as well as control via SNMP).
- ▶ Contact Closures & GPO: General Purpose input and output are available. This could be used for the power ON/OFF cycle as well as for configuration file switching (as required for N+1 operating).

Note: In most cases, it is recommended and sometime even required, to keep the original exciter installed within the transmitters, in particular if there is no “No-exciter” mode available. This would ensure that there is no critical alarm on the transmitter due to the exciter detection alarm.

Key References

Since its introduction, TWISTER solution has been deployed worldwide and at the different Broadcaster's sites as hereafter listed.

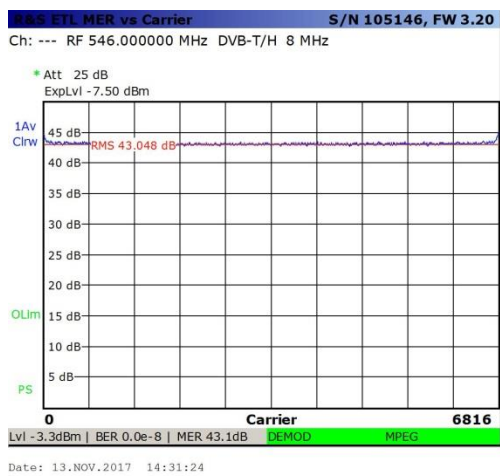


Figure 10: Key References

Illustrations



*Thales 1200W DVB-T to DVBT/T2 upgrade - France.
DualDrive TWISTER solution.*



*R&S 7000 upgrade – The Netherlands.
N+1 TWISTER solution
Improved MER from 39dB to 43dB!*



*NEC analog PCU 1110SSP/A 800W Transmitter
Upgrade with TWISTER from analog to Digital DVB-T/T2 – VietNam*

Conclusion

Since the early digitalization of the terrestrial DTV networks back in the early 2000s, especially in Europe, the first generation of DTV transmitters are now becoming outdated and obsolete. Terrestrial TV Broadcaster is facing a dilemma: how to upgrade their terrestrial infrastructure in an environment where TV revenues are not increasing and consequently their CAPEX investments are limited?

Both TWISTER and VORTEX come as compact rack exciters especially designed by TeamCast for straightforward integration within existing transmitter environment. Some very specific features have been designed to interface and to drive the transmitter PA stages in the most easy and efficient manner.

The gain in terms of RF signal performances achieved after the TX upgrade process with TWISTER or VORTEX has been recognized during multiple on-site installation and tests.

With TWISTER, TeamCast has been in position to offer a new alternative to Broadcasters to upgrade, refresh or recycle their existing transmitters extending useful lifetime service.

As introduced in this document, there are different reasons to push for TX upgrade such as standard migration, obsolete material replacement or to gain RF signal performance and power efficiency.

Furthermore, the transmitter upgrade with TeamCast can also take part of a global terrestrial DTV network renewal plan, in parallel with new transmitter purchases, and bringing the key advantage of switching to a new service plan in a much shorter term. This would have a positive impact for the broadcaster who can valorize its new service to its customer independently of the new transmitter installation constraint.

The decision for upgrading existing transmitter using TeamCast exciter has already been taken by major broadcasters worldwide for both technical as well as economical aspects. TeamCast team is in position now to share its experience and to study carefully each broadcaster use-case in order to propose the best scenario.



About TeamCast

TeamCast is a renowned and highly active member of the Digital TV ecosystem worldwide, with innovative technology offerings based on a solid expertise in Satellite and Terrestrial Digital TV transmission.

Created in 2003, and based at Rennes in France, TeamCast is deeply involved in the development, definition and verification of numerous broadcasting standards.

Today, major clients in the Broadcasting Industry from 50 different countries invest their confidence in TeamCast and its products. TeamCast has offices in Elmira (New York) and in Singapore to support the development of its business in North America and Asia, and to provide local sales and technical support services to its customers.

TeamCast is part of ENENSYS Group since June 1st, 2017.

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