ABB continues to grow its rail activities considerably around the world. As a major role as a supplier to the railway industry in France for several decades, ABB contributes reliable and cost-efficient solutions for both infrastructure and rolling stock.

For infrastructure, ABB substations contain all the necessary transformers, switchgear, protection and automation equipment that ensure the supply of stable power for train traction systems. On the rolling-stock side its broad portfolio of equipment and services, including traction transformers, converters, motors and many other components are used by vehicle manufacturers and railway operators.

The following background information focuses mainly on ABB rail activities in France. While this is by no means a comprehensive overview, it serves to illustrate how ABB has become a major supplier for train manufacturers and operators in this local market.

As the world's fifth largest and wealthiest economy [1] and a popular tourist destination, France understands that the mobility of people and goods are essential to the success of its economy: Global trade now requires the affordable and timely transportation of freight over long distances, while business and tourism depend on people travelling between cities. In fact, Paris is the second most important city for the world's 500 biggest companies' headquarters.

Paris, like many French cities -and cities all over the world- is feeling the effects of growing urbanization. In 2008, it was estimated that more than half of the world's population now live within urban neighborhoods. Forecasts predict that this figure will increase to 60 percent by 2030! This urban expansion is placing considerable strain on existing transportation infrastructures, with unprecedented levels of congestion becoming widespread in many urban areas. As well as impacting the quality of life of those subjected to it, this level of congestion also generates locally unacceptable levels of air pollution. Concerns over the environment, energy prices and congestion are leading many to look for ways to minimize the economical, ecological and spatial footprint of transportation. Large cities are becoming ever larger and with them the importance of transportation. Suburban rail networks are fundamental for providing reliable and efficient transport and many cities are moving to expand the reach and capacity of their transport networks. This is especially true in and around Paris where the commuter and regional services account for around one billion trips per year, or a whopping 80 percent of national rail usage!

Thus in France, as in many other countries, ambitious expectations are placed on railway networks, which results in continuous investment in commuter, regional, freight and national and international high-speed services. This investment, approximately €50 billion ($71 billion) over the next 15 years, has not been significantly affected by the global economic and financial downturn.

A rail revolution in France
France is considered a pioneer when it comes to public transport, especially very high-speed transport. At over 2,000 km and steadily growing, France today operates Europe's second largest high-speed rail network (behind Spain) known as the Lignes à Grande Vitesse (LGV) but posts the highest traffic figures. Since 1981 the French Train à Grande Vitesse (TGV) has been setting the pace in European high-speed rail operations. The initial maximum speed of 260 km/h recorded during its inaugural trip between Paris and Lyon has incrementally been raised over the years to 320 km/h. The world speed record of 574.8 km/h for a wheel-driven train was achieved during a test run of a prototype train set, ie, a shortened version of the TGV Duplex train set, in April 2007 on the LGV Est (Paris to Baudrecourt) route. The train set incorporated the Automotrice à Grande Vitesse (AGV) traction chain and the record is held jointly by the French railway companies Société Nationale des Chemins de fer Français (SNCF), Alstom and Réseau Ferré de France (RFF), the French railway infrastructure agency.

Over the next decades, billions of euros will be invested in infrastructure (which encompasses track, 1 AGV is the generic name of high-speed trains manufactured by Alstom, while TGV is an SNCF trademark.)
signaling, bridges, tunnels, stations, communication, power supply and electrification) and rolling stock. On the infrastructure side, there is a commitment to increase the high-speed rail network to 4,000 km by 2020. New lines will include Le Mans to Rennes (Bretagne-Pays de Loire extensions) and Tours to Bordeaux (LGV Sud Europe Atlantique extensions); Montpellier to Perpignan and Nimes to Montpellier by-pass (part of the Paris-Barcelona-Madrid route); and a second arm of the LGV Rhine-Rhône and Est Européenne (to Strasbourg) lines as well as Lyon to Turin and Marseille to Nice.

A program of LGV expansion beyond 2020 for a further 2,500 km has also been discussed that would include domestic and cross-border routes [2] [3]. For light-rail systems, 150 km of new lines are expected to be completed by 2020. For the Paris region, the Régie Autonome des Transports Parisiens (RATP) has been focusing on the upgrade of two metro lines, and the projects of Grand Paris Automatic Metro System and the Charles de Gaulle Express (PPP) which are currently in the decision process [3].

On the rolling stock side, SNCF has been investing both in the new TGV, suburban and regional train sets and the renovation of current rolling stock and stations. The RATP, in association with SNCF, has been focusing on the renovation of rolling stock and new rolling stock for the Réseau Express Régional (RER), the rapid transit system serving Paris and its suburbs.

**ABB’s contribution to infrastructure**

Much of the electric energy used by railways is actually drawn from the national grid. However, significant differences between railway electrification and national grids exist, such as the single- or two-phase power used mostly by AC-electrified railways compared to the three-phase power transmitted and distributed by domestic grids. In addition, the frequency used for electrification often differs from these grids and even when the same frequency is used, there may be synchronization problems. As both passenger and freight traffic continue to increase on existing tracks, combined with new high-speed rail projects, these grids are forced to deal with heavy and strong time-varying single-phase loads that have the potential to cause instability (eg, imbalance) in the network. Load balancing, used to overcome this problem, is concerned with transferring active and reactive power between different power-supply phases and this can be carried out using ABB’s SVC Light®.

SVC Light® benefits the power grids feeding railway systems by dynamically balancing non-symmetrical loads fed from two phases of three-phase supplying grids; mitigating the voltage fluctuations caused by heavy loads; eliminating harmonics injected into the supply grids by traction devices without the need for passive shunt harmonic filters; power-factor correction; and enabling adequate power quality. These benefits reduce, if not eliminate, the investments needed to upgrade the railway power-feeding infrastructure, an important fact that attracted the attention of RFF and SNCF.

RFF/SNCF has two SVC Light installations in its railway powering infrastructure. The first is installed in the Evron substation, which is situated on the rail network between Paris and Rennes. SVC Light was chosen not only for the technical benefits described above but also because the alternative, building a new overhead line, would have been much more costly and time consuming. In addition, the fact that a passive filter is not required (as all harmonics up to and including the ninth harmonic are filtered out) and the footprint of an SVC-Light solution is quite small were other deciding factors. The task of SVC Light in the Evron substation is to confine the grid unbalance at 90 kV to no more than 1 percent for a grid fault level (S_{ssc}) greater than or equal to 600 MVA under normal network conditions and no greater than 1.5 percent for 300 MVA ≤ S_{ssc} ≤ 600 MVA for abnormal network conditions. Measurements taken since SVC Light was installed show that the voltage imbalance does not exceed 1 percent.

The Mesnay substation, located along the Jura line linking France and Switzerland, contains an SVC-Light installation for dynamic balancing of railway loads. Rated at 63 kV 15 MVA, it can accommodate a single-phase active load of up to 16 MW. Its task is to confine grid imbalance at 63 kV to no more than 1 percent under normal network conditions and no greater than 1.8 percent for abnormal (N-1) network conditions.
On the electrified network, high-voltage equipment plays an important role in ensuring an uninterrupted supply, high network availability, and the protection of personnel and equipment. In railway substations, switchgear and circuit breakers ensure safe and flexible operation. ABB switchgear are popular because of their reliability; flexibility in configuration; ease of operation; and they require minimum maintenance. One such switchgear is the UniGear R for railway power supplies. This metal-clad, air-insulated switchgear can withstand internal arcs of up to 40 kA, which helps provide a safe working environment for railway employees by preventing dangerous electrical discharges. One of the first of these switchgear types was delivered to the Saint-Lazare railway station in Paris - one of the busiest train stations in Europe - in 2005 to feed two 25/1.5 kV transformers supplying auxiliary power to stationed train sets.

UniSec is ABB’s latest indoor air-insulated switchgear for medium-voltage secondary distribution and is based on a single versatile and modular platform. It features a metal-enclosed LSC2A-PM design, in accordance with loss-of-service continuity definitions in the IEC 62271-200 standard. Solutions for specific applications are configured using standardized modules. Sixty of these were ordered by the Régie des Transports de Marseille (RTM) who, together with the Marseilles Provence Metropole (MPM) are currently extending the subway lines as part of the “Line 2 substation” project, the objective of which is to better serve the outskirts of the city of Marseille. The RTM operates a fully integrated network with a configuration that compliments the three transportation modes: bus, tram and metro. More than 500,000 passengers travel this network everyday, with subway trips accounting for over half the total number of daily trips.

Other ABB medium-voltage secondary switchgear are used in substations that supply power to the Rhônexpress, a fast public tram that connects the centre of Lyon and Lyon-Saint Exupery Airport, the third busiest airport in France. In operation since August 2010, the Rhônexpress is expected to carry up to eight million passengers per year. Two types of secondary switchgear are used in the substations: the air-insulated UniSwitch and the gas-insulated \((\text{SF}_6)\) SafeRing.

Seven high-voltage substations, owned by RATP and connected to the main network operated by Réseau et Transport d’Electricité (RTE), are used to provide power to the RER, Metro and RATP tram systems in and around Paris. As part of its investments, the RATP has decided to refurbish two of these high-voltage substations, Denfert-Rochereau and Lamarck-Caulaincourt. ABB, in a multi-million euro contract, is providing turnkey control systems (one for each substation) to be connected to the RATP central substation, as well as 220 medium-voltage withdrawable UNIMIX WCB and UniGear ZS1 switchgear panels. UniMix switchgear with WCB-WSB units comply with the IEC 62271-200 standard and are suitable for secondary distribution applications where high performance is required. The UniGear switchgear is equipped with type REF 542Plus protection relays.

Outdoor circuit breakers form a vital part of the power infrastructure that supplies electricity to mainline trains via the overhead catenaries. They are used for isolating the supply to the catenaries, as well as for sectionalizing parts of the track during inspection and maintenance. ABB’s FSK II vacuum breaker, for single- \((1 \times 25 \text{ kV})\) and two-phase \((2 \times 25 \text{ kV})\) 50 Hz traction power-supply switching applications, comes equipped with a range of innovative features, such as a maintenance-free combination of magnetic actuator and electronic controller (this removes several moving parts). This combined with the fact that it is easy to adapt and integrate into new and existing installations and the engineering support provided by ABB attracted the interest of SNCF.

In 2006 it ordered 58 two-phase and 20 single-phase FSK II circuit breakers, and in 2007 this circuit-breaker type was installed along the LGV Est route taken by the record-breaking AGV in April of that year. Forty four FSK II circuit breakers were sold in 2010 for the Normandy-line upgrade.
As well as switchgear and circuit breakers, ABB’s portfolio also contains a broad range of vacuum cast-coil transformers for railway projects. There are basically two main application areas: substation distribution and traction. Whatever the application, these transformers are moisture-proof (making them suitable for operation in humid or heavily polluted environments) and they satisfy demanding installation requirements, such as reduced noise, vibration levels and limited space.

Over 100,000 units are currently in operation around the world, including more than 1,600 dry-type transformers present in railway applications. Between 2007 and 2009, 11 vacuum cast-coil transformers (with power ratings varying between 1,000 and 2,500 kVA) were used in substation distribution applications in France. Of that total, seven were supplied to the substations that power the trains in Reims, three to the Transports de l’Agglomération Grenoble (TAG), the tramway system in Grenoble, and one to Alstom Transport’s machine-traction laboratory in La Rochelle.

Rolling-stock side

Compared to regional rail systems, which operate between towns and cities, commuter rail services usually connect city centers to outlying suburbs within a range of around 60 km. Commuter trains need to stop frequently and this means rapid deceleration and acceleration, which places severe strain on components. Despite these harsh operating conditions, the train is expected to perform reliably and provide a dependable service, no matter the environmental conditions. It is precisely for this reason that the electric multiple units (EMUs) used by many modern commuter network operators around the world contain several key ABB technologies that allow these vehicles to display significantly higher levels of energy efficiency when compared to obsolescent DC rectifier electric trains, diesel trains and buses. In addition, they require relatively little space, thereby enabling the transport of large passenger numbers. The combination of traction-chain components, such as traction transformers, traction converters, motors and control equipment are the main determinants of a train’s operation performance and services.

In the global market, ABB is one of the very few independent suppliers of traction packages. Over the last 10 years, it has designed several thousand traction transformers and is the world leader in this field with a 50 percent market share. The company has long-term agreements with rolling stock manufacturers including Alstom, Ansaldo Breda, Bombardier, CAF, Siemens, Skoda and Stadler. Various types of traction transformers have been designed and delivered to practically all railway integrators around the globe for use on freight, regional, commuter and high-speed trains.

In France, one such beneficiary is Bombardier’s wider and state-of-the-art single-deck SPACIUM EMUs, which are operated by SNCF for the Syndicat des Transports d’Île-de-France (STIF), the Paris region transit authority. The SPACIUM EMUs, previously known as the Nouvelle Automotrice Transilien (NAT), will run between Paris-Nord and Paris-Est and from 2013 will run to and from Paris-Saint Lazare.

These commuter trains are designed to meet the requirements of speed, efficiency, comfort and reliability demanded by SNCF and will replace the ageing EMU fleet built in the 1960s. A total of 172 train sets were ordered with the option for a further 200, each of which will be fitted with two ABB traction transformers. Of the 172 train sets, 77 eight-car trains are for routes serving Paris-Nord; 55 seven-car trains for Saint-Lazare; and 40 eight car trains for Paris Est. They are capable of operating either on 25 kV 50 Hz or 1,500 V DC electrified lines.

These new EMUs are derived from Bombardier’s AGC family of trains, which also feature ABB traction transformers, in particular the standard AGC platform and the AGC XBiBi (the world’s first universal train) versatile versions. The transformers installed in the SPACIUM EMUs and the AGC XBiBi (which stands for dual mode and dual voltage) are roof-mounted silent transformers with cooling systems that ensure low noise emissions.

The AGC XBiBi train was developed by Bombardier for SNCF to meet the varying demands of SNCF’s network, which covers 29,500 km. Of this, 15,800 km are not electrified, 5,800 km are electrified at 1.5 kV DC and 7,900 km at 25 kV AC. The AGC XBiBi can run without stopping on all three power supply alternatives: diesel, AC and DC power. Prior to its...
introduction, passengers travelling the Marseille to Geneva (via Grenoble) route, which contains different power supply values, had to change trains whenever the power system changed or when traction equipment had to be exchanged. SNCF has ordered 612 of these trains from Bombardier and ABB is manufacturing the traction motors and transformers for all of them.

Other Bombardier-manufactured trains that will feature ABB traction transformers are the new and specially-developed regional double-deck EMUs ordered by SNCF in a multi-billion dollar contract. Under the name of Régio2N, these EMUs will see service in many French regions, including Aquitaine, Bretagne, Centre, Nord-Pas de Calais, Provence-Alpes-Côte d’Azur and Rhône-Alpes, and first deliveries are scheduled for the middle of 2013.

ABB traction transformers are also present in Alstom’s Coradia Polyvalent trains (named Régiolis by their French operator), which operate on French suburban rail networks. One of the prime considerations in the design of this single-level modular train was the reduction in weight by as much as possible. Because weight has a significant impact on operating costs and speed, independent suppliers were also required to reduce the weight of their products. ABB worked closely with Alstom to produce a high-performing transformer with DC line filter reactors and an auxiliary inductor with a total weight of only 2,650 kg.

An ABB traction transformer was used on the record-breaking AGV train that attained 575 km/h in April 2007. Source: Alstom Transport

An ABB traction transformer was used on the record-breaking TGV/AGC train that attained 574.8 km/h in April 2007, where again reduced weight was a major contributor to achieving this feat. An increased use of composites and aluminum allowed Alstom to make the AGV lighter: An entire train weighs 395 tons (compared with 430 tons for earlier AGV trains) and uses 15 percent less power. This new generation of AGV trains will attain commercial speeds of 360 km/h and the first of 25 trains ordered by the Italian company Nuovo Transporto Viaggiatori (NTV) will enter service in late 2011 in Italy.

ABB water-cooled traction motors are used in the bi-directional Bombardier Eurotram fleet that operate in Strasbourg. Over 1,400 of these, with a power rating of 38.5 - 45 kW, catenary 750 VDC were supplied during the 1990s. The motor design is optimized according to the requirements for a low-floor (ie, there are no steps between one or more entrances or the passenger cabin) vehicle meaning it is very compact so that it can fit with the bogie arrangement.

ABB’s more recent modular induction traction motors are used for the distributed power drive of a wide range of train types, including light-rail vehicles (LRVs), underground and overground metros, diesel or electric multiple units (DMUs or EMUs), high-speed trains and very high-speed trains. They feature a new electrical design and a competitive performance/weight ratio to meet increasing demands for energy-efficient electric traction motors in the rail industry. In addition these motors are designed to endure extreme temperatures and polluted environments.

ABB auxiliary converters supply the on-board energy in many of Alstom’s Citadis tramway fleets in operation in France, such as the one in Montpellier and Nice. Similar auxiliary converters are also installed on Alstom’s Tram-Train new generation for SNCF, and ADtranz tramways in Nantes have been reliably running with auxiliary converters for more than ten years. These converters are also found on SNCF’s narrow-gauge trains that operate in the demanding Mont Blanc region.

Rhônexpress, the new airport link in Lyon, operates LVFs from Stadler Rail with all the power electronics from ABB. The powerful, compact and light-weight traction converters with integrated auxiliary converters installed on these trains minimize energy losses and support the high availability of this fleet.

The demand for auxiliary power on trains has increased considerably in recent years. In addition to heating, ventilation and air-conditioning (HVAC) systems, staff and passengers expect facilities such as passenger information, entertainment systems and power sockets for laptops. ABB’s portfolio of low-voltage products are used to ensure a comprehensive and innovative control of services inside the train. For example, Alstom’s porteur polyvalent (known as Régiolis in France) and Bombardier’s PH (Regio2N) trains, plus the metro in Lyon and the tramways in Strasbourg feature either contactors, ABB’s insulation displacement connection (IDC) ADO terminal blocks, current and

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6 This process required numerous personnel to carry out tasks such as points change, uncoupling and coupling, and shunting and brake tests.
voltage sensors and miniature circuit breakers, all of which comply with the highest levels of requirements according to the standards NF F 16-101 (Railway rolling stock - fire behavior - choice of materials) and NF F 16-102 (Railway rolling stock - fire behavior - choice of materials - electrical equipment).

ADO is a connection technology and is based on miniature terminal assemblies. This connection block eliminates the need for stripping, soldering or screwing in the wire and it is secure and highly reliable, making it suitable for use in harsh environments that are subject to vibrations or corrosion.

ABB low-voltage ADO terminal blocks, contactors and circuit breakers also feature on the high-speed international trains operated by Thalys and Eurostar, both of which share the Paris to Brussels route with Eurotunnel and French domestic TGV trains (A, R, Duplex, PBKA, PSE), which also use contactors to control motors and fans.

Providing reliable and effective protection against over voltages on contact wires is extremely important in helping trains to run smoothly and constantly. To increase the availability of the power supply and protect rolling stock equipment and the traction grid, ABB surge arrestors, particularly type POLIM-H ND, are widely used in railway applications in France. All surge arresters for railway applications incorporate the latest metal-oxide technology, and are shock and pollution resistant.

In addition to surge arrestors, voltage limiters, type HVL 120-0.3, are used in installed DC traction systems to provide effective protection for personnel and equipment by eliminating high potential differences between the rails and earthed metallic parts, such as masts or bridge railings.

Maintenance and refurbishment projects
Rather than performing maintenance and engineering in house, railway companies are now increasingly entrusting this work to external contractors so that they can concentrate on the operations side of their business. From ABB’s perspective as an equipment manufacturer, providing service to railway operators has the additional advantage that the understanding of maintenance needs and of the behavior of equipment throughout its lifetime is fed back within the organization and used to improve future designs.

ABB can support customers with spare parts and maintenance planning, and it can carry out major retrofits, both on the infrastructure and rolling-stock sides, by upgrading products, thereby enabling them to operate more efficiently and economically.

On the infrastructure side ABB won an order worth €11 million ($16 million) at the end of 2009 from the RATP for the refurbishment of two underground substations to ensure the efficient and reliable power supply for the rail system in and around Paris. The Lamarck-Caulaincourt and Denfert-Rocherau 63/15 kV substations supply power to the suburban railway and metro lines and the stations of the RER in Paris. ABB is responsible for the engineering, supply, and installation and commissioning of this turnkey project. It will supply products including medium-voltage switchgear, such as the highly reliable UniGear and UniMix, 15 kV switchboards and auxiliary transformers. A substation automation system compliant with the IEC 61850 global substation communication standard, and integrated control and protection equipment will also be commissioned.

Eurotunnel operates a fleet of dedicated Bo-Bo-Bo locomotives on its shuttle trains transporting cars, coaches and lorries through the Channel Tunnel between England and France. As the tunnel is more than 100 meters below sea level, trains enter it through inclined sections at either end. The locomotives must not only be powerful enough to start the heaviest train on these gradients, but the tunnel's significance and length (50.5 km) have led to stringent demands in terms of fire protection and redundancy which these locomotives must fulfill. Between 2006 and 2008, ABB was responsible for overhauling the 15-year old traction transformers of 17 of these locomotives, the scope of which included oil analysis before and after the overhaul, inspection, cleaning, diagnostic measurements, testing, optimization and expertise.

Similar work was required on the transformers of three of SNCF’s BB36000 locomotives. The work carried out on these non-ABB transformers included:

- Exchanging the active part and reactors (windings and core).
- The replacement of all the gaskets and damaged
accessories such as low- and high-voltage bushings, oil-level indicator and valves.

– The revision of the pump and cooling system.

– Electrical routine tests according to IEC standards.

– Oil analysis after repair.

Robots and rail
In recent years, ABB has been extending its offerings and expertise beyond solutions for rail infrastructure and rolling stock. As a robotics supplier, the company is keen to prove that its robotics can also revolutionize the rail industry.

Tools used previously for assembling road vehicles can just as well serve the rail industry: For example, the FlexFramer is one such tool that has been designed for main body assembly; the FlexiCell is a spot-welding cell built from standardized components; ModulFex is used for the sub-assembly of underbody, body sides, engine compartments and roofs; while SafeMove provides a predictable robot motion that can be restricted to exactly what is needed by the application.

ABB has already provided SNCF with automated spray painting booths to its Périgueux site in south-west France in response to the SNCF’s demand to reduce paint consumption, increase production capacity and improve environmental standards. The solution included a preparation area, painting booth, a paint thinning area and a curing oven, which was equipped with two ABB IRB 5400 robots. The oven technology provided by ABB reduced the normal four-hour drying time to a mere 55 minutes. In addition, there was a decrease in required space as robots could be placed on shelf systems, walls or even on ceilings. In SNCF’s case this meant the space needed dropped from 210m² to 80m² [4].

Mid-life fleet overhaul of Euroshuttle locomotives. Picture: Eurotunnel

ABB performed factory repairs on the transformers of three of the SNCF’s BB36000 locomotives
SNCF
The Société Nationale des Chemins de fer Français (SNCF) is France’s national state-owned railway company. SNCF operates the country’s national rail services, including the LGV, France’s high-speed rail network. Its functions include operation of rail services for passengers and freight, and maintenance and signaling of rail infrastructure owned by Réseau Ferré de France (RFF).

RFF
Réseau Ferré de France (RFF) is the French railway infrastructure agency. It owns and manages the French railway network and decides on what targets to apply in terms of traffic management, and how the network is run and maintained. It also decides of the network development and is responsible for organizing funding.

RTE
Réseau de Transport d’Électricité (RTE) is the transmission system operator of France. It is responsible for the operation, maintenance and development of the French high-voltage transmission system. RTE is a wholly-owned subsidiary of the partially public-owned French generator Électricité de France (EdF).

RATP
The Régie Autonome des Transports Parisiens (RATP) is the major transit operator responsible for public transportation in Paris and its surroundings. It is under the authority of the Syndicat des Transports d’Île-de-France (STIF), the Paris region transit authority. Its infrastructure includes parts of the RER network, the Paris Métro system (16 lines), an extensive bus network and three tram lines (the newest tram line, T4, is operated by SNCF). It also operates the Montmartre funicular and the Orlyval rubber-tyre LRV system serving Orly airport.

RER
The Réseau Express Régional (RER) is a rapid transit system serving Paris and its suburbs. It has successfully combined existing rail infrastructure with the Paris Metro system so that the city centre and the surrounding suburban areas are connected, providing an efficient and fully integrated transport system. It is operated by the Régie Autonome des Transports Parisiens (RATP) and SNCF.

STIF
Syndicat des Transports d’Île-de-France (STIF) is the authority that controls the Paris public transport network and coordinates the different transport companies operating in Île-de-France, mainly the RATP, the SNCF and Optile.
Background information
ABB and the railway industry

For more information

References


For help with any technical terms in this press kit, please go to: www.abb.com/glossary