

HYDROPOWER AND RIVER ENGINEERING



CNR ENGINEERING

AT YOUR SERVICE... TO DESIGN AND MANAGE YOUR PROJECTS IN FRANCE AND ALL OVER THE WORLD



HYDROPOWER AND RIVER ENGINEERING

04



MAINTENANCE OF A
PRODUCTION UNIT - CHAUTAGNE
HYDROPOWER PLANT



CONSTRUCTION OF THE
LOCKS OF ANGLEFORT

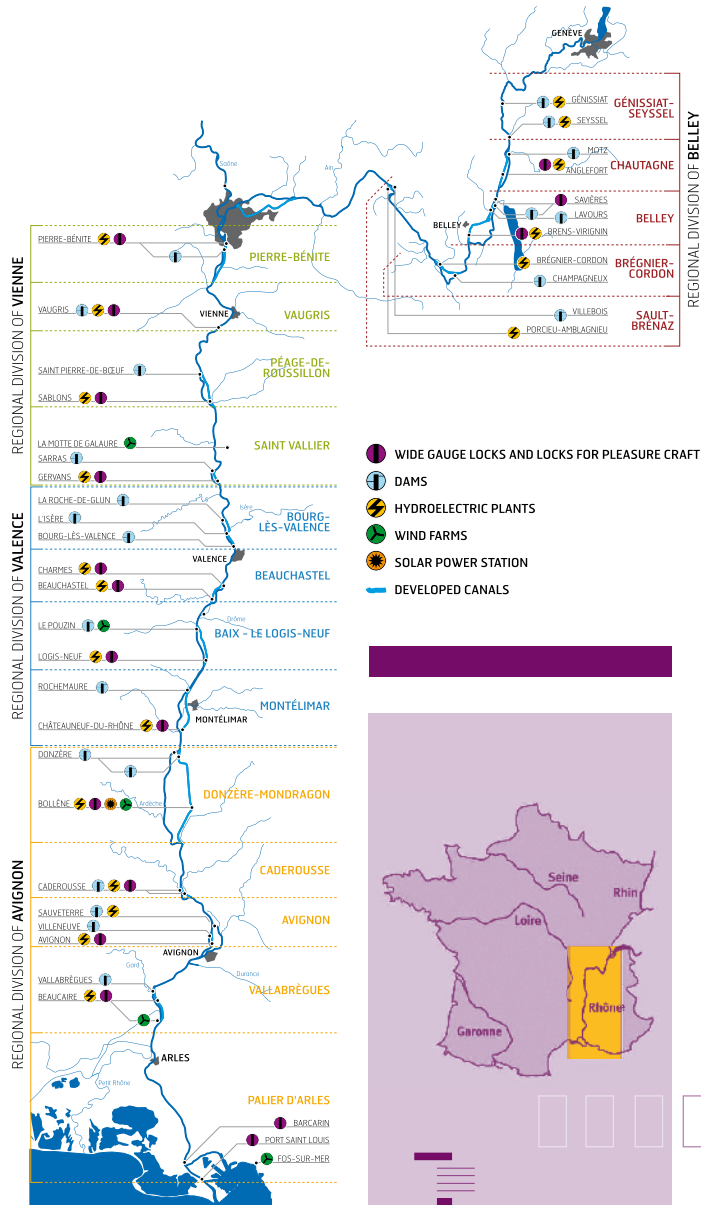
CNR ENGINEERING IS THE COMPAGNIE NATIONALE DU RHONE'S ENGINEERING AND CONSULTING OFFICE AND IS COMPOSED OF HIGHLY QUALIFIED MULTIDISCIPLINARY TEAMS WHOSE EXPERTISE IS BASED ON 75 YEARS EXPERIENCE IN DEVELOPING AND OPERATING THE RHÔNE. JOIN THE MANY CLIENTS THAT CALL ON THE COMPETENCES OF CNR ENGINEERING.

CNR Engineering's teams can help you to carry out large scale **river** and **hydro-power projects** by offering **innovative solutions** and **well-mastered technologies**.

Highly qualified engineers and technicians work on hydropower plants, navigable waterways, river development and restoration, and the hydraulic and hydrological management of river systems.

An **integrated engineering office** that works to ensure the **efficient operation of developments and ports** on the Rhone, **CNR Engineering** manages the design and construction of all the technical projects on CNR's concession, including the **necessary studies, assessments, tests, measurements** and **controls**. Working hand in hand with the owner, our engineers and technicians are trained to **listen to your needs** and **satisfy your requirements**.

CNR Engineering's activities have been certified **ISO 9001** since 2000.



CNR, MORE THAN 75 YEARS OF EXPERIENCE DEVELOPING AND OPERATING THE RHONE

CNR has been granted the concession to operate the Rhone from the Swiss border to the Mediterranean Sea since 1933 and carries out **three interdependent missions** that were entrusted to it in 1934: **hydropower production, navigation and irrigation and other agricultural uses.**

It has built **19 hydropower plants** on the river, it has opened up a **wide-gauge waterway 330 km** long between Lyon and the sea and it permits the **irrigation of crops**; consequently it is a major actor in the Valley's economic development. Fully involved in overcoming the challenges of the present, CNR is a **major producer of electricity generated from renewable sources** (25 % of national hydropower), acting a driving force for river traffic and to preserve the natural heritage of the Rhone Valley.

The company's invests for the benefit of the population of the Rhone Valley in line with its plans of Missions in the General Interest (MIG).

The hydraulic engineering expert of the GDF SUEZ Group in France, and an international reference in hydropower and river engineering, CNR is **France's second largest electricity producer** and has been awarded **TÜV SÜD certification** for its **100 % renewable electricity production.** In line with its Strategic Business Plan, it is currently involved in an ambitious industrial program to develop its production sources in hydropower, wind power and solar energy.

AT YOUR SERVICE...

... TO DESIGN YOUR INFRASTRUCTURES

CNR Engineering has its own **experimental hydraulics and measurement laboratory**. Almost unique in France, it satisfies every demand for the **physical modelling** of complex hydraulic, river and closed conduit flows used to study, for example, lock designs, sediment transport and the sizing of hydraulic structures.

Its competences also cover testing materials such as concretes, mortars and rock-fill to evaluate their resistance to scouring and hydraulic impacts.

... TO ENSURE EFFICIENT AND LASTING PERFORMANCE

The diversity of the hydraulic structures operated by the Company gives **CNR Engineering** unrivalled experience in **diagnostics, maintenance** and **refurbishment**.

CNR Engineering also offers advanced **consulting and diagnostics services** to improve the performance of river and hydropower facilities.

CNR produces hydropower generated exclusively by run-of-the-river plants requiring the precise management of low reservoir volumes, thus **CNR Engineering** has exceptional expertise in **regulation**. These severe constraints have led it to design and implement efficient flow rate and reservoir level regulation based on a predictive approach.



... TO ACQUIRE AND PROCESS WATER RESOURCE DATA

In partnership with IRD (Institut de Recherche pour le Développement), **CNR Engineering** has developed the HYDROMET® software to permit the remote data acquisition, storage, automatic processing and diffusion of **hydro-meteorological data**. HYDROMET® manages the **data acquisition** and **water resources** for a large number of purposes: hydropower production, operating development schemes, flooding and low water levels, and monitoring water quality.



CNR TEAM





FOCUS



A SCALE MODEL

... TO ENHANCE THE ENVIRONMENT

A precursor in the area of ecological and plant engineering, CNR's know-how covers every technique for restoring, rehabilitating and creating natural environments. Consequently, it participates in projects to manage natural and river environments in collaboration with local actors.

... TO PREDICT HYDROLOGICAL CONDITIONS

Optimising the operation of the developments on the Rhone is crucial to ensure the dual goal of safety and hydropower production. To do this, CNR Engineering has developed a **full array of hydrometeorological prediction tools**.

From rainfall (OPALE®) and snow melt (FLOCON®) forecasting to predicting the flow rates of tributaries (PHARE®), it offers **unique expertise** for designing fully integrated systems adapted to operational contexts. These tools are **robust, efficient and ergonomic**, forming an ideal software suite for every hydropower producer.



CENTRALISED REMOTE CONTROL OF CNR'S DEVELOPMENT SCHEMES

UNIQUE MODELLING EXPERTISE

CNR Engineering relies on the company's laboratory dedicated to hydraulics studies, measurements and experiments, a vital tool for understanding complex hydraulic flows. It enjoys **extensive** and **constantly updated experience** in the field of navigation and has recently built four physical models of locks to solve complex problems:

- **International recognition has been earned for the modelling of the new locks of the Panama Canal**, and most particularly the hydraulic filling and emptying systems, due to their exceptional size.
- the **Freycinet gauge locks of Chautagne and Belley** (Ain, France): the development of secured access for pleasure craft and the optimisation of the filling and emptying system,
- the **future wide gauge lock of Cremona** (Italy) to optimise the design of the hydraulic filling and emptying system,
- the **lock of Vallabrègues** (Gard, France), one of 14 wide gauge locks that ensure navigation between Lyon and Marseilles: the study of adapting the chamber filling and emptying system to new operating constraints in view to improving environmental performance.



DESIGNING AND MANAGING YOUR PROJECTS IN FRANCE AND ELSEWHERE IN THE WORLD

CNR'S EXCEPTIONAL EXPERIENCE AS DESIGNER AND OPERATOR OF MAJOR CIVIL ENGINEERING STRUCTURES ON THE RHONE HAS LED IT TO PROVIDE SERVICES IN THE SECTORS OF HYDROPOWER AND RIVER ENGINEERING IN FRANCE AND ABOUT THIRTY OTHER COUNTRIES.

AREAS OF EXPERTISE

NAVIGABLE WATERWAYS:

P. 10

locks, canals, industrial ports and marinas.

HYDROPOWER PLANTS:

P. 12

low and medium head hydropower plants, small hydropower plants, dams, automated and remote controlled operation.

RIVER DEVELOPMENT AND RESTORATION:

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dikes, weirs, fish passes, white water stadiums, ecological engineering, phytoremediation, impact studies.

HYDRAULIC AND HYDROLOGICAL MANAGEMENT OF RIVER SYSTEMS:

P. 16

hydrological studies and prediction models, hydrometry, hydrometeorological networks, hydraulic studies using mathematical and physical models, mapping, GIS (Geographic Information Systems).

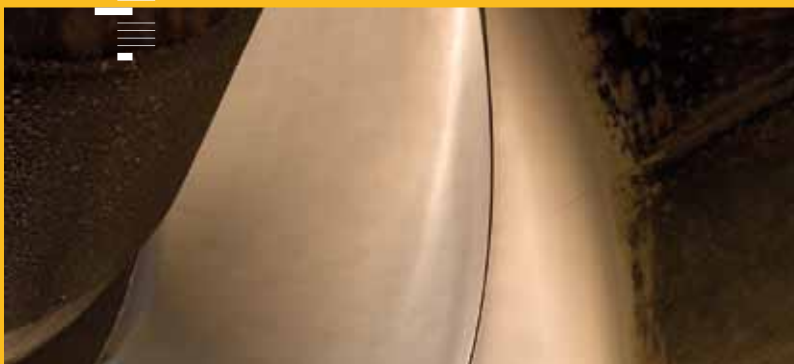


CHAUTAGNE: THE ANGLEFORT HYDROPOWER PLANT AND THE CONSTRUCTION OF A LOCK





A TURBINE: THE CHAUTAGNE DEVELOPMENT SCHEME



A THIRD OF CNR ENGINEERING'S ACTIVITY IS CARRIED OUT FOR CNR ITSELF, A THIRD IS CARRIED OUT IN THE FRAMEWORK OF ITS MIG AND A THIRD IS TAKEN UP BY CONTRACTS WITH EXTERNAL CLIENTS IN FRANCE AND ABROAD.



SERVICES

CONSULTING AND ANALYSES

- Analyses
- Diagnostics
- Environmental and social impact studies
- Technical and economic feasibility studies
- Assistance for the operation and maintenance of hydropower plants and river developments
- Consulting for improving the performances of hydropower plants and river developments.

ENGINEERING AND CONSTRUCTION MANAGEMENT

- Preliminary designs, tender designs and detailed designs
- Assistance to the owner
- Construction management

INTERNATIONAL EXPERTISE



NAVIGABLE WATERWAYS

CNR HAS GAINED CONSIDERABLE KNOW-HOW FROM ITS EXPERIENCE AS OPERATOR OF THE WIDE GAUGE WATERWAY ON THE RHONE FROM LYON TO THE SEA WHICH IT HAS PUT TO GOOD USE OVER THE LAST 30 YEARS AS CONSULTANT FOR CLIENTS IN FRANCE AND ABROAD, HELPING THEM TO UPGRADE THEIR FACILITIES AND CREATE NEW WATERWAYS.

CNR Engineering offers a global and realistic approach that incorporates environmental concerns as well as operating constraints. The structures are designed with **sustainable development in mind**, taking into account structural, environmental, social and institutional parameters, and risk analyses. They are also designed in view to **optimising** river maintenance.

- Locks, river crossings
- Master plans for navigable waterways
- Development of navigable canals and rivers
- Development of industrial ports and marinas
- Bathymetric surveys of navigable channels.



THE PEDRO MIGUEL LOCK - PANAMA CANAL



A MOCK-UP TO 1/30TH
OF THE NEW PANAMA LOCKS





FEW REFERENCES

CNR

In the framework of its MIG plans, CNR has started the construction of two new double Freycinet gauge locks on the upper Rhone, at Chautagne and Belley. They are intended to extend the navigable waterway for leisure boats between Seyssel and Brégnier-Cordon. The project is scheduled to end in 2010. CNR Engineering devotes its expertise to restoring partial navigability to the upper Rhone by carrying out the studies, design, construction management, and supervision of the project.

FOR EXTERNAL CLIENTS

• Danube (Romania)

CNR has provided technical assistance to improve navigation conditions on the Danube along the joint Romanian-Bulgarian section.

The study was funded by the European Union and carried out in a consortium with Technum, Imdc, Tractebel Engineering and Trapec.

• The Lys Mitoyenne (France - Belgium)

Preliminary technical and regulatory studies to modify the Lys Mitoyenne to Vb* gauge in the extension of the Deûle to create a link between the Seine and Escaut.

This study was performed on behalf of Voies Navigables de France in a consortium with Technum and Imdc.

*gauge permitting the passage of a self-propelled barge or a pusher convoy 110 metres long and 11.40 metres wide.

• Seine-Nord (France)

Preliminary studies of the layout of the wide gauge Seine-Nord canal that will link the Seine and Oise basin with the North European river network.

This study was performed on behalf of Voies Navigables de France in a consortium comprising Coyne et Bellier, Tractebel Development Engineering, Technum and Desvigne.

• Panama Canal (Panama)

Since 2002, CNR has participated in the project to design and build the third line of locks for the Panama Canal. This contract, won in the framework of the Post Panamax consortium that groups several companies belonging to the GDF SUEZ Group*, is a world first given the structure's dimensions and the lock performances demanded.

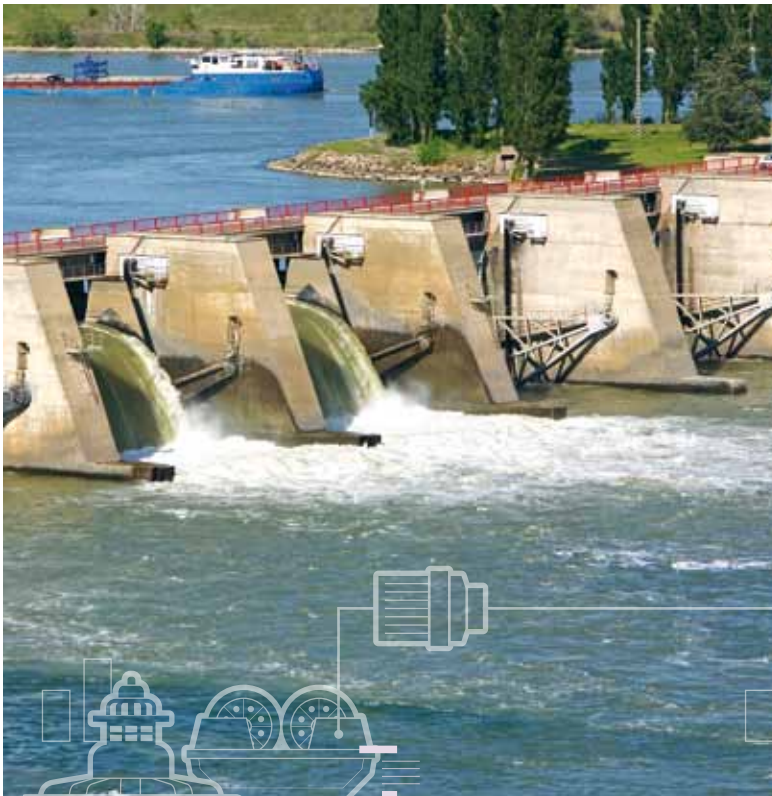
CNR Engineering has worked in particular on the study of the hydraulic filling and emptying system for the locks, by using mathematical 1D, 2D and 3D models as well as a physical model of the new locks. This extremely large model (60 m long x 20 m wide) built to a scale of 1/30th, faithfully reproduces the new Panama locks. It was built at Lyon-Gerland at the CNR's Experimental Hydraulics and Measurement Laboratory.

*Tractebel Engineering, Coyne et Bellier, Technum and CNR



HYDROPOWER DEVELOPMENT SCHEMES

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THE RESERVOIR DAM OF THE VALLABRÈGUES
DEVELOPMENT SCHEME



ASSEMBLING A NEW
ROTOR AT CHANCY-POUGNY
(SWITZERLAND)

AS DESIGNER AND OPERATOR OF HYDROPOWER PLANTS, CNR IS FRANCE'S SECOND LARGEST ELECTRICITY PRODUCER. CNR ENGINEERING DIVISION PARTICIPATES IN BOTH DESIGNING NEW PROJECTS AND RENOVATING EXISTING STRUCTURES. IT ALSO PROVIDES ITS ADVICE AND DIAGNOSTICS TO OPTIMISE THE OPERATION AND MAINTENANCE OF HYDROPOWER PLANTS.

- low and medium head hydropower plants,
- small hydropower plants,
- dams,
- automated and remote controlled operation,
- regulation,
- optimisation and management of production,
- assistance to operation and maintenance.





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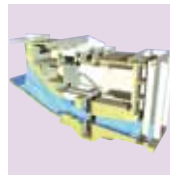


INSIDE
A TURBINE

FEW REFERENCES

CNR

In the framework of its MIG plans, CNR has started building two small hydropower plants on the Rhone with capacities of 4 and 7 MW and heads of 6 and 11 m respectively. These two small hydropower plants are designed to harness compensation water and thus produce renewable energy. **CNR Engineering** is carrying out the studies, and the design and construction management.



FOR EXTERNAL CLIENTS

• Switzerland

Renovation of the Chancy-Pougny hydropower plant owned by SFMCP in which CNR owns 27.8 % of the shares. The project comprises the replacement of the 5 existing turbines by Kaplan turbines, the renovation of electric equipment and the instrumentation and control.



• Uruguay

Studies for the installation of additional equipment for the hydropower plant of Gabriel Terra and increasing the hydropower potential of the Rio Negro.

• France

City of Toulouse. CNR is the overall design and construction manager of the small hydropower plant of Cavaletade on the Garonne River, with a capacity of 1 MW (in a consortium).

CNR ENGINEERING USES ITS EXPERTISE...

... TO OPTIMISE THE OPERATION OF THE HYDROPOWER PLANTS ON THE RHONE

Following the deregulation of the energy markets, the Compagnie Nationale du Rhône became an **independent** integrated energy producer. Given the constraints of the electricity market and the characteristics of its run-off-river plants, it was obliged to master the **technical aspects** of its role as operator. **CNR Engineering** set up the tools and facilities required to operate and maintain the structures on the Rhone, by developing an **operational network** for hydro-meteorological prediction that covers every step of the process, from collecting the raw data (precipitation levels, flow rates, meteorological parameters) to predicting **hydropower production**.

In the framework of setting up the Rhone Production Management Centre, **CNR Engineering** has developed the **optimisation tools** OPALÉ® (rainfall precipitation forecasting by analogy), PHARE® (hydrological forecasting of inflows from the Rhone's tributaries) and AEGIR® (application for managing radar imaging for operational use) to **improve** the placement of production on the electricity market, whatever the prevailing hydraulic conditions, while conforming to the operating and safety instructions of the 19 dams and hydropower plants of the Rhone. These hydrometeorological forecasting tools are used to **control flows** during flooding while monitoring the **security of the structures**.



RIVER DEVELOPMENT AND RESTORATION

CNR ENGINEERING RELIES ON THE EXPERIENCE OF ITS MULTI-DISCIPLINARY TEAMS AND THE INNOVATIVE SOLUTIONS DESIGNED BY ITS R&D (RESEARCH AND DEVELOPMENT) TO CARRY OUT RIVER DEVELOPMENT PROJECTS THAT INCORPORATE A MULTITUDE OF TECHNICAL, ENVIRONMENTAL AND SOCIOECONOMIC DIMENSIONS.

The Rhone is bordered by **more than 400 km** of dikes designed and built by CNR. The dikes on the concession are constantly controlled, monitored and maintained to ensure they provide efficient protection. **CNR Engineering** also carries out **hydrological** and **ecological restorations** of river environments (the Old Rhone, oxbows, secondary branches and wetlands). **Knowledge and understanding** of streams, lakes and large rivers are all assets that **CNR Engineering** puts to good use by offering a wide range of services: diagnostics, analyses, preliminary studies, detailed designs, impact studies, engineering and construction management and assistance to the owner.

- dikes, bank protection;
- weirs;
- fish passes;
- restoration of natural environments;
- environmental management plans;
- white water stadiums.



A FISH PASS ON THE DRÔME WEIR

FOCUS



DIKES ERECTED
ON THE RHÔNE

FEW REFERENCES

CNR

In the framework of its MIG plans, CNR works in partnership with the Water Agency and local authorities **to restore the environmental and hydraulic conditions** of 22 oxbows located close to the hydropower plants of Chautagne, Belley and Brégnier-Cordon. **CNR Engineering** has performed studies aimed at **preserving** and **restoring** the conditions of aquatic environments and their biotopes. These projects involved earthworks and planting along nearly 20 km of riparian environment.

FOR EXTERNAL CLIENTS

• Colombia

Feasibility and design studies of the **restoration of the Canal del Dique**: control of sedimentation in Cartagena bay, improvement of navigation conditions, restoration of wetlands around the canal, electromechanical equipment.

• Vietnam

Technical assistance to the Vietnamese Ministry of Agriculture relating to **flood protection projects** in the Red River delta.

• France

Development of the banks and surroundings of the lakes of Viry-Chatillon and Grigny: engineering and construction management of the **restoration** and **enhancement of a leisure and ecological site**, paths, bank protection and creation of wetlands.

Restoration of the banks of the wide-gauge network in the Nord and Pas de Calais departments: studies to draft a master plan for 300 km of the wide-gauge network covering all the navigation canals of the northeast.

DIKE DIAGNOSTICS AND REINFORCEMENT (OUTSIDE THE CNR CONCESSION)

The reservoir dikes are often very old structures built of very different materials whose strength has been called into question by heavy floods. **CNR's expertise gained** from managing run-of-the-river plants allows it to offer dike reinforcement diagnostics: geophysical and geotechnical surveys, the calculation of risk levels, and the design of reinforcement works. For example, **CNR Engineering** carried out the diagnosis, design, construction management and repair of the dike of St Just d'Ardèche [07] for the Intercommunal Syndicate for the Banc Rouge Dikes. This dike had two breaches following the flood of the Rhone in November 2002. It also provides **diagnostics for dikes** involving public security, such as for the dikes of Verdun sur le Doubs and the dikes of the Verjux [71].



HYDRAULIC AND HYDROLOGICAL MANAGEMENT OF RIVER SYSTEMS

THE MEKONG HYCOS PROJECT, THE MEKONG RIVER IN LAOS



WATER LEVEL GAUGE



FORECASTING AND MANAGING THE HYDRAULIC AND HYDROLOGICAL CONDITIONS OF THE RHONE ON A DAILY BASIS HAVE LED CNR TO DEVELOP EFFICIENT AND PROVEN METHODS AND TOOLS (A HYDRAULICS LABORATORY, 1D AND 2D MATHEMATICAL MODELS, DEDICATED SOFTWARE).

It offers this know-how in France and abroad, in particular for **drawing up river basin** management plans at regional and national scale and setting up and operating hydrometeorological data acquisition and processing tools.

- hydrological studies and prediction models,
- hydrometry and hydrometeorological networks
- hydraulic studies using mathematical and scale models (laboratory),
- GIS mapping and flood risk management.





FEW REFERENCES

FOR EXTERNAL CLIENTS

- **Laos-Thailand-Vietnam-Cambodia**

Study for setting up **hydrometeorological** stations on the main tributaries of the Mekong (30 stations) and training staff to operate a measurement network on behalf of the Mekong Commission (Mekong-HYCOS project under the aegis of the WMO).

- **Brazil-Bolivia-Paraguay**

Setting up a **water resource observatory** for the upper Paraguay watershed, with a hydrological and water quality measurement network (20 stations) as well as an Internet site for diffusing data in real-time.

- **Senegal**

Study of a plan **to alert the populations** living along 1,200 km of the Senegal River in the case of exceptional and catastrophic floods (dam breach), in a consortium with the Coyne et Bellier engineering office.

- **France**

Study of flood risks for Greater Lyon: cartographic study considering different **flood scenarios**.

FOCUS



THE FREDERIC MISTRAL, CNR'S HYDROGRAPHIC SURVEY BOAT

THE EXPERTISE OF CNR ENGINEERING...

... IN MEASUREMENT NETWORK MANAGEMENT

In order to monitor the hydrometeorological conditions of the Rhone and its tributaries (a watershed of 100,000 km² with a wide range of hydrological characteristics), CNR has operated a measurement network comprising 220 remote transmission stations **for more than 40 years** (level, flow rate, rainfall, salinity, etc.). **CNR Engineering** works constantly to develop and upgrade this measurement network. The calibration of water level measurement stations and the formulation of stage-discharge curves are carried out by a gauging team equipped with **high level equipment** (ADCP - Acoustic Doppler Current Profiler). Its expertise gained from the Rhone also leads it to carry out projects to set up and upgrade measurement networks elsewhere. It has developed and currently markets the HYDRO-MET[®] tool in partnership with IRD (Institut de Recherche pour le Développement). This tool permits collecting measurement data, then processing and storing it before diffusing it in real-time.



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