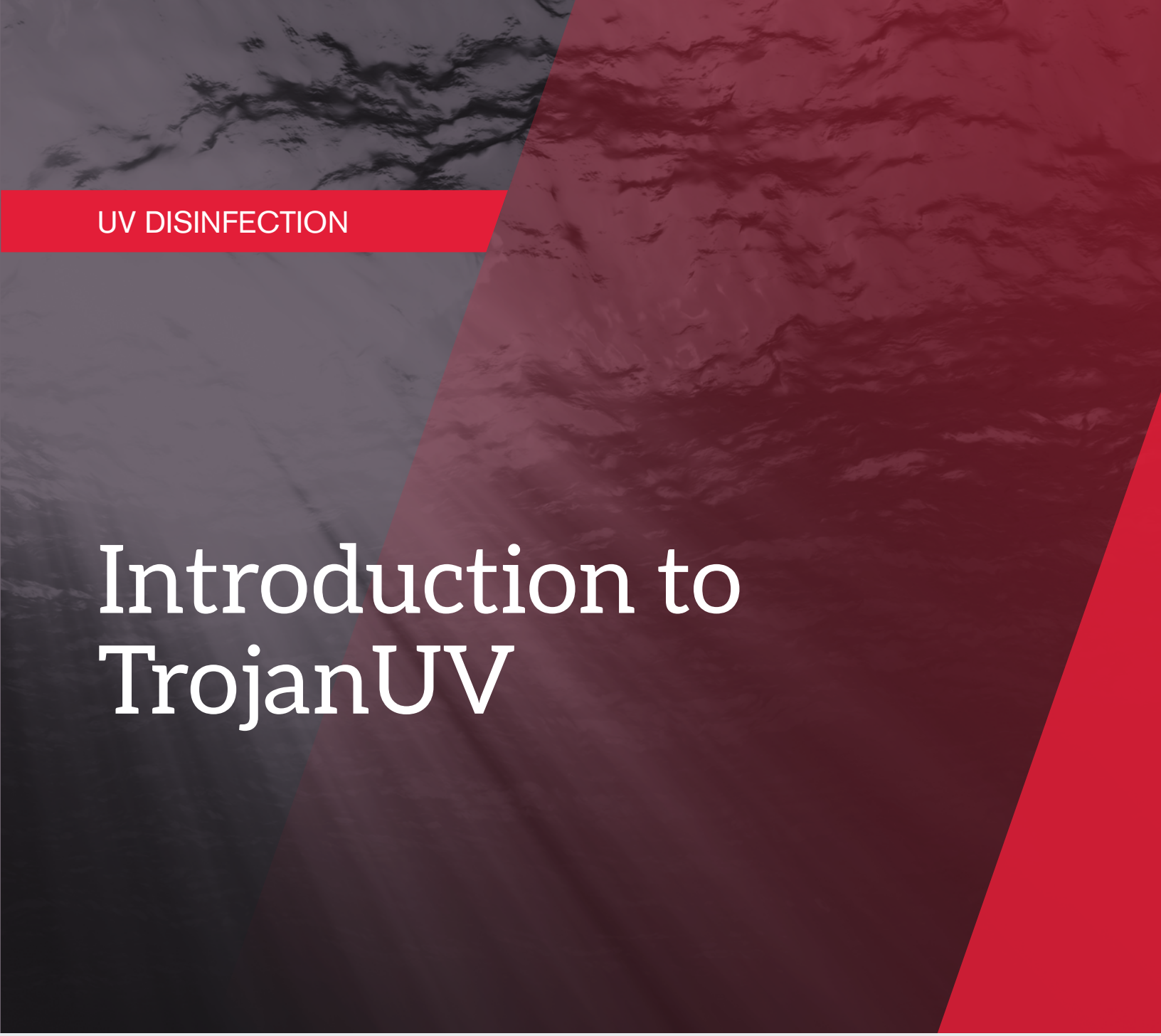


UV DISINFECTION

Introduction to TrojanUV

TROJAN UV™

Water Confidence™

Applications for Ultraviolet (UV) Disinfection

Disinfection of primary, secondary or tertiary wastewater effluent

Disinfection of high quality wastewater for reuse purposes

Treatment of stormwater, combined or storm sewer overflows

Disinfection of groundwater or surface water for drinking

Advanced oxidation (UV + hydrogen peroxide) for indirect potable reuse (aquifer recharge) and destruction of chemical contaminants such as pesticides and algal toxins in drinking water.

Wastewater disinfection in Alkhor, Qatar – 380 m^3/hr (2 MGD)

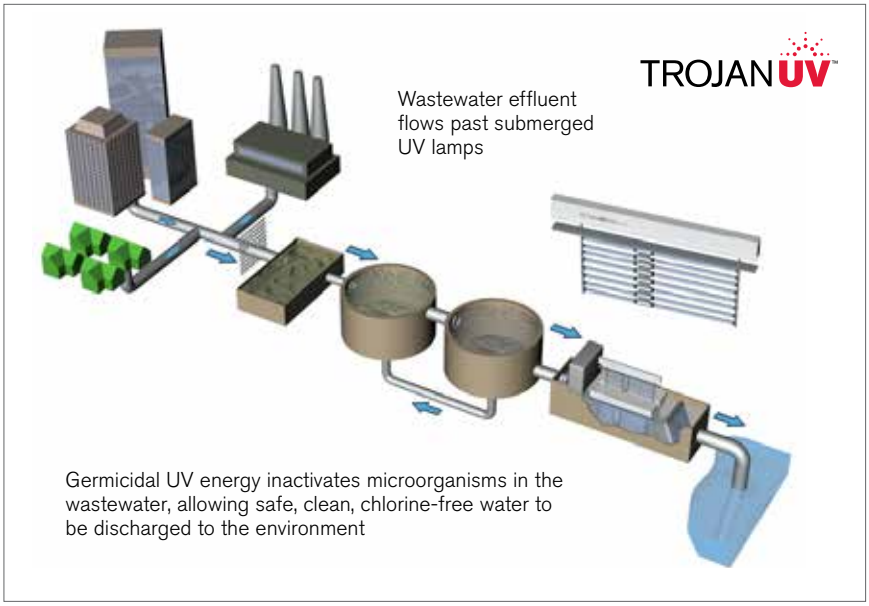
Drinking water disinfection in Tianjin, China – 6,250 m^3/hr (40 MGD)

Why Disinfect with TrojanUV?

- UV has been used to disinfect water since the early 1900's
- Bacteria, viruses and protozoa are inactivated – eliminating their ability to cause infection
- Inactivates *Cryptosporidium* and *Giardia* – two dangerous protozoa that are resistant to chlorine
- Cost-effective for both new treatment plants and existing plants that are upgrading or adding disinfection
- Safe for operators and the community - UV is a physical, chemical-free process that adds nothing to the water but light
- Safe for the environment – UV does not create disinfection by-products
- Requires a small physical footprint – reducing construction time and costs
- Highly reliable – provides consistent, confident disinfection through proper design, validation and product features
- Environmentally sustainable - recognized as the "greenest" disinfection solution
- TrojanUV systems have been installed globally – disinfecting billions of gallons of water every day

Wastewater Treatment

Disinfection is the final step in the wastewater treatment process. Bacteria, virus and protozoa populations are inactivated before wastewater is discharged into oceans, lakes and rivers. Wastewater disinfection is critical for the protection of public health and the environment. Discharged wastewater becomes the drinking and recreational water for downstream communities and has a major effect on aquatic and plant life in receiving water bodies.



Why Disinfect Wastewater with UV?

- UV is very cost-competitive with chemical disinfection - new treatment plant construction can be significantly cheaper than chlorine. See Figure 1.
- UV offers much lower operation & maintenance costs than chlorine
- UV has the lowest impact on the environment compared to other disinfection processes. See Figure 2.
- Unlike chlorine, UV cannot be overdosed and has easy, automatic dosing
- UV is extremely safe – no transportation, storage or handling of toxic, corrosive chemicals is required
- UV treats wastewater and returns it to water sources with no carcinogenic or harmful by-products

Cost Analysis

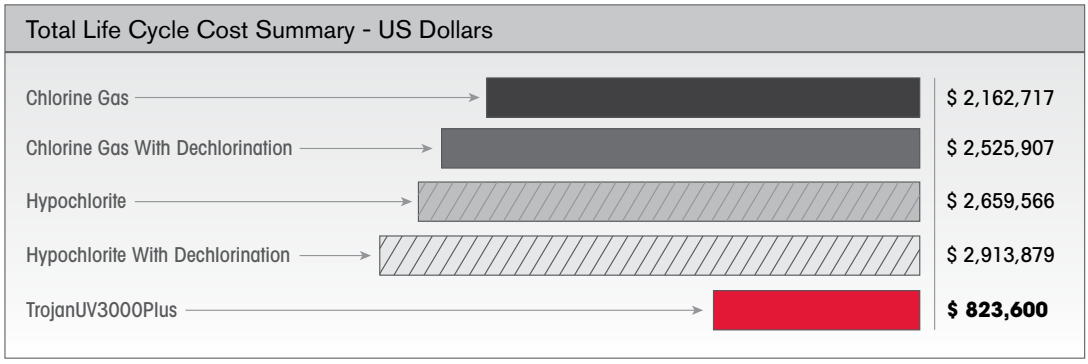
The cost to install and operate UV disinfection systems has decreased dramatically over two decades – thanks to advancements in UV lamp technology, overall system design and new product features – such as automatic cleaning. These advancements have reduced the number of UV lamps required, the electrical power consumption and total construction costs.

When evaluating disinfection options for a new treatment plant, UV has lower total cost than chlorine because of a much smaller footprint and reduced construction costs. The reaction time for the UV process takes only seconds, so a small flow-through channel is all that is required (compared to large chlorine contact basins).

UV also has lower operating costs which comprises of replacement lamps and electrical consumption. These costs are typically lower and more predictable than the volatile costs for purchasing, generating, shipping and storing chemicals for chlorine disinfection.

Most municipalities evaluate costs based on total life cycle cost – which includes installed capital expenses plus long-term (20 years) operating costs.

Figure 1. The cost of disinfection options were evaluated for a new wastewater plant in Brazil with a flow rate of 2,365 m^3/h (15 MGD). Factors accounted for include capital cost, equipment installation & construction, chemicals, lamp and power and maintenance costs. Their choice to implement UV over chemical alternatives would save the municipality between $1.3 – $2 million dollars over a 20 year period.



Environmental Benefits

TrojanUV, in collaboration with the University of Western Ontario in Canada, performed a Life Cycle Assessment to evaluate the overall environmental impact of UV and chemical disinfection. It was determined that UV had the lowest environmental impact in all impact categories (e.g. global warming potential, human health effects, ozone depletion, etc.). Factors that led to UV's positive results included small footprint, reduced construction, UV lamp recycling and not needing to generate chemicals.

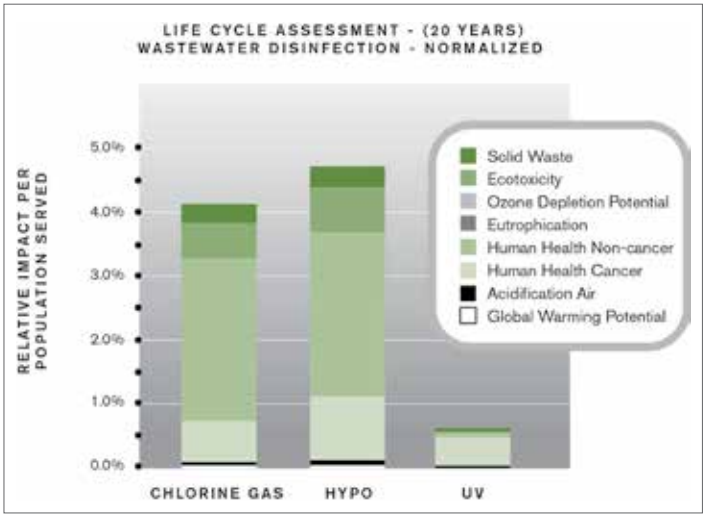


Figure 2. This Life Cycle Assessment is based on a 50,000-resident city in Washington, USA. The environmental impact of installing and operating UV is significantly lower than chlorine-based disinfection.

TESTIMONIALS

"There was some skepticism about how UV would perform - its effectiveness. That's all gone, it's proven itself."

"Given the operational costs, its effectiveness and the safety factor, UV is the best system available both operationally and for the environment."

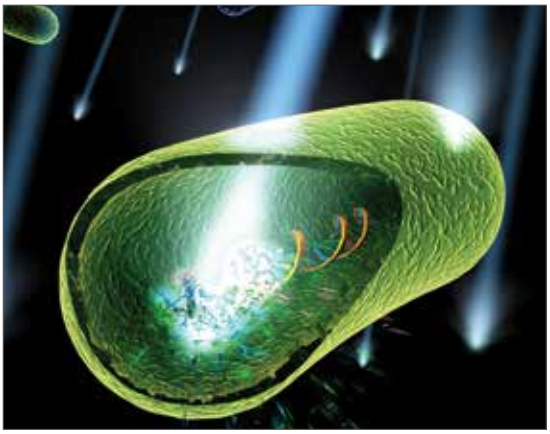
"We are right in the middle of town and a chlorine accident would have been disastrous."

What is UV Light?

Ultraviolet (UV) light is a form of light that is invisible to the human eye. The wavelength of UV light is shorter (i.e. stronger) than visible light, yet weaker than X-ray light. Specific UV wavelengths, between 200 and 300 nanometers, are categorized as germicidal. These wavelengths are able to destroy microorganisms in water, specifically bacteria, viruses and protozoa.

How UV Light Disinfects

Microorganisms in the water are exposed to UV light when they pass by the special germicidal lamps in TrojanUV systems. The UV energy instantly destroys the genetic material (DNA) within bacteria, viruses and protozoa, eliminating their ability to reproduce. Unable to multiply, the microorganisms die and no longer pose a health risk. UV technology makes it possible to inactivate harmful microorganisms, including *E.coli*, *Cryptosporidium* and *Giardia*.

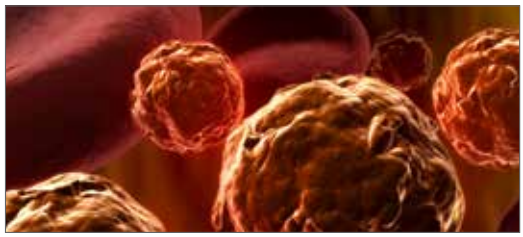


Microorganisms in the water are exposed to UV light from the TrojanUV system that destroys their DNA, eliminating their ability to cause infection.

Drinking Water Treatment

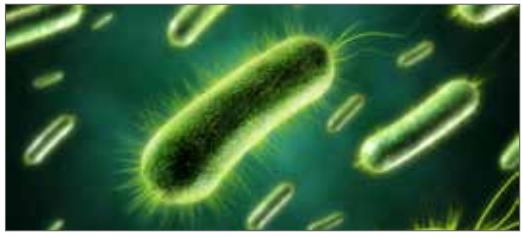
Disinfection is the critical final step in the treatment of drinking water. If untreated and ingested, bacteria, viruses and protozoa can cause severe, even fatal health conditions. *Cryptosporidium* and *Giardia* are chlorine-resistant protozoa that are ubiquitous in nature. Disinfection with UV inactivates these microorganisms - protecting public health and providing water confidence. Different microorganisms have different sensitivity to UV and chlorine, so it's critical to know what's in your water and your regulatory requirements. Alternatively, UV and chlorine can be used simultaneously to provide protection against the full spectrum of microbes, providing reliable multi-barrier protection.

Municipalities around the world – from rural wells to cities serving millions of people – have installed UV disinfection to protect their residents.



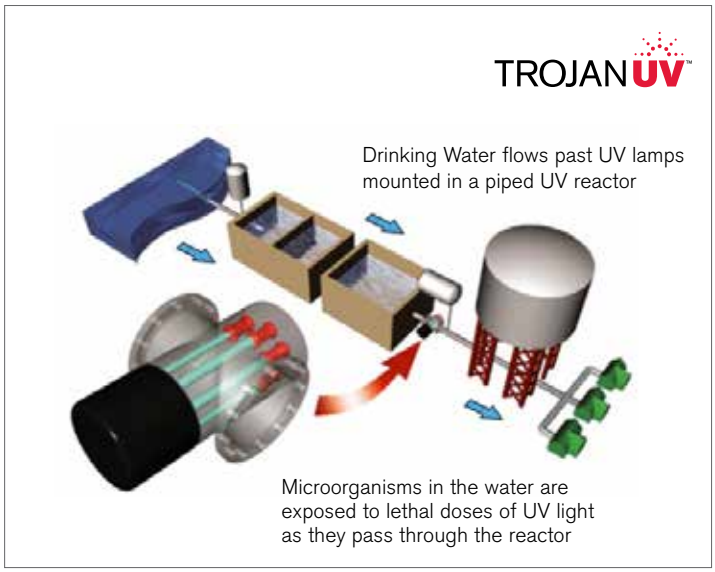
Viruses (e.g. *Polio, Hepatitis A*)

Protozoa (e.g. *Cryptosporidium, Giardia*)



Bacteria (e.g. *E.coli, Salmonella*)

UV is a highly effective way to safeguard water against microorganisms, including viruses and those protozoa that are extremely resistant to chlorine, such as *Cryptosporidium* and *Giardia*.



Why Disinfect Drinking Water with UV?

- UV costs 1/5th that of ozone disinfection and 1/10th the cost of membrane filtration. See Figure 3.
- UV protects against all microorganisms treated by chlorine – including viruses – as well as chlorine-resistant protozoa (*Cryptosporidium* and *Giardia*).
- UV provides public safety and peace of mind when added as an additional disinfection step to chlorine, called a "multi-barrier approach"
- UV enables municipalities to be proactive in meeting and exceeding new regulations

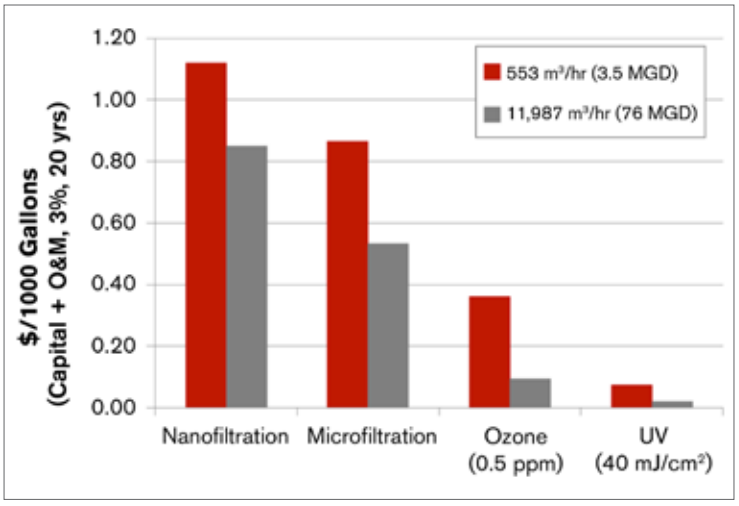


Figure 3. This analysis demonstrates, for both small and large plants, that UV is the most cost-effective technology when compared to nanofiltration, microfiltration and ozone technologies.

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UV is a simple and cost-effective disinfection solution that can be easily retrofitted into existing treatment plants. The contact time required for the UV process is only seconds so the footprint required for treatment is relatively small, eliminating the need for large contact tanks and lowering construction costs.

Features incorporated into UV systems minimize the time and expense needed to operate and maintain them. Cleaning the quartz sleeves that enclose lamps can be completed without operator involvement, using an automatic cleaning system. A touch-screen operator interface allows for easy monitoring of each UV system and can have a lamp dimming feature that allows operators to match UV dose to actual disinfection requirements.

Drinking water disinfection in Neustadt, Ontario - 47 m^3/hr (208 GPM)

Demonstrated Performance

All TrojanUV drinking water systems are bioassay validated according to United States Environmental Protection Agency (USEPA) recommendations and/or German DVGW protocol. DVGW validations offer the assurance of 40 mJ/cm^2 dose delivery while USEPA validations offer treatment flexibility, lower costs and energy while delivering a specified log reduction of target contaminant. Bioassay validation demonstrates that the regulated or required UV dose is delivered for the specified operating conditions. This validation ensures dose delivery and water confidence.

TESTIMONIALS

"We wanted a multi-barrier system for community safety. We had some issues with contact time with CT, so we really needed a multi-barrier system for better disinfection."

"We were concerned about the disinfection by-products related to chlorination. UV treatment gives us the confidence of a multi-barrier system while reducing the use of chlorine. It's perfect."

About TrojanUV

TrojanUV has led the development of water treatment solutions using environmentally friendly UV light. Today, we have the largest installed base of UV systems in operation on the planet, and many of our innovations define the industry standards for safeguarding water from the damaging effects of microbial and chemical contamination.

TrojanUV is part of the Trojan Technologies group of businesses (trojantechnologies.com). Collectively this group is dedicated to providing water confidence and has played an important role in the development of many of today's water treatment innovations. Several of the products developed by these businesses are installed in large applications around the world, and are relied upon to effectively treat the most challenging of waters.

TROJAN UV™
A TROJAN TECHNOLOGIES BUSINESS

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