The CrISTAL Project

Critical Infrastructures Security Testing & Analysis LAB

PenTesting SCADA & NCI

Real life experiences and case studies

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HITB SecConf 2008 DUBAI

DEEP KNOWLEDGE SECURITY CONFERENCE

14TH - 17TH APRIL 2008 - UNITED ARAB EMIRATES

http://cristal.recursiva.org/

$ whois raoul

Founder @ 

OPST, OPSA, Key Contributor for OSSTMM (1.5, 2.0, 2.1, 3.0)

Board of Directors of:

CLUSIT, ISECOM OWASP-Italy, Telecom Security Task Force

CrISTAL, Project Manager for Hacker's Profiling Project

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Security Evangelist @

Member / Board of Directors:

AIP, AIPSI, CLUSIT, ILS, IT-ISAC, LUGVR, OPSI, Metro Olografix, No1984.org, OpenBeer, Sikurezza.org, Spippolatori, VoIPSA.

CrISTAL, HPP, Recursiva.org

What is SCADA?

Going commercial...

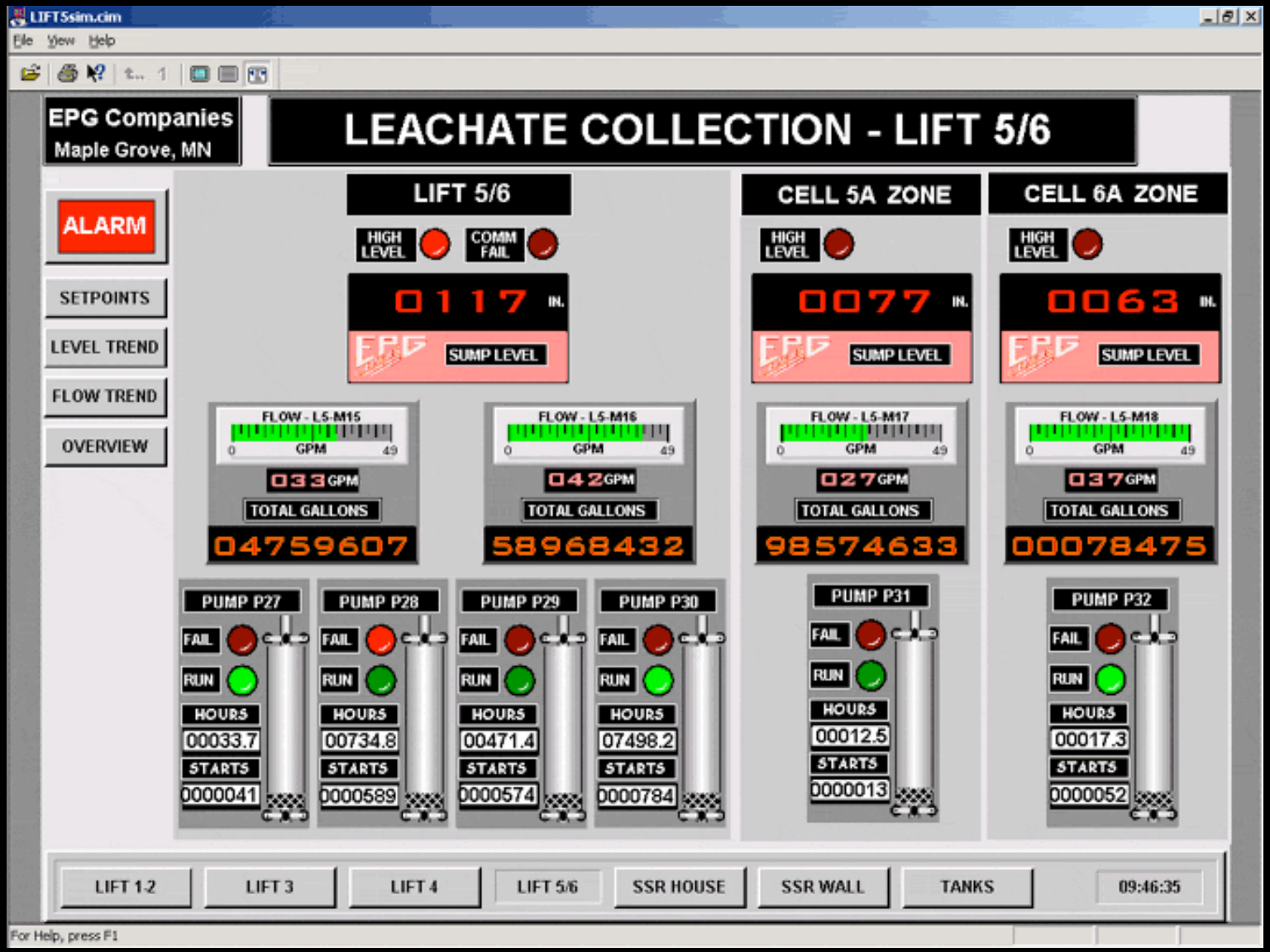
Terroristic video spot about SCADA security

SCADA

“Supervisory Control And Data Acquisition”.

It’s the monitoring branch of an automated infrastructure that decides “what to do” on the basis of “what is happening” (event driven).

Managing pumps...



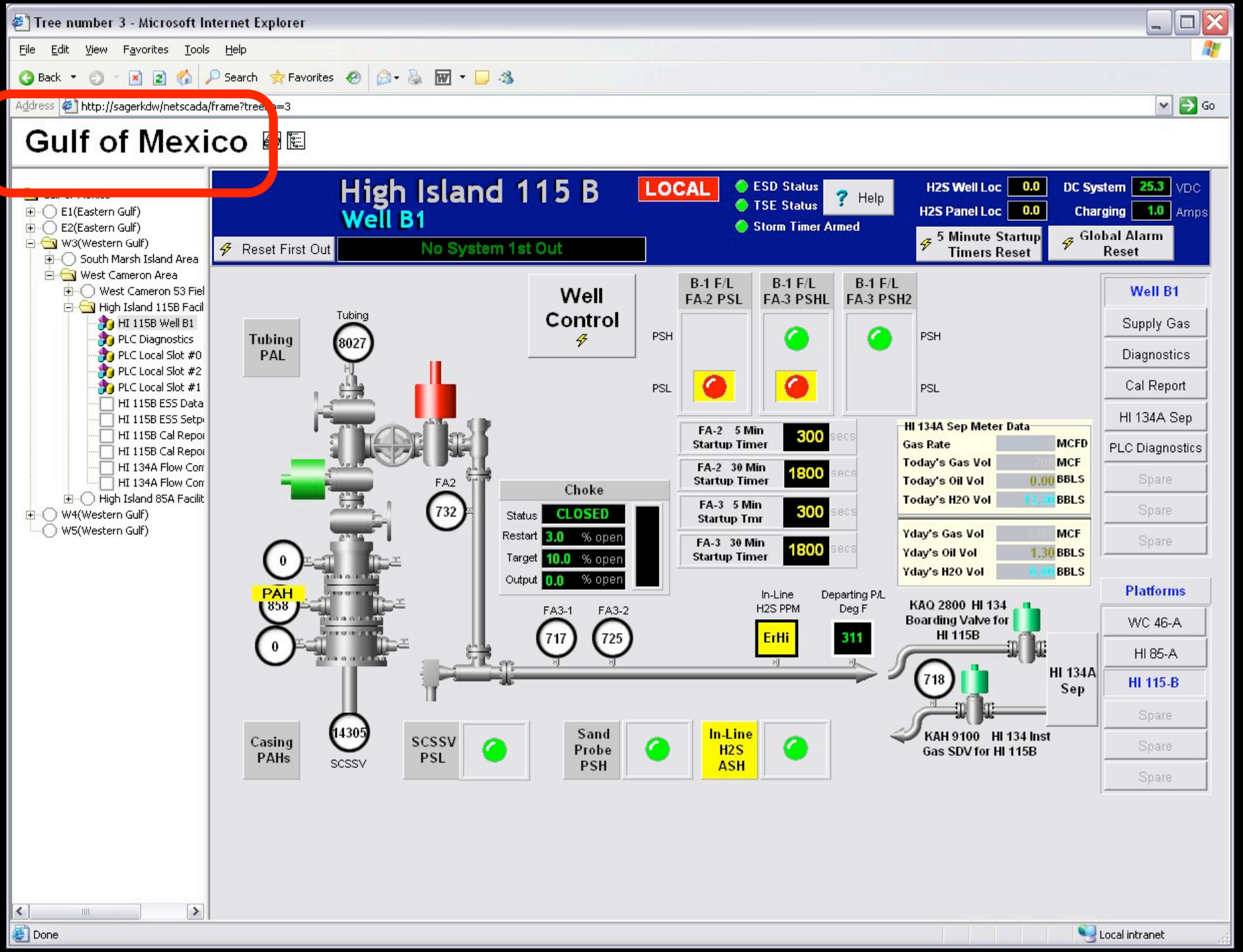
http://www.nbtinc.com/Software/telemetry-software.html

Industrial Automation

It is reality since many years

But market is migrating infrastructures:

from proprietary, obscure and isolated systems
towards standard, documented and connected ones



http://www.scadalink.com/netscada%20EI-155%20Web%20image.jpg

Critical Infrastructures

Many SCADA infrastructures are responsible for:

Power and Nuclear plants, Gas, Oil, Water distribution, Transports

but true life taught us that lack of communications crated more panic than huge incidents..

Critical National Infrastructures

Sector	Sample Target Sub-sectors
Energy and Utilities	*Electrical power (generation, transmission, nuclear)*
	Natural gas
	Oil production and transmission systems
Communications and Information Technology	*Telecommunications (phone, fax, cable, satellites)*
	Broadcasting systems
	Software
	Hardware
	Networks (Internet)
Finance	*Banking*
	Securities
	Investment
Health Care	*Hospitals*
	Health-care facilities
	Blood-supply facilities
	Laboratories
	Pharmaceuticals

Critical National Infrastructures

Sector	Sample Target Sub-sectors
Food	*Food safety*
	Agriculture and food industry
	Food distribution
Water	*Drinking water*
	Wastewater management
Transportation	*Air*
	Rail
	Marine
	Surface
Safety	*Chemical, biological, radiological, and nuclear safety*
	Hazardous materials
	Search and rescue
	Emergency services (police, fire, ambulance and others)
	Dams

Critical National Infrastructures

Sector	Sample Target Sub-sectors
Government	*Government facilities*
	Government services (for example meteorological services)
	Government information networks
	Government assets
	Key national symbols (cultural institutions and national sites and monuments)
Manufacturing	*Chemical industry*
	Defence industrial base

Parts of SCADA systems

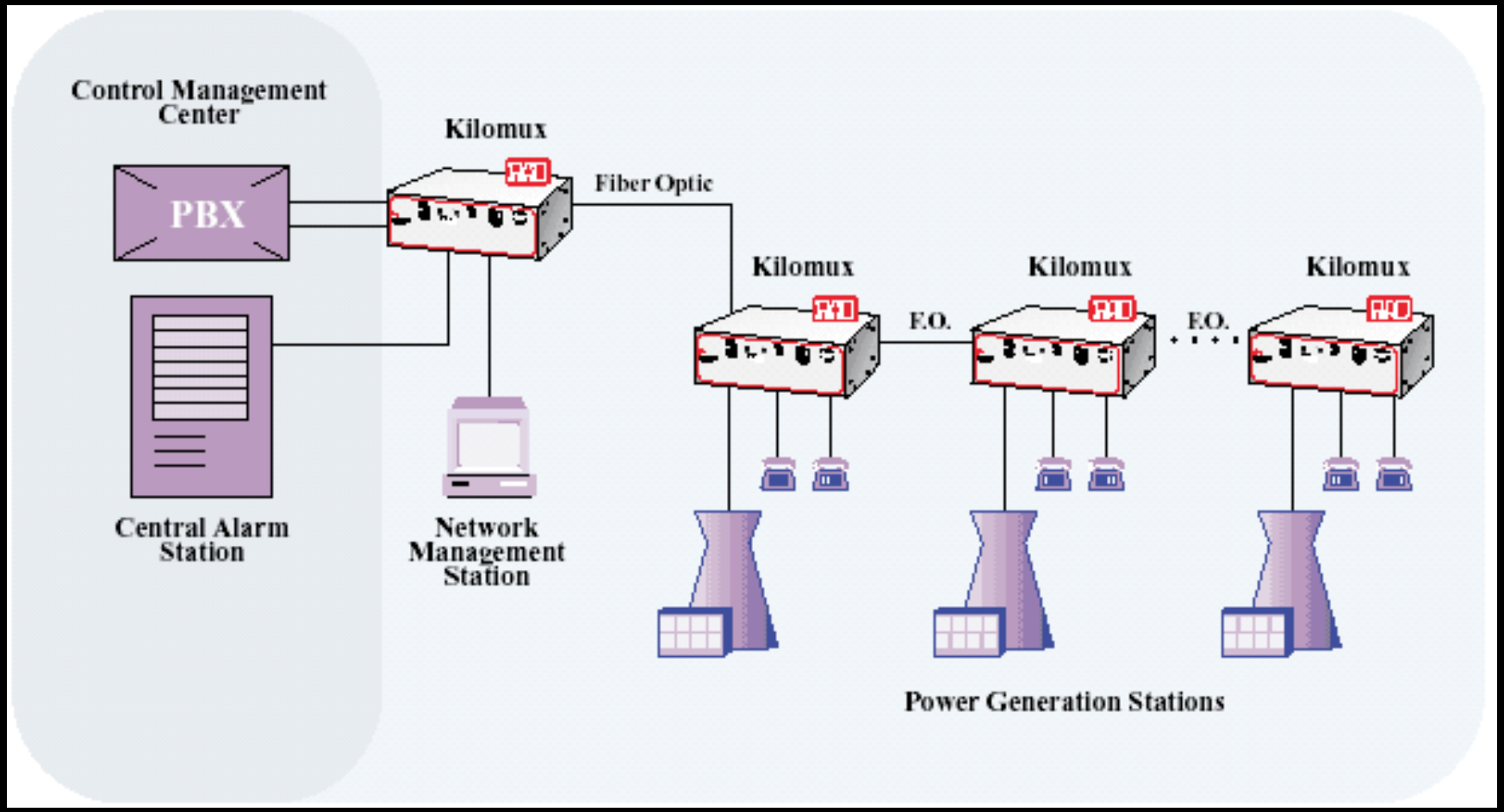
Human Machine Interface (HMI)

Remote Terminal Unit (RTU)

Programmable Logic Controller (PLC)

Communication infrastructure

A complex infrastructure: Enel



http://www.radfiber.com/Article/0,6583,27608,00.html

Enel is the biggest power distributor in Italy

SCADA Issues

Hackers know about it! :)

A lot of presentations by SCADA people talk about

- DefCon, BlackHats and similar events
- on-line password and vulnerability databases
- legacy IT tools implementing SCADA scanning/ testing/assessing features…

It seems that the outside world is really worried about hackers :)

Problems caused by ...

Vendors

People

Technology

Incidents

Customers

Incidents

People can die...

"About 3:28 p.m., Pacific daylight time, on June 10, 1999, a 16-inch-diameter steel pipeline owned by Olympic Pipe Line Company ruptured and released about 237,000 gallons of gasoline into a creek that flowed through Whatcom Falls Park in Bellingham, Washington. About 1.5 hours after the rupture, the gasoline ignited and burned approximately 1.5 miles along the creek. Two 10-year-old boys and an 18-year-old young man died as a result of the accident. Eight additional injuries were documented. A single-family residence and the city of Bellinghamís water treatment plant were severely damaged. As of January 2002, Olympic estimated that total property damages were at least $45 million."

http://www.cob.org/press/pipeline/whatcomcreek.htm

Tech details

"The Olympic Pipeline SCADA system consisted of Teledyne Brown Engineering20 SCADA Vector software, version 3.6.1., running on two Digital Equipment Corporation (DEC) VAX Model 4000-300 computers with VMS operating system Version 7.1. In addition to the two main SCADA computers (OLY01 and 02), a similarly configured DEC Alpha 300 computer running Alpha/VMS was used as a host for the separate Modisette Associates, Inc., pipeline leak detection system software package."

SCADA can save lives...

"5. If the supervisory control and data acquisition (SCADA) system computers had remained responsive to the commands of the Olympic controllers, the controller operating the accident pipeline probably would have been able to initiate actions that would have prevented the pressure increase that ruptured the pipeline."

http://www.cob.org/press/pipeline/whatcomcreek.htm

The explosion...

The accident took place in the early morning of 29 July 1995, at TransCanada PipeLines Limited (TCPL) compressor Station 30, about three kilometres southeast of Rapid City. The Board concluded that the initial rupture and fire occurred on a 42-inch natural gas pipeline (100-4) as a result of a pre-existing stress corrosion crack (SCC) in a piece of pipe downstream of the compressor station.

The resulting explosion and fire destroyed much of the communications system at the compressor station and made it difficult to shut off the flow of gas in line 100-4. As a result, natural gas pipeline 100-3, a 36-inch line adjacent to line 100-4, sustained fire damage that weakened it, and it too ruptured and caught fire.

the report...

The TSB investigation also discovered a problem with the supervisory control and data acquisition (SCADA) system. This fault in the SCADA system delayed the shutdown and isolation of lines 100-4 and 100-3

http://bst-tsb.gc.ca/en/media/communiques/pipe/1997/comm21.asp

...and Background...

"The stupid thing that is not in the report is that the low pressure and temp alarms had been malfunctioning and an engineer had dialed into the station with no password and disabled the alarms because it had been keeping him up with his pager. This engineer should not have had access but knew about the back door modem in the compressor station."

Emerson

Power Outages

Saturday, January 19, 2008; Page A04

In a rare public warning to the power and utility industry, a CIA analyst this week said cyber attackers have hacked into the computer systems of utility companies outside the United States and made demands, in at least one case causing a power outage that affected multiple cities.

CIA Policies

"The CIA wouldn't have changed its policy on disclosure if it wasn't important," Paller said. "Donahue wouldn't have said it publicly if he didn't think the threat was very large and that companies needed to fix things right now."

http://www.washingtonpost.com/wp-dyn/content/article/2008/01/18/AR2008011803277.html

Technical problems

Antivirus

SCADA systems need real-time performance.

Antivirus would degrade performances enough to make the system useless or dangerous.

Although SCADA systems are vulnerable to viruses!

Worms

"In August 2003 Slammer infected a private computer network at the idled Davis-Besse nuclear power plant in Oak Harbor, Ohio, disabling a safety monitoring system for nearly five hours."

NIST, Guide to SCADA

Patch

Patching systems is a known problem in the IT world

Changing anything is a nightmare in the SCADA world.

SLA :)

"Our service contractor provides us patches once a year."

CSO of a power distribution company

PenTesting

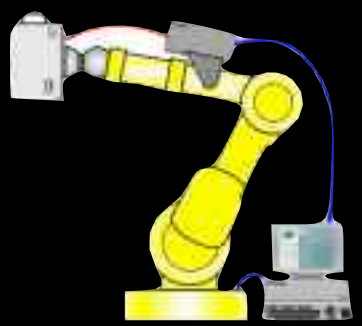
PenTesting old, small, very simple, projected-to-be-isolated devices may lead to service disruption.

The market is trying to provide a useful, but mainly "assured" method to assess SCADA networks security.

Although periodical security testing is a need, and cannot be simply ignored.

Zombie

"While a ping sweep was being performed on an active SCADA network that controlled 9-foot robotic arms, it was noticed that one arm became active and swung around 180 degrees. The controller for the arm was in standby mode before the ping sweep was initiated."



NIST, Guide to SCADA

Physical separation

Because of all these reasons, SCADA networks

must be strongly protected from

a perimeter point of view:

VLANs, DMZs, filtering, content filtering, IDS...

Vendors

Vendor Live witness

Insecure by default?

Traffic in clear text

No data encryption

No authentication

No accounting

Customers


Mr. Rossi, CIO
in a Power Distribution Company
Customer live witness
(no disclosure agreement)
The last project has been a hard work:

Common mistakes

Merged IT and SCADA network

(no physical or logical separation)

RAS/VPNs provide too much simple remote access

Default configurations

No backups at all

No tested disaster recovery plan

People...

...were used to ...

http://www.metroland.org.uk/signal/amer01.jpg

...but now have to work with...

http://www.ihcsystems.com/section_n/images/efficientdredgingnewsapril2005_Page_09_Image_0002.jpg

Blockbuster

"The power plant monitoring system was unresponsive. When emergency services arrived, they found the operator watching a DVD on the HMI system".

CSO of a power distribution company

Disgruntled employee

Vitek Boden, in 2000, was arrested, convicted and jailed because he released millions of liters of untreated sewage using his wireless laptop. It happened in Maroochy Shire, Queensland, may be as a revenge against his last former employer.

http://www.theregister.co.uk/2001/10/31/hacker_jailed_for_revenge_sewage/

Sabotage

Thomas C. Reed, Ronald Regan's Secretary, described in his book "At the abyss" how the U.S. arranged for the Soviets to receive intentionally flawed SCADA software to manage their natural gas pipelines.

"The pipeline software that was to run the pumps, turbines, and values was programmed to go haywire, after a decent interval, to reset pump speeds and valve settings to produce pressures far beyond those acceptable to pipeline joints and welds."

A 3 kiloton explosion was the result, in 1982 in Siberia.

http://www.themoscowtimes.ru/stories/2004/03/18/014.html

Newspaper call them "Hackers"

"Russian authorities revealed this week that Gazprom, a state-run gas utility, came under the control of malicious hackers last year. […]

The report said hackers used a trojan horse program, which stashes lines of harmful computer code in a benign-looking program."

http://findarticles.com/p/articles/mi_qa3739/is_200403/ai_n9360106

Thieves

Lagos, Nigeria - "At least 40 people died because of fire injuries coming from a pipeline they were trying to open to steal petroleum."

[…]

"One year ago more than 250 people died in the same circumstances near Lagos."

http://news.bbc.co.uk/2/hi/africa/6209845.stm

Terrorists

"On August 2007 Anti Imperialist Team placed a complex and powerful home-made bomb at the pipeline in Vicenza, North of Italy, the one that take kerosene from the NATO base in Aviano to the Vicenza's one".

http://www.ansa.it/opencms/export/site/notizie/rubriche/daassociare/visualizza_new.html_127962764.html

DON'T PANIC!

Security Standards

The IT 5-10 years ago ...

"The present state of security for SCADA is not commensurate with the threat or potential consequences. The industry has generated a large base of relatively insecure systems, with chronic and pervasive vulnerabilities that have been observed during security assessments. Arbitrary applications of technology, informal security, and the fluid vulnerability environment lead to unacceptable risk. […] Security for SCADA is typically five to ten years behind typical information technology (IT) systems because of its historically isolated stovepipe organization."

http://www.tswg.gov/tswg/ip/SustainableSecurity.pdf

Which future?

SCADA security evolution is at the same point IT security was 5 years ago.

Differences are to be understood, and a similar approach and security path has to be done

Does exists any SCADA Security Standard?

SCADA Security Standards

BS7799-ISO27000 Information sec. management systems – Specification with guidance for use

ISO/IEC 17799:2005 Information Technology – Code of practice for information sec. management

ANSI/ISA S.99.1 Security for Manufacturing and Control Systems

ANSI/ISA SP99 TR2 Integrating Electronic Sec. into Manufacturing and Control Systems Env.

ISO/IEC 15408 Common Criteria

NIST System Protection Profile for Industrial Control Systems (SPP-ICS)

CIDX Chemical Industry Data Exchange - Vulnerability Assessment Methodology (VAM) Guidance

ISPE/GAMP4 – Good Automated Manufacturing Practices

PCSF Process Control System Forum ; **NERC** standards ; **AGA** standards ; **NISCC** Guidelines

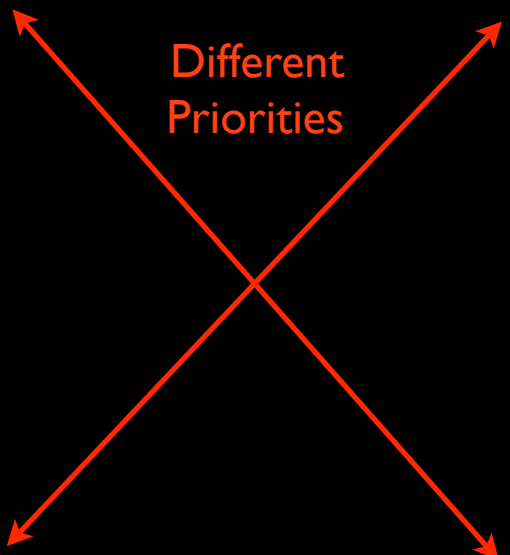
IS027000 vs. ISA-99.00.01

Traditional IT systems

Confidentiality

Integrity

Availability



Manufactoring and Control System

Availability

Integrity

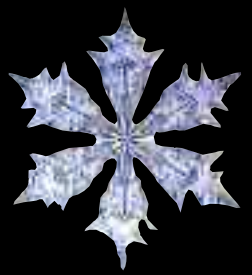
Confidentiality

The CrISTAL Project

http://cristal.recursiva.org/

CrISTAL

Critical Infrastructures Security Test & Analysis Lab was born in 2007 from some everyday-working-on-security and often-working-on-scada professionals, to inform the world about SCADA issues.



http://cristal.recursiva.org/

Project Objectives

- talk with people, as many people as possible
- exchanging experiences related to SCADA security
- perform more technical research
- measure the SCADA's market real security level
- write documents / white papers
- write necessary tools
- create a FDL methodology to pentest SCADA

Team - Key People

Elisa Bortolani

Raoul Chiesa

Alessio L.R. Pennasilico

Enzo M. Tieghi

Competences

Technical	Organizational
Analysis	Measurement
Security Testing	Education
Hardening	Ergonomics

Team - Organizations

AIPSI, ISSA Italian Chapter

AIP, Italian Association of IT Professionals

University of Verona (I.T. Science Dpt, Robotic Dpt, Psycho Dpt)

UNICRI, United Nations Interregional Crime and Justice Research Institute

Alba S.T. - implements and hardens infrastructures

@Mediaservice.net - security testing

Servitecno - designs and implements SCADA products

Trilance - GAS & Electrical Company Software House

First Steps

- ✓ released a paper for CLUSIT
- ✓ workshops at different events in Italy and Europe
- ✓ workshops for students at universities
- ✓ a first public case history, chosen among our available references and research partner companies

Companies

Airliquide.com (Cryogenics, Industrial and Medical Gas Distribution)

Mil Mil (Healthcare)

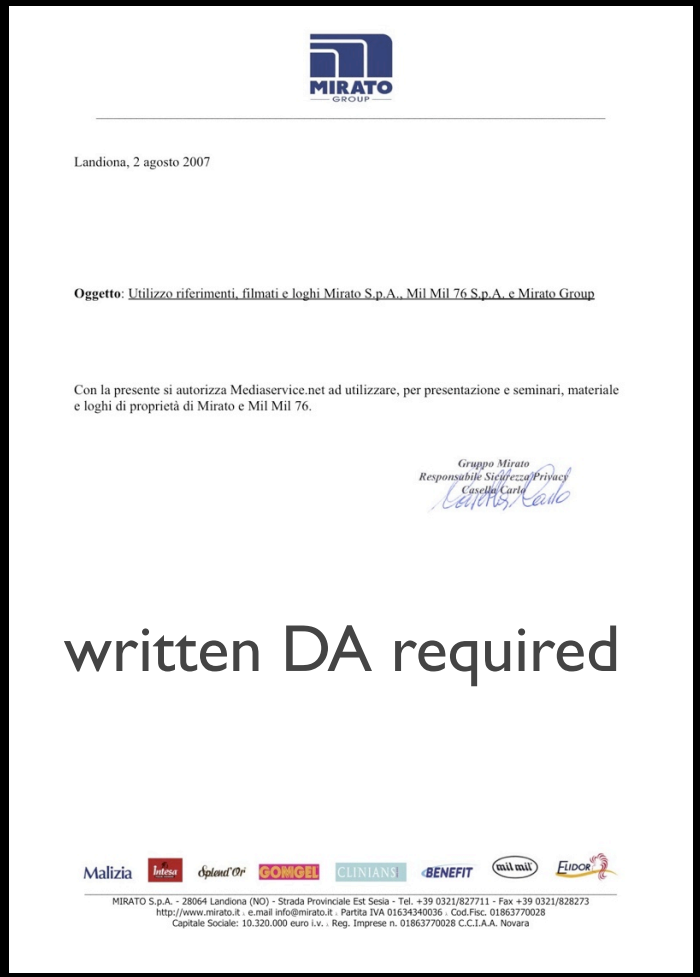
Mirato (Healthcare)

Sovema (Manufacturing)

Multiutility (Power & Gas)

Sant Luis (Manufactoring)

Others (NDA signed)



MIRATO GROUP

Landiona, 2 agosto 2007

Oggetto: Utilizzo riferimenti, filmati e loghi Mirato S.p.A., Mil Mil 76 S.p.A. e Mirato Group

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Capitale Sociale: 10.320.000 euro i.v. . Reg. Imprese n. 01863770028 C.C.I.A.A. Novara

Sovema case history video

Case History: SOVEMA® Battery Manufacturing Equipment

"… is the world leader committed with the manufacturing of battery making equipment ..."

Established 38 years ago

average 30 MLN US Dollars sales/year

Italy: about 100 employees, 10.000 sq

Offices in Europe, Asia and U.S.A.

Profibus towards ethernet

Sovema always used SIEMENS Profibus technologies

then some customers demanded for Ethernet

and they implemented a new solution...

Infrastructure details

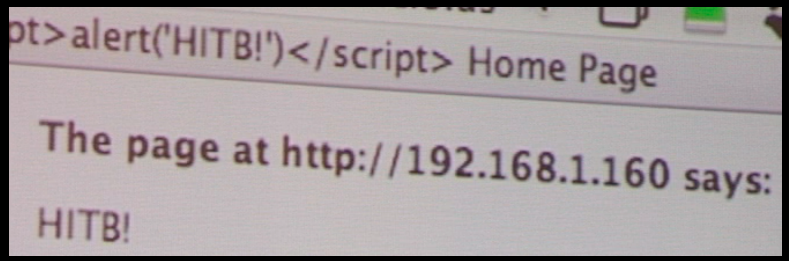
A new internal test-bed

A PLC with expansion card

An operator panel

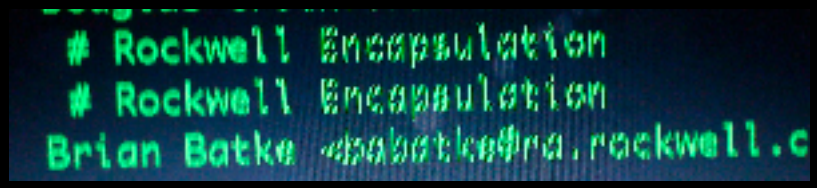
Visual alert about PLC operations

The Testbed


pt>alert('HITB!')</script> Home Page
The page at http://192.168.1.160 says:
HITB!


Allen-Bradley
PanelView
HIGH RATE DISCHARGE TESTER
BATTERY STOP
BATTERY CLAMP
TEST. HEAD
UP
DOWN
ROLLER C.
SILEN. RING
ALRM DISPL.
RESET ALRM
MSG DISPL.
ESC
F1
F2
F3
F4

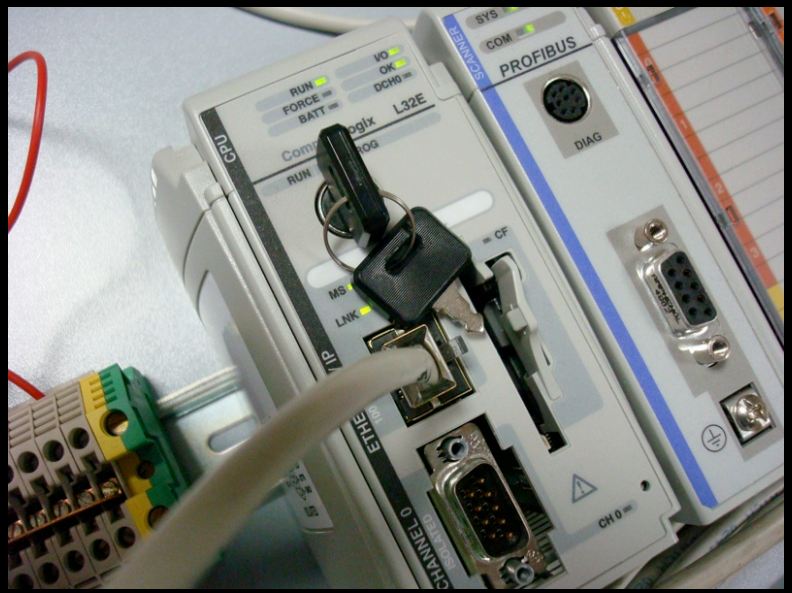

Allen-Bradley
PANELVIEW PLUS 400
MADE IN U.S.A.
CAT 2711P-K4M20A SER A REV C
100-240 VAC 0.6-0.3A
50/60 HZ 60VA


Rockwell Encapsulation
Rockwell Encapsulation
Brian Batke

Topology

192.168.1.161

TCP/IP (CIP)



192.168.1.160

Profibus
raw in/out

Tools

brain - always needed!

nmap - let's meet ...

nessus - just to be sure about stupid things :)

wireshark - do you feel the net inside yourself? :)

custom scripts/commands/hacks/test/experience

.160 Open ports

rockwell-encap (44818/tcp)

http (80/tcp)

snmp (161/udp)

rockwell-csp2 (2222/udp)

rockwell-encap (44818/udp)

No access to PLC functions trough HTTP or SNMP /

No parameters can be changed trough HTTP /

No HTTP authentication / Remote monitor via CIP

.161 Open ports

rockwell-encap (44818/tcp)

streetperfect (1330/tcp)

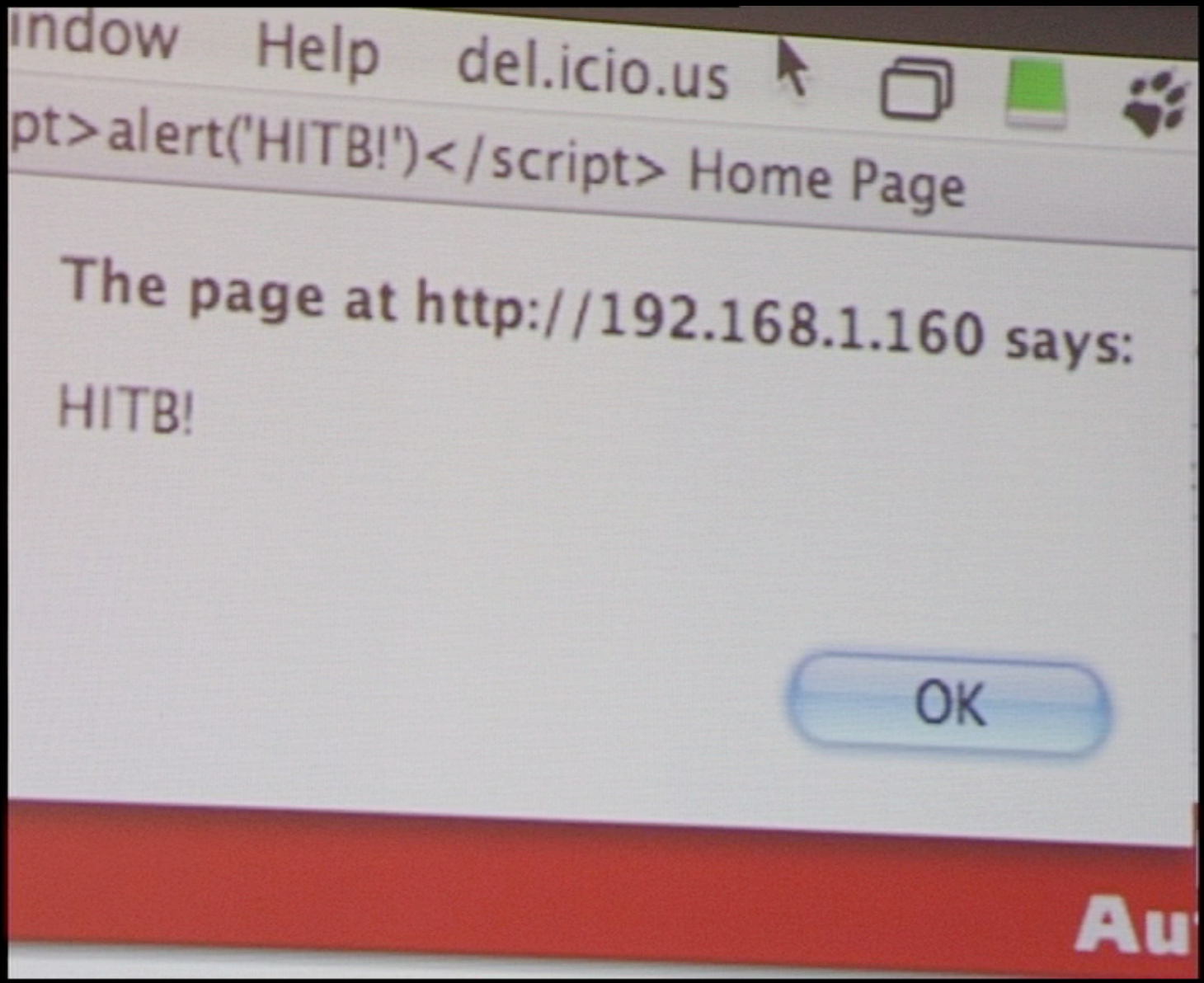
intersan (1331/tcp)

netbios-ns (137/udp)

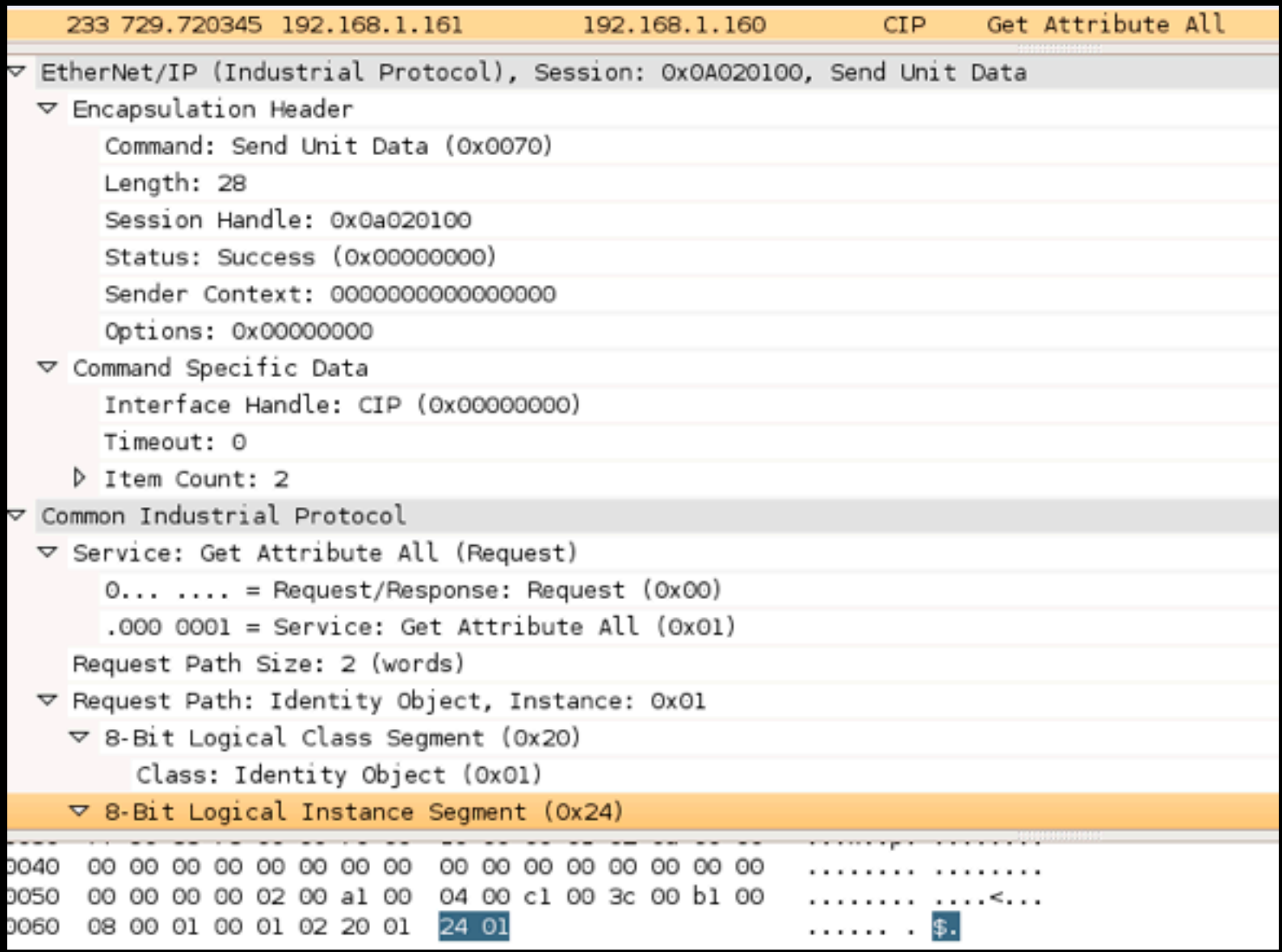
Managed trough the display / Monitored via CIP by a HMI /

Honours the source-route option / File server available

XSS


indow Help del.icio.us
pt>alert('HITB!')</script> Home Page
The page at http://192.168.1.160 says:
HITB!
OK

Clear Text Traffic



DoS

- nmap -sV / -O
- ping -f
- ping -s > 56200
- Traffic > 10 Mb/s

All conditions that make both devices unresponsive

Results

DoS:

- ping -f, ping -s 56200, nmap -sV/-O

WEBugs2.0:

- xss, no auth, but no parameters to change

Protocol:

- cleartext, easily forgeable

- snmp, but useless on SCADA, only IP

Considerations

Very simple device (both HW&SW), very tailored:

- very simple to DoS
- some “silliness”, but nothing terrible
- no huge bugs
- emerged the need for specific tools ...

Todo

- involve more people
- release a periodic bulletin about market status
- write more tech&org articles/white papers
- create a larger pool of public case histories
- write some tools (i.e. CIP injector)
- release a PenTesting methodology under FDL

Conclusions

Best Practices /I

- ✓ Split into VLANs/DMZs
- ✓ Firewall / Content Filtering / IDS
- ✓ Implement device redundancy
- ✓ Take care about physical security
- ✓ Update and verify documentation
- ✓ ... and apply policies

Best Practices /II

- ✓ Disable unused services
- ✓ Adopt AAA solutions
- ✓ Use encryption (i.e. VPN)
- ✓ Implement Quality of Service
- ✓ Use test-bed for simulations/security tests
- ✓ periodically run security tests (with a declared and common methodology)

Bibliography /I

http://csrc.nist.gov/publications/drafts/800-82/Draft-SP800-82.pdf

https://www.blackhat.com/presentations/bh-federal-06/BH-Fed-06-Maynor-Graham-up.pdf

http://cansecwest.com/slides06/csw06-byres.pdf

http://www.mayhem.hk/docs/scada_univr.pdf

http://darkwing.uoregon.edu/~joe/scada/

http://www.physorg.com/news94025004.html

http://ethernet.industrial-networking.com/articles/articledisplay.asp?id=206

http://www.apogeonline.com/libri/88-503-1042-0/ebook/libro

http://www.sans.org/reading_room/whitepapers/warfare/1644.php

http://www.digitalbond.com/SCADA_Blog/SCADA_blog.htm

Bibliography /II

http://www.securityfocus.com/news/11402

http://www.ea.doe.gov/pdfs/21stepsbooklet.pdf

http://www.visionautomation.it/modules/AMS/article.php?storyid=32

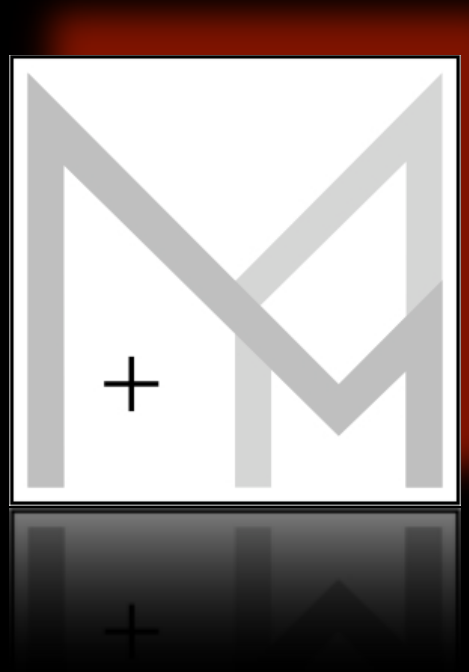
http://www.cob.org/press/pipeline/whatcomcreek.htm

http://www.securityfocus.com/news/6767

http://www.iscom.istsupcti.it/index.php?option=com_content&task=view&id=16&Itemid=1

http://books.google.it/books?id=xL3Ye3ZORbgC

Visual Credits



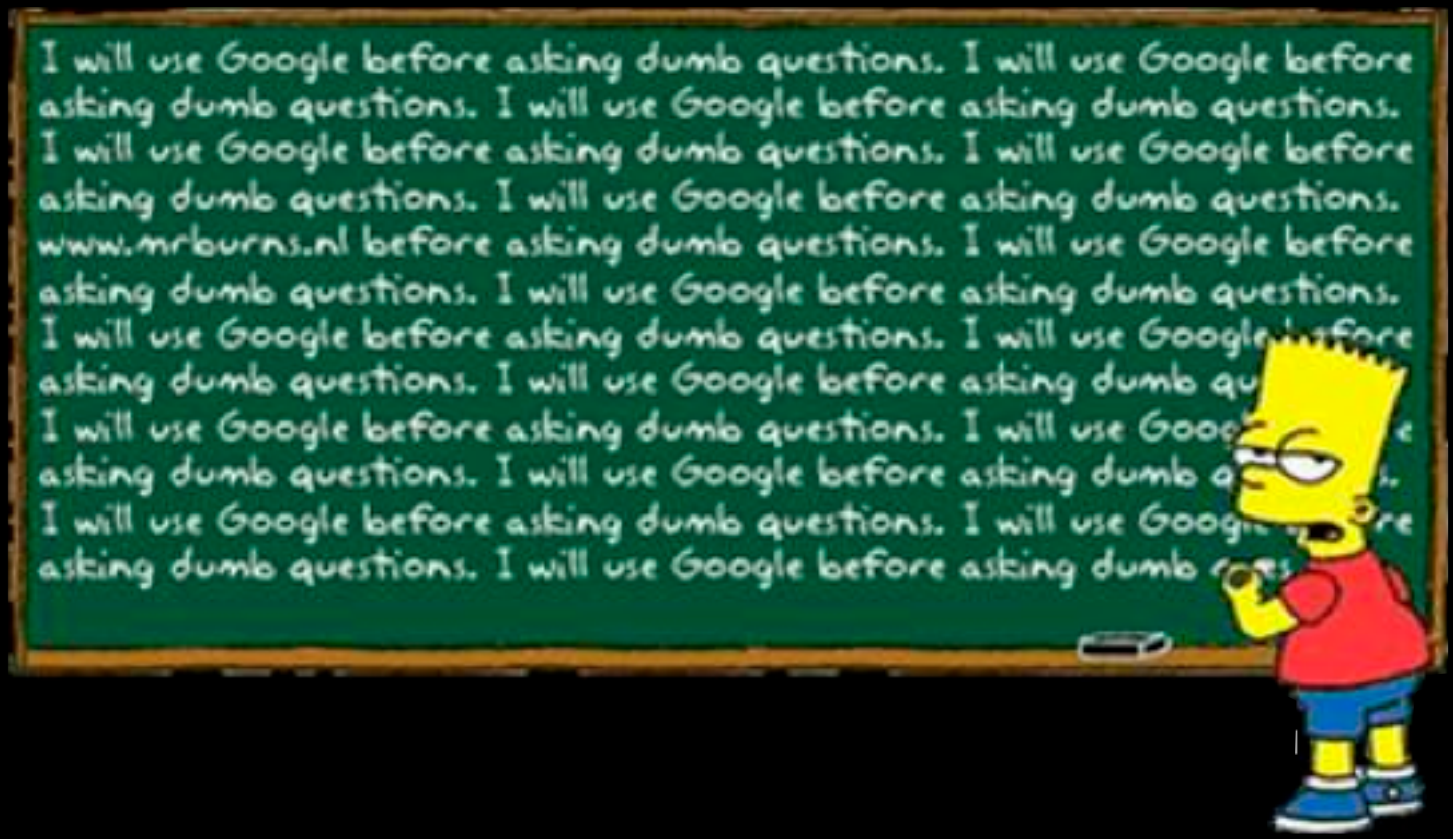
For graphics, video and ideas thanks to

Studio Miliani

http://www.miliani.it/

video@miliani.it

Questions?



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Thank You!

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