

Power Grid Monitoring and Controlling

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East China Electric Consulting Co.,Ltd**

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NASPI Meeting in Montreal Canada**

1 Introduction – China Power Industrial

2 Why WAMAP

3 WAMAP System Requirements

4 WAMAP System Specifications

5 WAMAP Features & Comparisons

6 Conclusion

China power industrial has the fastest growth in the world.

By the year 2010, the total installed generating capacity will reach 862GW;

By the year 2020, it will be 1,324GW.

Just took one year, in 2006, China gained 110GW installed capacity.

Took over 100 years, China got it's first 100GW generate capacity.



-- New development

The world first 1,000kV AC and 653km transmission line was operated since Aug, 2006 in China. It includes three substations and a double transmission line with 5 million kVA power capacity.

It connects North China Grid to Central China Grid. The cost was over 6 billion RMB.



First 1,000kV Model Line



AC Model line Opening Ceremony

-- *New development*

By the end of 2010, China State Grid will add 1,000kV transmission lines with 4,200 km and 9 substations with total capacity at 39 million kVA.

By the year 2020, China will install interstate, super high voltage power transmission line with load capacity over 200 GW. It will be 15% of the nation's total Installed units.



1,000kV AC Model Pole & Tower Test

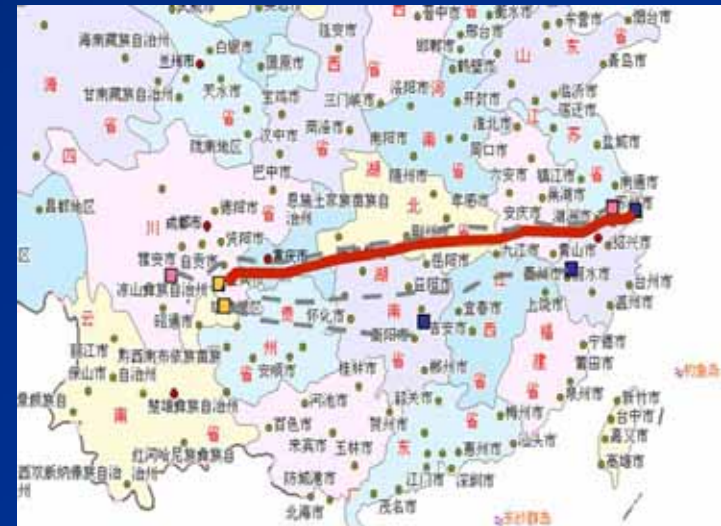
-- *New development*

The model $\pm 800\text{kV}$ DC transmission line project was launched by China State Grid in May 2007. It brings the power over 2,000km and cross 8 provinces from Sichuan in south-west of China to Shanghai in east China. It is projected to be done In the year 2012.

The maximum transmission capacity is 7,000MW. It costs over 18 billion RMB.



$\pm 800\text{kV}$ Model line Opening Ceremony



$\pm 800\text{kV}$ DC Model line Map

WAMAP -- Wide Area Monitoring Analysis Protection and controlling system

What WAMAP does:

- To meet today's high standards of power safety requirements
- Total solution for large scale power grid
- 3-state data acquisition platform
- Dynamic database design
- System analysis and online decision-making
- Online fault-simulations

How it was built:

A large scale R&D project -- WAMAP

Five years of research and development (2002 – 2007)

Hundreds of engineers were involved in WAMAP

- 9-2002 to 9-2003 System define and Study
- 10-2003 to 9-2004 Initial design and detail design
- 6-2004 to 7-2005 Phase-1 developing and FAT
- 8-2005 to 3-2006 Past RTDS test
- 11-2004 to 12-2005 PMU installation
- 4-2006 to 9-2006 Phase-1 field setup and SAT
- 1-2006 to 10-2006 Phase-2 development and FAT
- 10-2006 to 3-2007 Final phase-2 installation and SAT
- 6-2007 Phase-3 finalizing in Jiangsu, a sub grid of ECG

People who was involved in WAMAP Project

East China Gird Company (ECG)

East China Electric Consulting Co., Ltd. (ECEC)

Nanjing Automation Research Institute (NARI)

East China Electric Information Engineering Co., Ltd. → PMU Installer

NARI Technology Development Co., Ltd. (NARI TECH) }
China Electric Power Research Institute (EPRI) } PMU Supply
Beijing Sifang Automation Co., Ltd }

East China Electric Power Test & Research Institute

Shanghai Jiao-Tong University

And

ABB, Alston, SEL, WESCON (involved in WAMAP RTDS test)

1 Introduction – China Power Industrial

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5 WAMAP Features & Comparisons

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The **tremendous growth** of China's power system requires a high reliable power system which has become a major challenge for the power engineers of China.

The East China power Grid (ECG) covers four provinces and Shanghai city which are the **most developed regions** in the country. In this region of 471,400km², the land is only 4.8% of the nation's total, it creates over 30% of the GDP of the country.



China Map with circled East-China Region

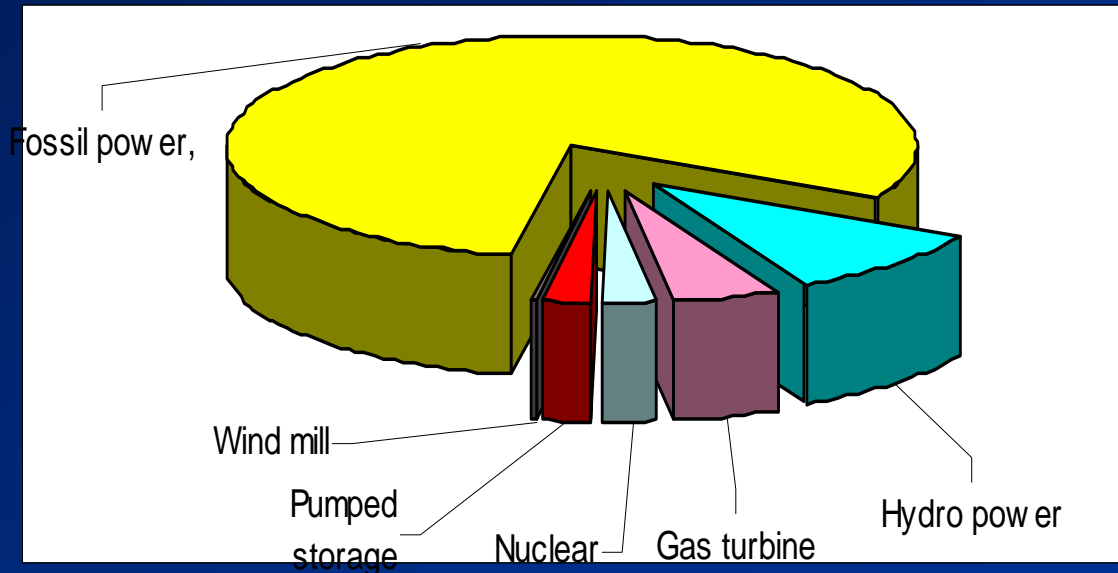


ECG's 500kV transmission lines in 2006

- Since 2006, ECG has become the **world 2nd largest wide area power grid** with maximum power load of over 100,000 MW after US PJM Company. In this summer ECG's peak load has reached over 120,000 MW.
- By the end of 2006, ECG boosted 500kV transmission lines with 15,600km, and 60 substations of 500kV with total capacity of 95 million kVA.
- In an increasingly complex power system as well as the ever greater demands in a market-driven environment in East China, power blackout prevention has become a major concern by the power companies and the government.

By the end of 2006, the total installed the capacity of power generate units in ECG has achieved 152GW.

The power that was supplied by the outside of region through 500kV DC transmission lines was accumulated up to 34.5 billions kWh in 2006.



Fossil power	80.0%
Hydro power	10.1%
Gas turbine	4.8%
Nuclear	2.7%
Pump storage	2.1%
Wind mill	0.3%

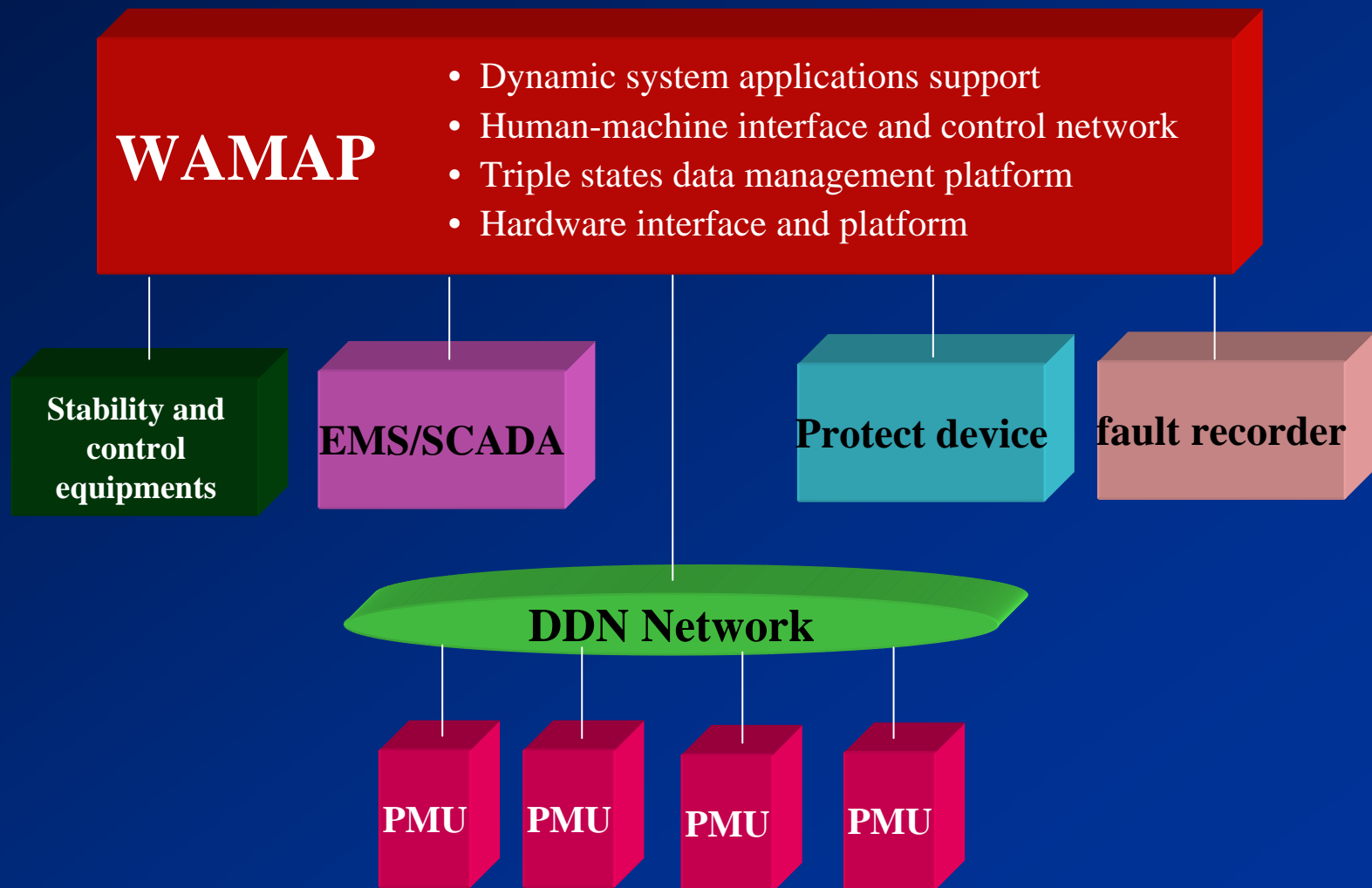
- 1 Introduction – China Power Industrial
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- 3 WAMAP System Requirements**
- 4 WAMAP System Specifications
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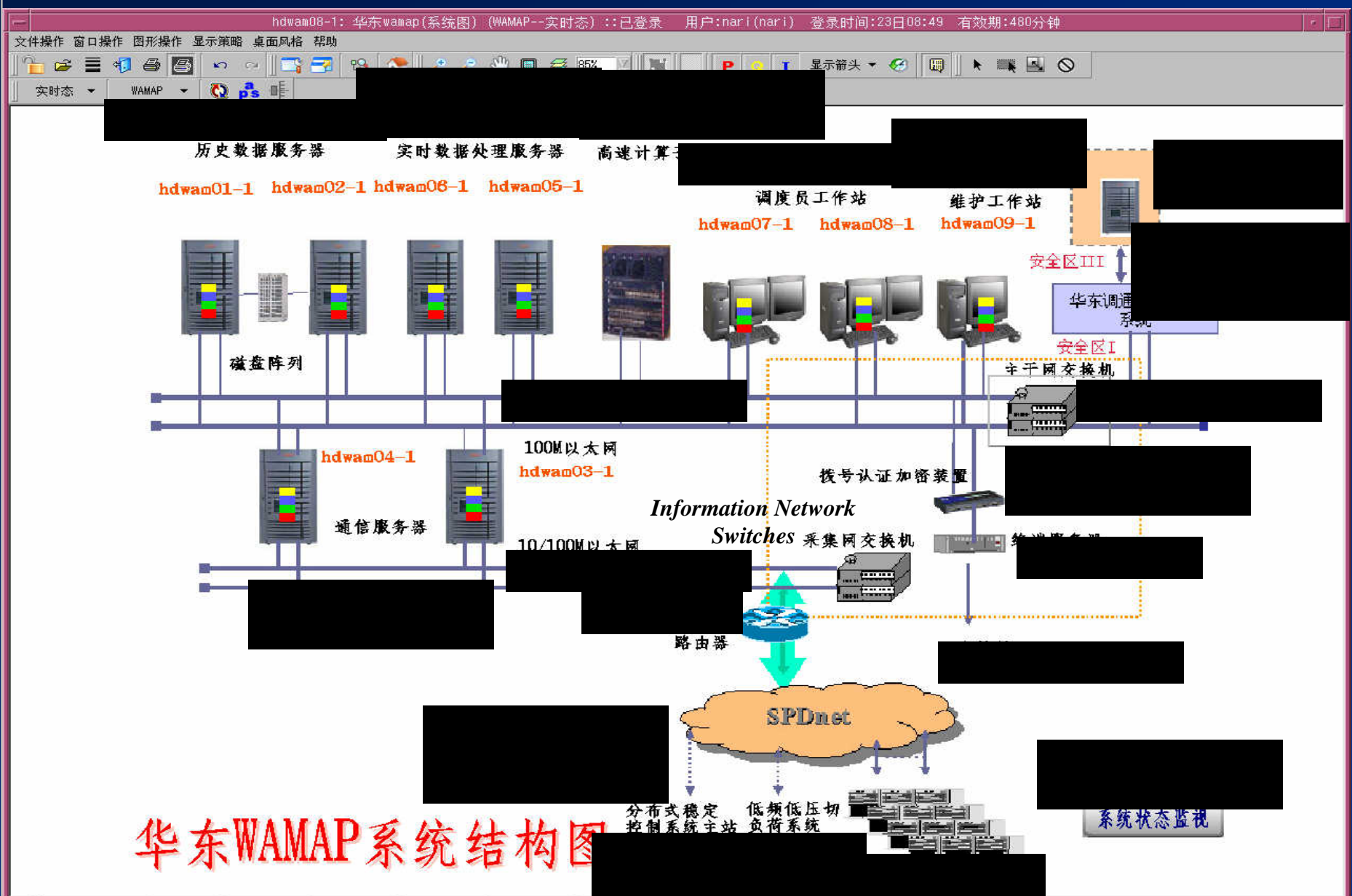
The WAMAP system requirements are:

1. To monitor and acquire steady state data as well as dynamic and transient states data.
2. To analyze the dynamics of a power system so that it can provide a decision-making assistance as well as prevention control assistance.
3. To generate a fast fault-analysis report and support an online decision making assistance.
4. To monitor the quantity and quality of the add-on services of power market.

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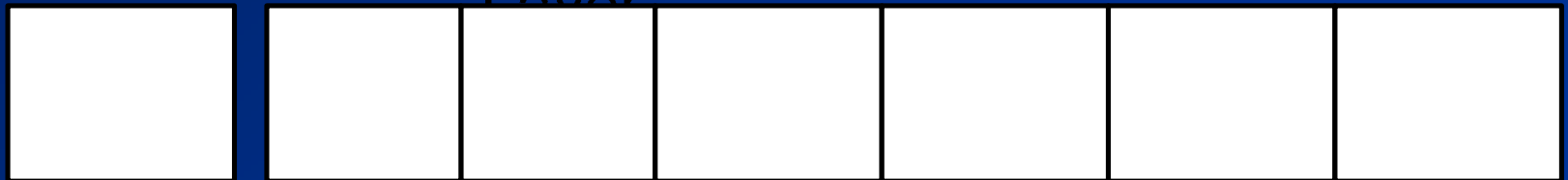
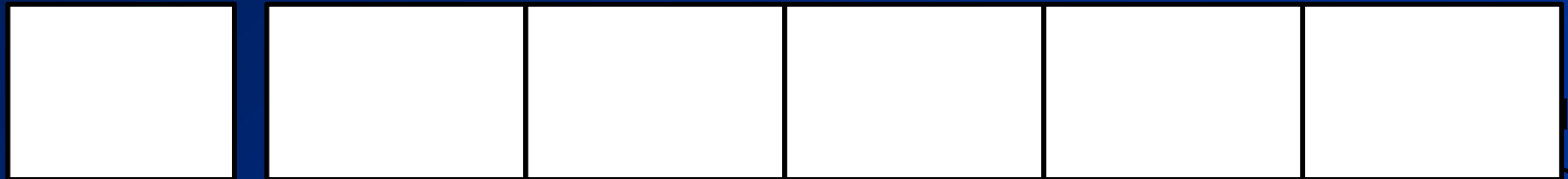
WAMAP System Configuration





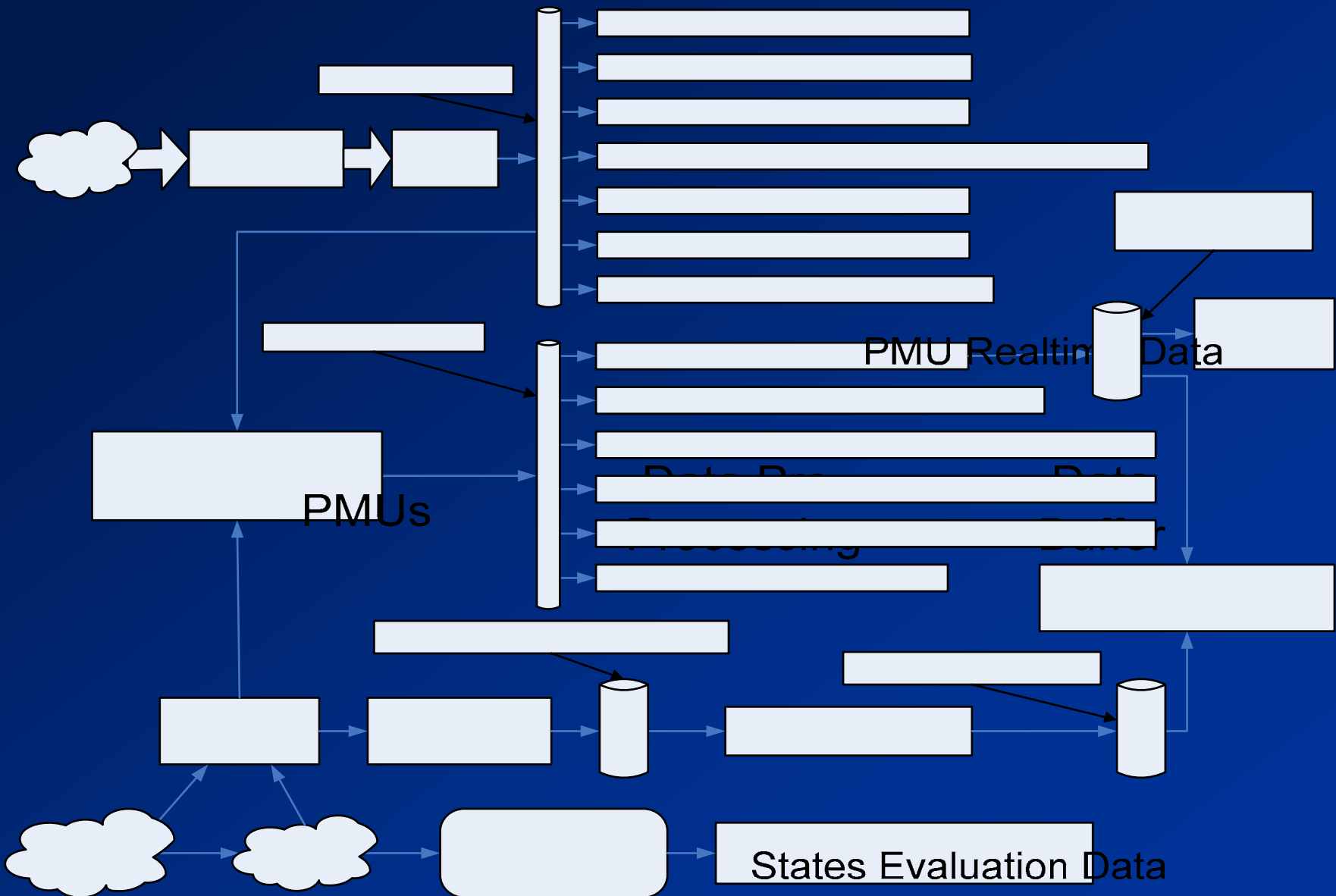
华东WAMAP系统结构图

WAMAP System Software Configuration



analysis
recognition
and Analysis
Online
Ana
Pro

WAMAP System Data Flow



WAMAP System Key Technical Specification

- System Processing Capacity: 5,000 bus points and 200 cases in 3 minutes per cycle.
- CPU power: Parallel processing method with 32 CPUs.
- SCADA/EMS Sampling Rate: 12,500 points, 2 min per cycle.
- CIM file communication format between ABB-EMS and WAMAP system.
- PMU transmission speed : 25 to 100 frame per second.
- PMU data memory storage capacity: 14 days.
- PMU standards: IEEE 1344-1995 (R2001),IEEE Std C37.118-2006

Three phases in system development

- Phase I, the main focus is on building the system's platform, the distribution of the PMUs, and the acquisition of the dynamic real-time data of the power system.
- Phase II, is based on the acquired dynamic real-time data, an algorithm is designed to analyze rotor angle, voltage, and frequency stability of the power system.
- Phase III, is an online safety evaluation and control are executed.

In Phase I,

The main focus is on the data acquisition, offline analysis and simulation.

1. Power grid dynamic performance monitoring.
2. Fast real-time fault analysis and intelligent alarm system based on the PMU information.
3. Detailed fault analysis based on the integrated power grid information.
4. Add-on service for power quality monitoring.
5. Low Frequency Oscillation (LFO) online monitoring.
6. Simulation modeling and parameter validation.

In Phase II,

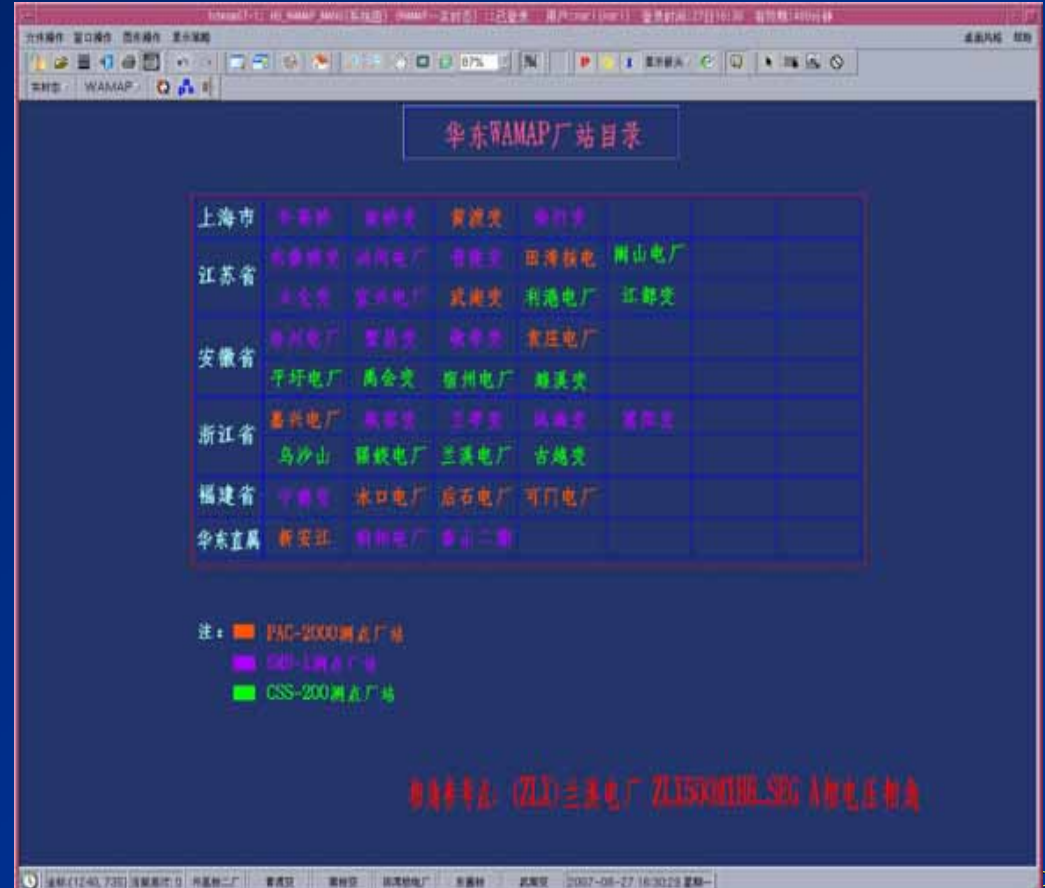
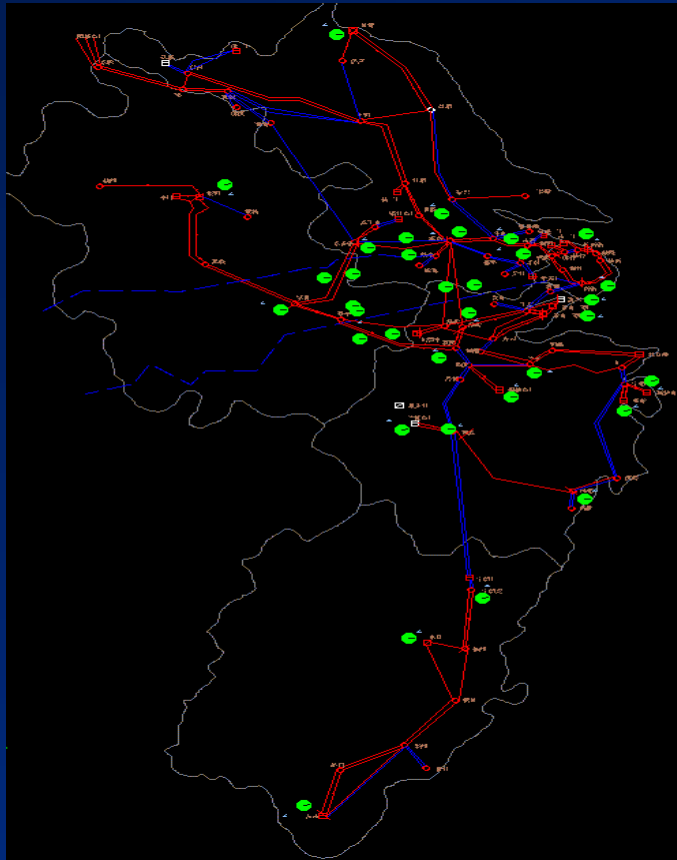
1. Integration of the State Estimation method (SE) with the PMU data
 2. LFO analysis.
 3. Online analysis and projections for rotor-angle, voltage, frequency, safety, and stability.
 4. Online monitoring for power transmission.
 5. Modeling and parameter checking.
- *In addition to the monitoring of the dynamics, the safety, and the stability of a power system, the WAMAP system provides prevention and alarm controls for a power system.*

In Phase III,

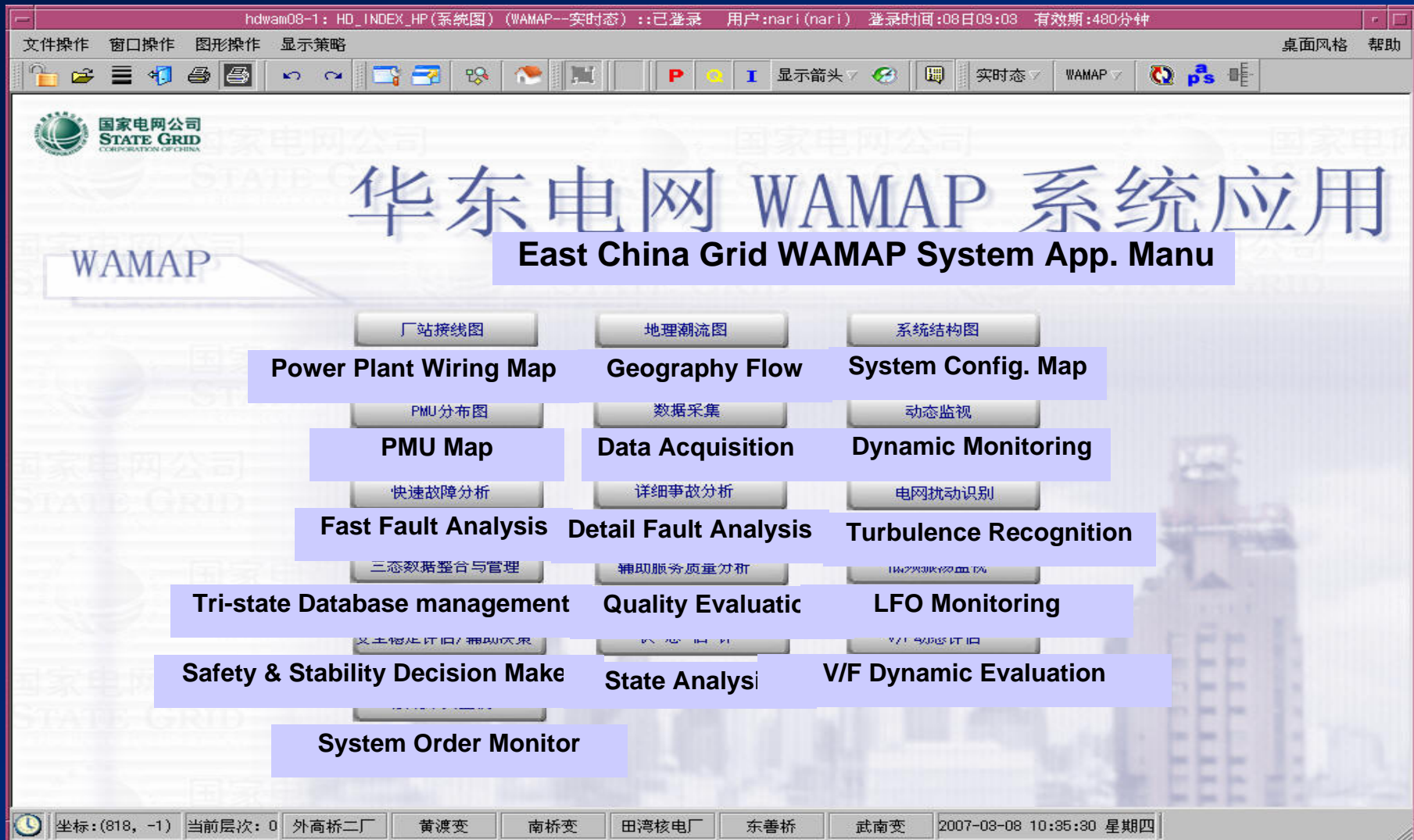
The main focus is on the implementation of the control functions.

1. To make an online dispatching adjustment by using the “Real-Time Prevention and Control Strategy Table”. The order is sent to the related generators via the AGC system and to the security control equipment.
2. To control the rotor angle of the local Power System Stabilizer’s (PSS) in order to eliminate LFO.
3. To provide a wide area protection control.
4. To provide some assistance for post-contingency decision-making.

- 40 sets PMU have been installed in power plants & substations of ECG.
- The information over 150 PMU's from four provinces will be integrated into ECG's WAMAP system in the near future.



GUI-1, WAMAP User Interface (App. Layer)



hdwam04-1: 动态监视应用(系统图) (WAMAP--实时态) ::已登录 用户:nari (nari) 登录时间:08日10:18 有效期:480分钟

文件操作 窗口操作 图形操作 显示策略 桌面风格 帮助

63% 显示箭头

实时态 WAMAP



East-China Grid WAMAP System Application Maun – Dynamic Monitoring

华东电网 WAMAP 系统应用

动态监视应用

WAMAP 10:20:38

Generator Monitoring

发电机功角监视
Rotor-angle Monitoring

功角量测超限监视
Rotor-angle Over Limit Monitoring

内电势相角监视

发电机出力监视
Output Power Monitoring

机组相量量测监视
Vector Monitoring

发电机监视

Trans. Line Monitoring

有PMU的线路功率监视
Power monitoring for line with PMU

联络线潮流监视
Data Bus flow monitoring

线路相角差监视
Line-angle Monitoring

线路功率超限监视
Line Power Over Limit Monitoring

线电压监视
Line Voltage Monitoring

相对相角超限监视
Related Angle Over Limit Monitoring

电压量测超限监视
Voltage Over Limit Monitoring

线路监视

母线电压监视

Frequency Monitoring

频率监视
Frequency Monitoring

子系统频率监视
Sub System Frequency Monitoring

频率量测超限监视
Frequency Over Limit Monitoring

频率监视

备用相角参考点列表

备	
1	母:
	母:
3	母:

饼图表示的多个功角
All Angle Display

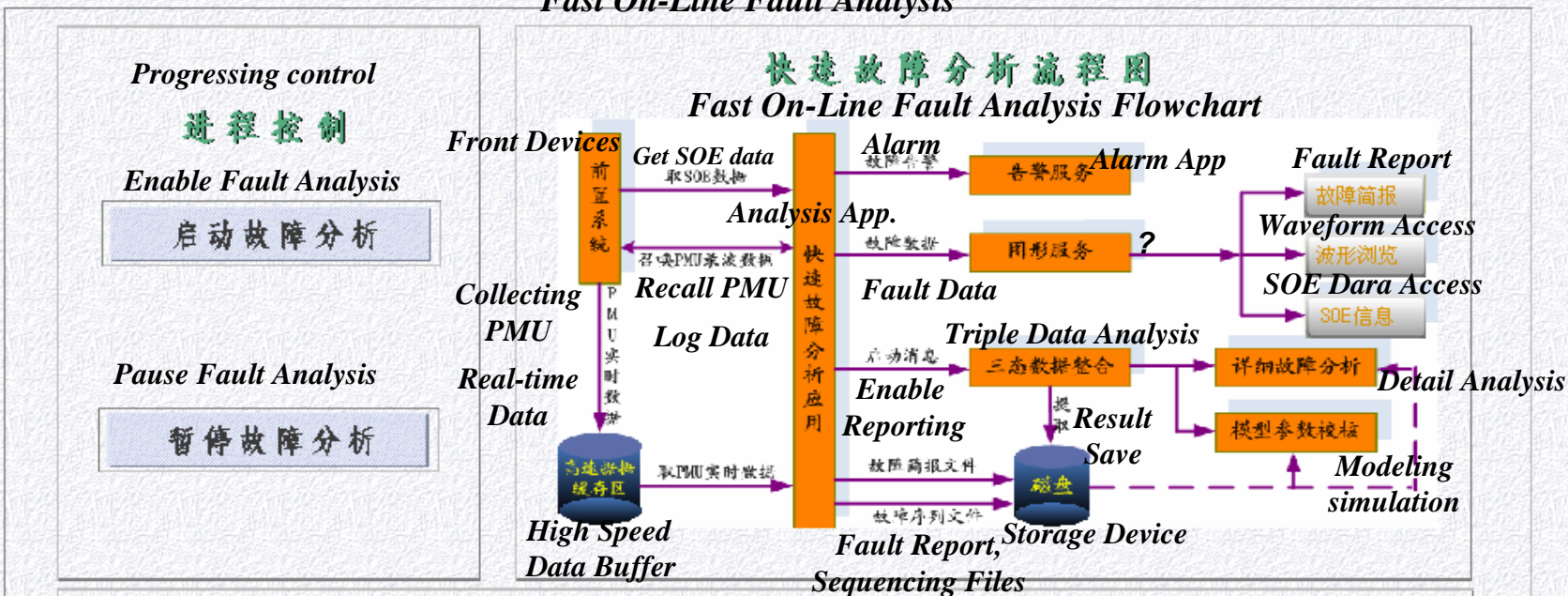
相角参考点: (JWN)武南变电所 JWN500M1BB_SEG A相电压相角



快速故障分析

21:17:30

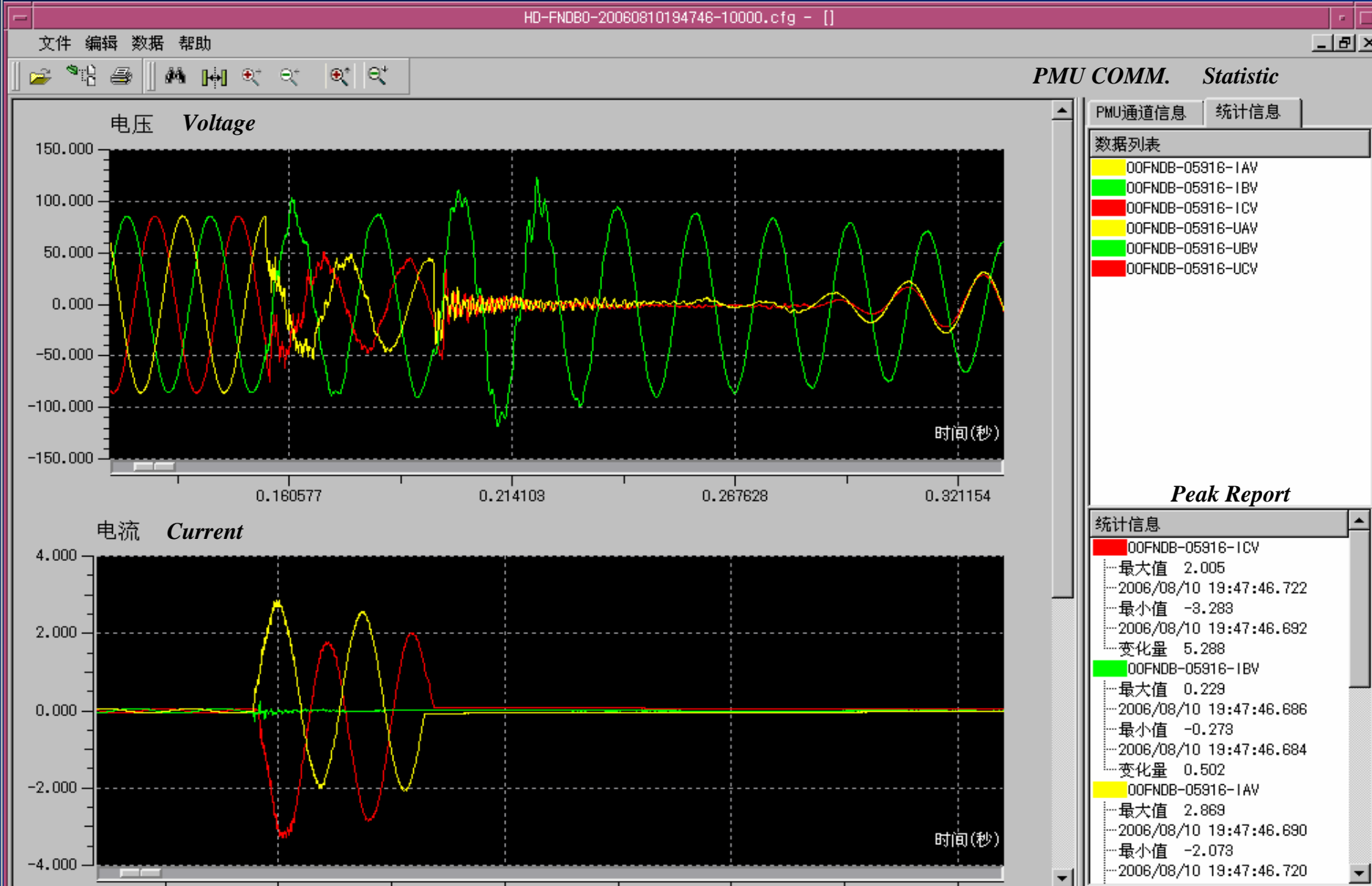
Fast On-Line Fault Analysis



快速故障分析报警区 **Fault Event Logging**
2007/02/02/ 17:35:57.270 发生故障

运行状态 快速故障分析应用正常运行中..... **Fast On-line fault analysis in progress...**

500KV Line Fault due to “SONWEI” Typhoon in FuJian, June 2006



华东电网 WAMAP 系统应用
——快速故障分析

WAMAP

- 单城量测**
 - 单城量测故障在线监测
 - 单城量测故障事件计算
 - 单城量测故障历史查询
- 双城量测**
 - 双城量测故障在线监测
 - 双城量测故障事件计算
 - 双城量测故障历史查询
- 相关应用**
 - 电网在线扰动识别
 - 电网扰动识别事件在线监测
 - 电网扰动识别事件计算
 - 电网故障案例历史查询

2024年08月26日 10:10:10 用户: 10.10.10.10 10.10.10.10

电网扰动识别事件统计

电网名称	厂名	2024年08月26日			2024年08月25日			2024年08月24日		
		事件数	成功率	失败率	事件数	成功率	失败率	事件数	成功率	失败率
华东电网	上海	10	80%	20%	15	75%	25%	12	85%	15%
浙江电网	杭州	8	70%	30%	10	60%	40%	9	75%	25%
江苏电网	南京	12	90%	10%	18	85%	15%	14	80%	20%

快速故障分析历史查询

时间	故障类型	故障位置	故障原因	故障持续时间	故障影响范围
2024-08-26 10:00:00	单相接地	110kV 线路	雷击	15分钟	10kV 用户
2024-08-26 09:30:00	三相短路	220kV 变电站	设备故障	30分钟	50kV 用户
2024-08-26 09:00:00	单相接地	110kV 变电站	绝缘老化	10分钟	10kV 用户

快速故障分析历史查询

时间	故障类型	故障位置	故障原因	故障持续时间	故障影响范围
2024-08-26 10:00:00	单相接地	110kV 线路	雷击	15分钟	10kV 用户
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2024-08-26 09:00:00	单相接地	110kV 变电站	绝缘老化	10分钟	10kV 用户



单城故障信息事件计算

时间	故障类型	故障位置	故障原因	故障持续时间	故障影响范围
2024-08-26 10:00:00	单相接地	110kV 线路	雷击	15分钟	10kV 用户
2024-08-26 09:30:00	三相短路	220kV 变电站	设备故障	30分钟	50kV 用户
2024-08-26 09:00:00	单相接地	110kV 变电站	绝缘老化	10分钟	10kV 用户

GUI -5, Add-on Services for Power Quality Monitoring

国家电网公司 STATE GRID CORPORATION OF CHINA
 East-China Grid WAMAP System Application Maun – Add-on Services for Power Quality Analysis

华东电网 WAMAP 系统应用

WAMAP

辅助服务质量分析

WAMA

1st F-Turning

2nd F-Turning

Grid Frequency Characteristic

Generator Operation status online monitoring
 机组运行状态在线监视

One time F-Turning Monitoring
 机组一次调频动作情况

After F-Turning Recalculation
 机组一次调频事后计算

F-Turning History Data
 机组一次调频历史查询

机组一次调频

Generator AGC Monitoring
 机组AGC调节性能在线监视

AGC Post Calculation
 机组AGC调节性能事后计算

AGC History Data
 机组AGC调节性能历史查询

机组二次调频

Grid Frequency Characteristic Monitoring
 电网自然频率特性在线监视

Grid Natural Frequency Characteristic Post Analysis
 电网自然频率特性事后计算

Grid Natural Frequency Characteristic History Data Access
 电网自然频率特性历史查询

电网频率特性

Frequency Point Monitoring
 频率测点监视

Grid Frequency Turbulence History Data Access
 频率扰动案例历史查询

GUI – 6A, Example of Frequency Monitoring of a Power Plant

hdwam08-1: WAM_AS_PFR机组一次调频事后计算(参数模板图) (WAMAP--实时态) ::已登录 用户:nari(nari) 登录时间:21日08:07 有效期:480

Name of -> **(ZQNGJ) 强蛟电厂 ZQNGJ2002FGEN** <- ID # of generator
 Power Plant

2007/08/19 10:14:25 至 2007/08/19 10:15:15
 共计 50.0 s 点数 100 间距 0.50 s 状态 **正常**

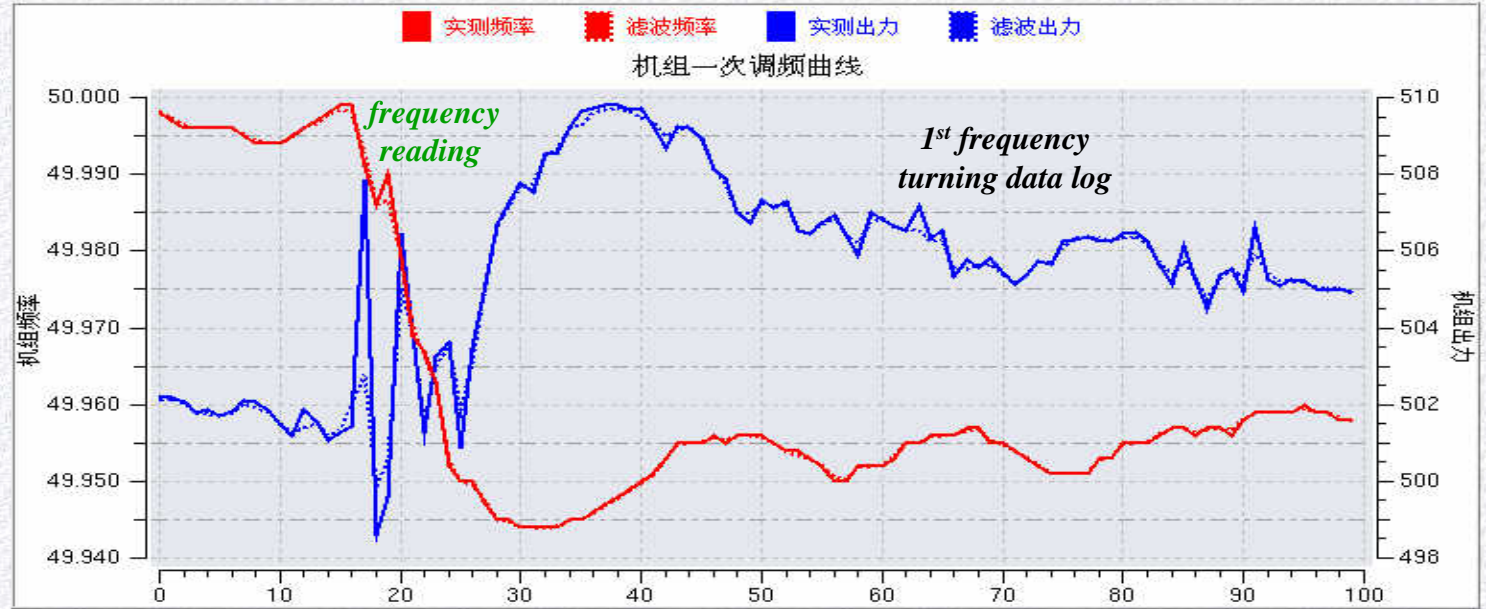
调差系数	6.9 %	延迟时间	0.0 s	调频死区	0.049 Hz
15.1 %	6.0 %	0.0 %	0.0 s	49.5 %	0.033 Hz

最近一次计算信息

机组类型	火电									
额定出力	600 MW									
机组频率(Hz)	频率初值	49.992	频率极值	49.944	对应频率	49.947	频率末值	49.955	频率变化	-0.037
机组出力(MW)	出力初值	502.5	对应出力	508.5	出力极值	509.7	出力末值	509.0	调频贡献	6.51

统计性能

统计次数	1
Tolerance	1
调差系数	6.9 %
平均值	6.9 %
偏差率	15.1 %
延迟时间	0.0 s
平均值	0.0 s
偏差率	0.0 %
调频死区	0.049 Hz
平均值	0.049 Hz
偏差率	49.5 %



GUI – 6B, Frequency Monitoring of a Power Plant (Example)

Event Time: 2007.8.26 19:20:53,

Location: Luo-He power plant in Anhui

Event Log: 600MW 4# generator was shut down.

WAMAP Monitors the responses of the regulation of excitation system of generators.

Qianjiao plant in Zhejiang



Wushashan plant in Zhejiang



Kemen plant in Fujian



Houshi plant in Fujian





GUI-8, Low Frequency Oscillation (LFO) Online Monitoring

hdwam08-1: LFO_低频振荡监视(WAMAP图形) (WAMAP--研究态) ::从主控台登录 用户:nari(nari)

文件操作 窗口操作 图形操作 显示策略 桌面风格 帮助

华东电网低频振荡在线监视

East-China Grid Low Frequency Oscillation (LFO) Online Monitoring

Start 启动监视

Exit 退出监视

Device Status Monitoring
监视设备状态

Real-time Grid Flow Monitoring
实测电网潮流

History, LFO models
历史振荡模式

History, Event Analysis
历史案例分析

History, LFO Data Analysis
历史数据研究

Control Parameter Setting
控制参数设置

? Status Calculation
计算节点状态

实测有功角有功曲线 *Real Rotor Angle Wave Form*

(ZQNGJ)强蛟电厂 ZQNGJ2001FGEN (SXUH)徐行变电站 5113

功角实时曲线 有功实时曲线

起始时刻2007/09/02 11:02:05

系统低频振荡安全信息 *System LFO Safety Information*

系统当前状态: 系统出现低频振荡!

系统最严重振荡模式 *Worst case LFO model*

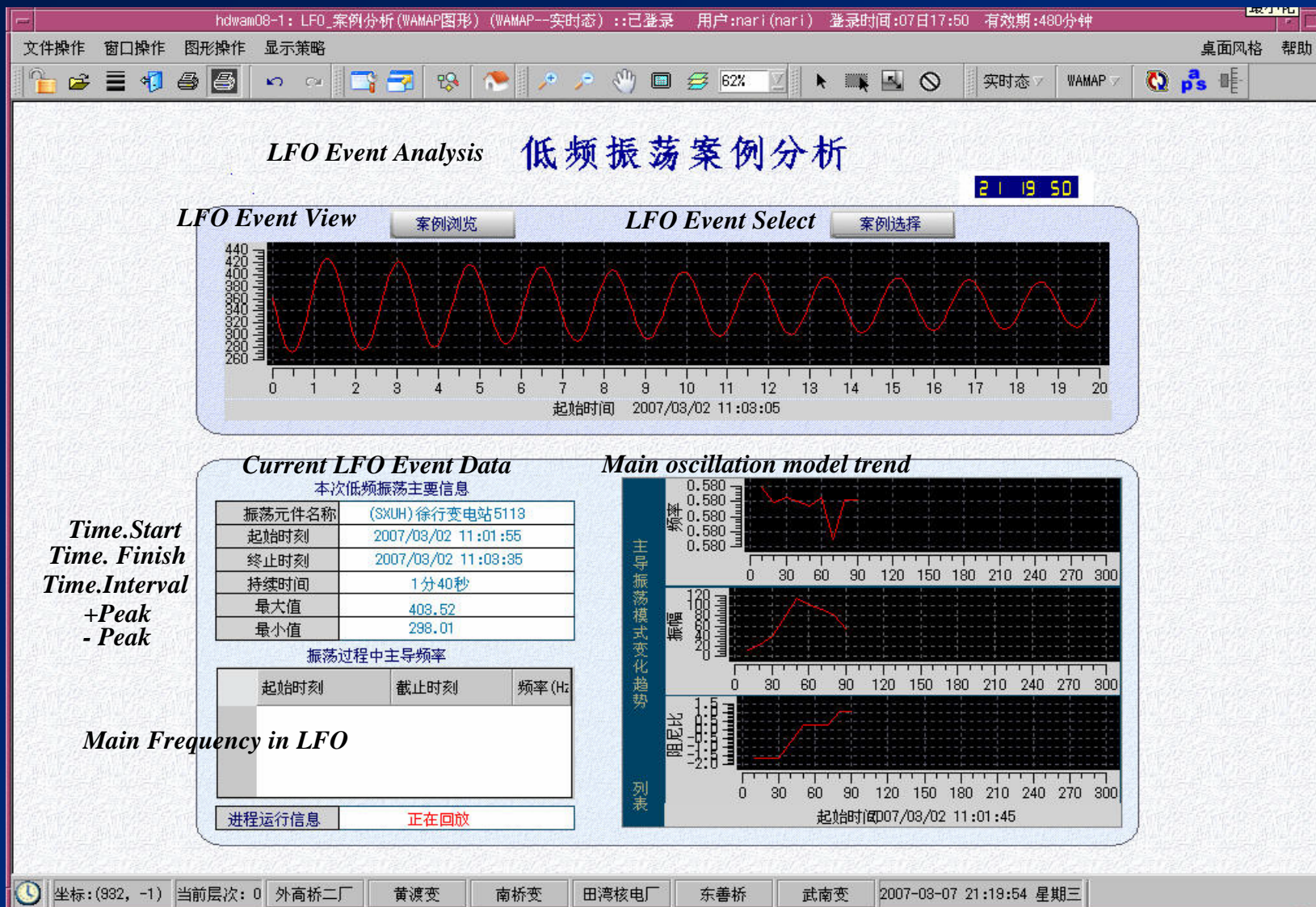
元件名称	状态	振幅	频率 (Hz)	阻尼比 (%)	参与机组
1 (SXUH)徐行变电站 5113	警告	51.53	0.58	-1.65	

LFO = 0.58 Hz

参与机组列表

监视进程运行信息: 运行正常 | 本轮计算耗时: 2秒408毫秒

GUI-9, Low Frequency Oscillation (LFO) Analysis



Ex. Report : Integration of the State Estimation (SE) with PMU data

Load flow	5905 line active power	5905 line reactive power	5915 line active power	5915 line reactive power
SCADA (Normal)	-143.2	-84.1	-241.6	-53.0
SE (Normal)	-136.3	-90.0	-239.0	-43.0
SCADA (Err. Introduce)	-200	-120	-320	-80
SE (Err. Introduce)	-169.2	-95.0	-268.5	-47.0
SE with PMU (weight factor = 0.01)	-157.0	-93.0	-260.2	-44.2
SE with PMU (weight factor = 1.00)	-138.7	-93.2	-241.0	-47.0

GUI-10, Turbulence Online Identify – Cut off test on 600MW Generator

Turbulence Info.

电网扰动信息

Turbulence Type

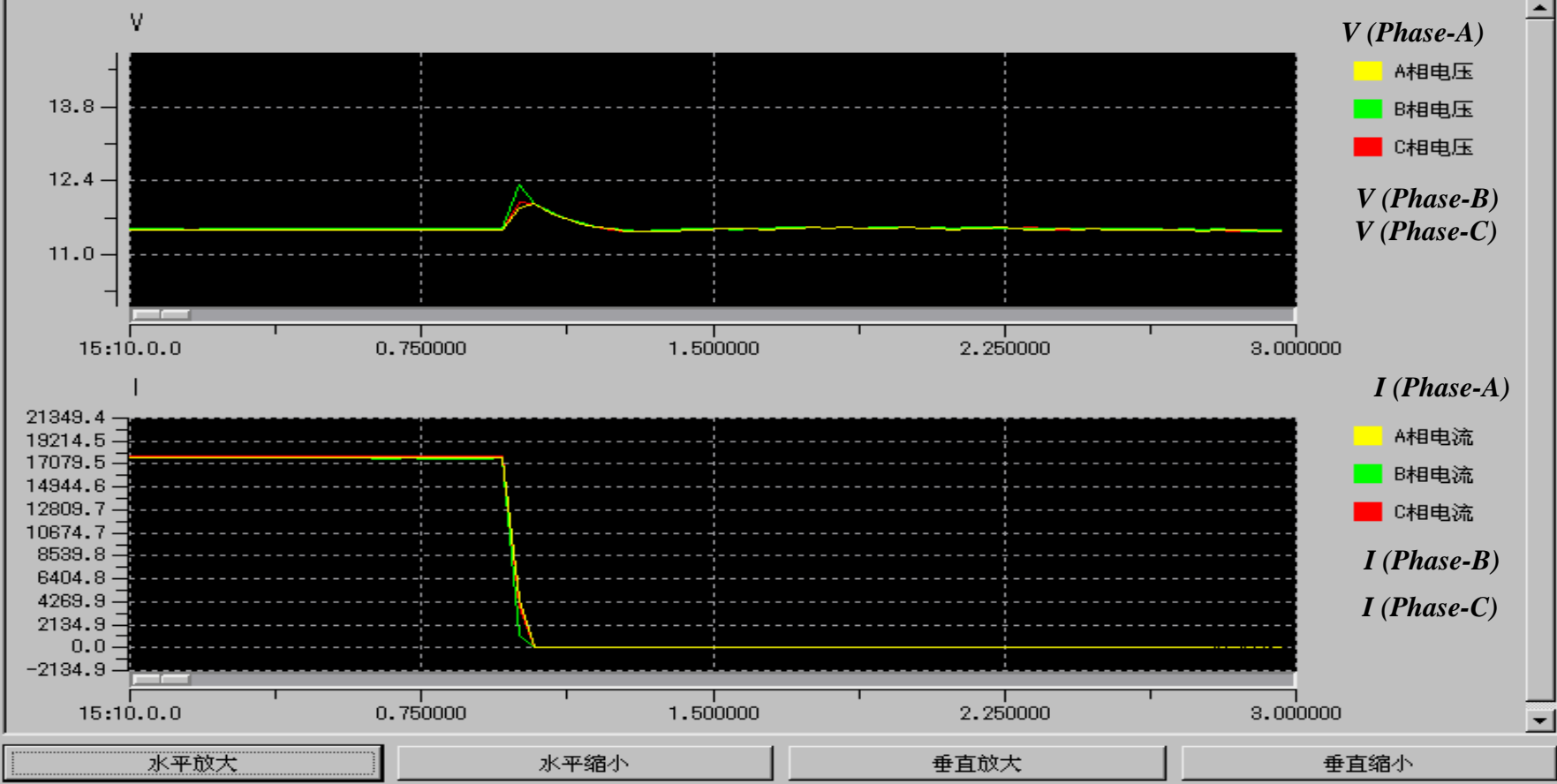
设备: ZWSS2003FGEN 时间: 2006/09/22 23/15/11:880

类型: 切机扰动

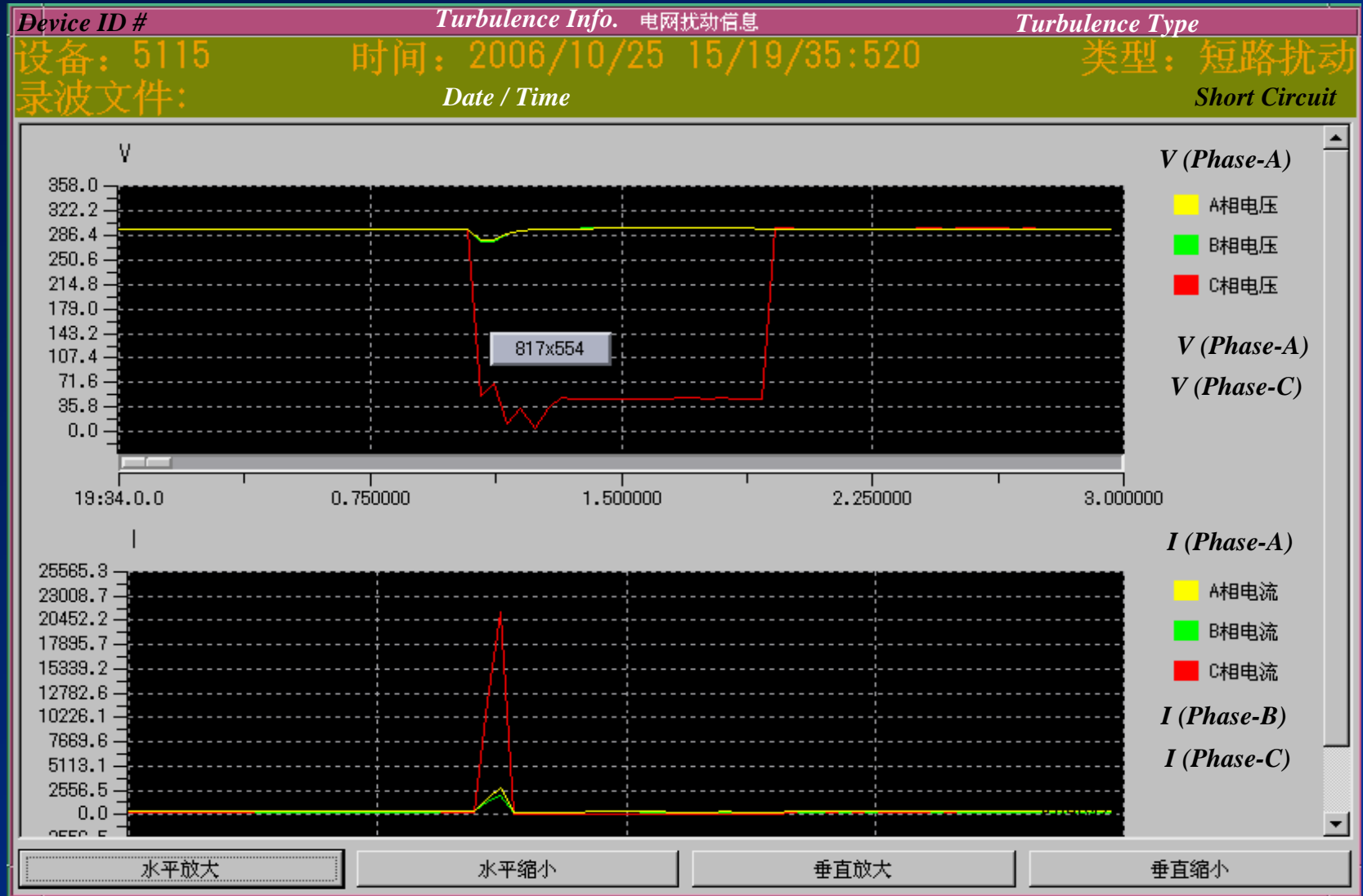
录波文件: Device ID #

Date / Time

Cut off Turbulence



GUI-11, Turbulence Online Identify -- Short Circuit in a 500kV Line



GUI-12, Online Safety Analysis Based On V & F

hdwam07-1: WAMS_PQ_INDEX_unit(WAMAP图形) 本地比网络版本高 (WAMAP--实时态) ::从主控台登录 用户:nar l(nar l)
桌面风格 帮助

文件操作 窗口操作 图形操作 显示策略

实时态 WAMAP

电压和频率动态安全评估

V & F Dynamic Safety Estimation

电压和频率最小裕度曲线

V & F Minimum safety gap curve

V Safety Limit F Safety Limit

V_Safety_Status

电压安全状态: 电压安全 V SAFE

电压裕度最小值: 87.71 **V_Gap_Min.**

裕度最小母线: (ZPY)瓶窑变电所 ZPY500M1BB-SEG

F_Safety_Status

频率安全状态: 频率安全 F SAFE

频率裕度最小值: 78.62 **V_Gap_Min.**

裕度最小母线: (ZJX2C)嘉兴二厂 ZJX2C500M1BB-SEG

V Bus Monitor

监视电压母线

Real-time Voltage

线电压当前值

F Bus Monitor

监视频率母线

V_Over Limit

电压量测超限

Safety Gap History Data

历史裕度查询

Real-time Frequency

频率当前值

Control Parameters Setting

控制参数设置

F_Over Limit

频率量测超限

坐标:(736, 617) 当前层次: 0 外高桥二厂 黄渡变 南桥变 田湾核电站 东善桥 武南变 2007-08-09 14:18:12 星期四

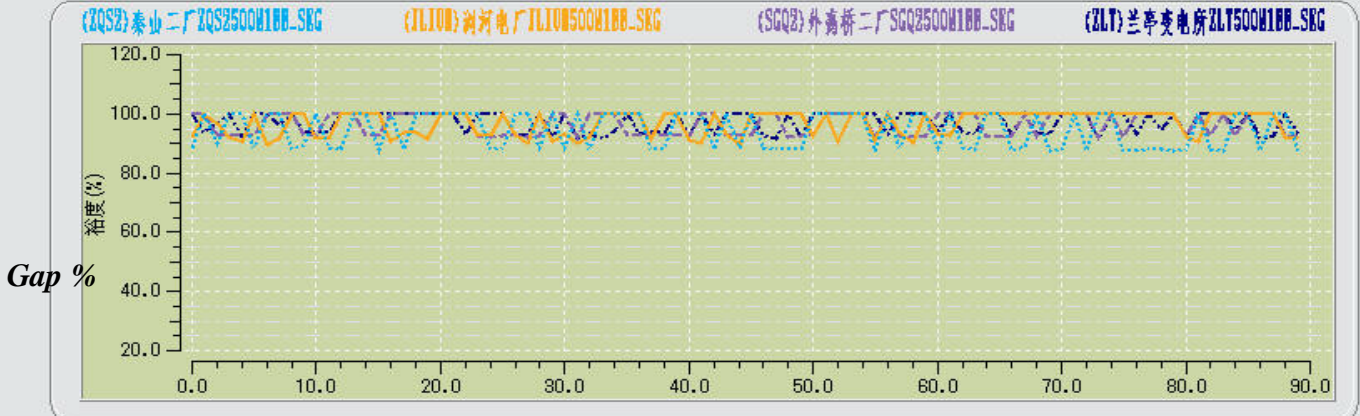
GUI-13, Online Safety Margin Analysis for Bus Voltage

hdwam08-1: WAMS_PQ_电压监视母线(WAMAP图形) (WAMAP--实时态) ::已登录 用户:nari(nari) 登录时间:07日17:50 有效期:480分钟

文件操作 窗口操作 图形操作 显示策略 桌面风格 帮助

实时态 WAMAP

母线电压安全裕度 BUS Voltage Safety Estimation



母线	Bus name	区域Area	安全状态 Safety Status	安全裕度(%) Safety gap%	阈值 Threshold (p.u)	持续时间 Time Interval
1	(ZQS2)泰山二厂 ZQS2500M1BB_SEG	华东直属	电压安全	87.70	0.75	1.00
2	(JL1UH)浏河电厂 JL1UH500M1BB_SEG	江苏	电压安全	91.79	0.75	1.00
3	(SGQ2)外高桥二厂 SGQ2500M1BB_SEG	上海	电压安全	92.22	0.75	1.00
4	(ZLT)兰亭变电所 ZLT500M1BB_SEG	浙江	电压安全	93.42	0.75	1.00
5	(JL6)利港 JL6500M1BB_SEG	江苏	电压安全	94.01	0.75	1.00
6	(AXC)敬亭变电所 AXC500M1BB_SEG	安徽	电压安全	94.88	0.75	1.00

坐标:(945, -13) 当前层次: 0 外高桥二厂 黄渡变 南桥变 田湾核电厂 东善桥 武南变 2007-03-07 21:14:40 星期三

GUI-14, Online Safety Margin Analysis for Bus Frequency

hdwam08-1: WAMS_PO_频率监视母线(WAMAP图形) (WAMAP--实时态) ::已登录 用户:nari(nari) 登录时间:07日17:50 有效期:480分钟
桌面风格 帮助

文件操作 窗口操作 图形操作 显示策略

母线频率安全裕度

BUS Frequency Safety Estimation

(APV)平圩电厂APV500M1BB-SRG
(WNS)后石电厂WNS500M1BB-SRG
(JTW)田湾核电厂JTW500M1BB-SRG
(ZLT)兰亭变电所ZLT500M1BB-SRG

母线	Bus name	区域 Area	安全状态 Status	安全裕度 (%) gap%	门槛值 (Hz)	持续时间 Interval
1	(ALH)洛河电厂 ALH500ZM1BB_SEG	安徽	频率安全	77.91	49.00	0.50
2	(JJ1NL)晋陵变电所 JJ1NL500M1BB_SEG	江苏	频率安全	77.99	49.00	0.50
3	(JL1UH)浏河电厂 JL1UH500M1BB_SEG	江苏	频率安全	78.02	49.00	0.50
4	(FNDB)宁德变电站 FNDB500M1BB_SEG	福建	频率安全	78.06	49.00	0.50
5	(ZQS2)秦山二厂 ZQS2500M1BB_SEG	华东直属	频率安全	78.07	49.00	0.50
6	(JTW)田湾核电厂 JTW500M1BB_SEG	江苏	频率安全	78.11	49.00	0.50

坐标: (530, -3) 当前层次: 0 外高桥二厂 黄渡变 南桥变 田湾核电厂 东善桥 武南变 2007-03-07 21:16:26 星期三

hdwam07-1: _HD_安全稳定实时预警(WAMAP图形) (EACCS--实时态) ::从主控台登录 用户:nari(nari)

文件操作 窗口操作 图形操作 显示策略 桌面风格 帮助

实时态 EACCS

图层信息 安全稳定评估--安全稳定实时预警

系统状态 **安全** 详细信息 静态安全分析故障后潮流发散. **Real-time Alarm for Safety and Stability**

系统安全建议

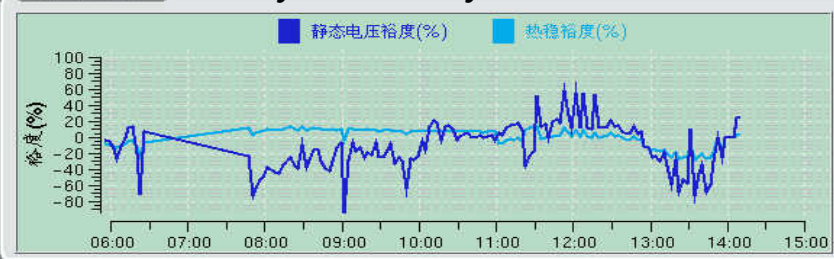
安全稳定实时预警

断面时刻 2007/08/09 14:10:17

→ 极限 → 静态极限 → 暂态极限 → 功角极限 → 电压稳定

静态安全 Steady state Safety

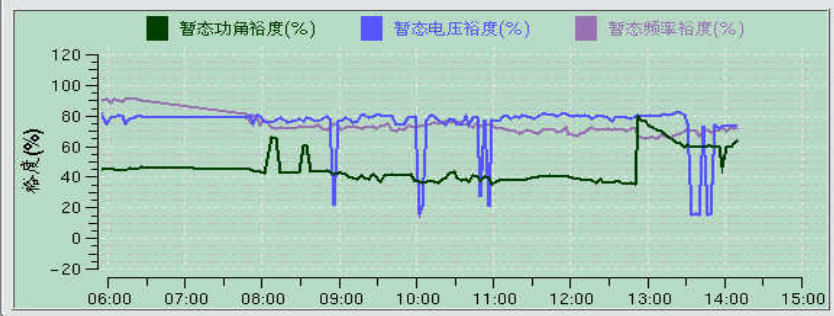
→ 暂态详细信息 → 静态详细信息 → 基态模态分析 → 辅助决策 → 详细历史查询



静态电压裕度(%) 24.50 → 详细信息 → 历史查询
电压敏感母线数 **1** 母线名称 (AFD) 颍州变电所 AFD500W1BB-SBG

热稳裕度(%) 3.00 → 详细信息 → 历史查询
敏感元件个数 **1** 元件名称 (JY2C) 扬二厂-(JJJ) 江都变电所 5203

暂态安全 Transient state Safety



暂态功角裕度(%) 64.41 → 详细信息 → 历史查询
敏感机组个数 **2** 机组名称 (JXDT) 徐塘电厂 JXDT2007FGEN

暂态电压裕度(%) 73.57 → 详细信息 → 历史查询
电压薄弱母线数 **0** 母线名称

暂态频率裕度(%) 72.47 → 详细信息 → 历史查询
频率薄弱母线数 **0** 母线名称

静态安全关键故障	扬江5204线无故障跳	静态安全裕度(%)	3.00
暂态安全关键故障	三堡-双洮一回三永跳双回(对侧)	暂态安全裕度(%)	64.41
关键断面	肥西-繁昌	限制原因	不受限
静态电压稳定关键断面	苏北-苏南断面	静态电压稳定裕度(%)	48.54
关键故障	泰斗5293线无故障跳		

GUI – 16, Online Evaluation of Active Power Limitation on Steady State Voltage Stability

hdwam07-1: _HD_静态安全稳定极限(WAMAP图形) (EACCS--实时态) ::已登录 用户:nari(nari) 登录时间:07日09:29 永久有效

文件操作 窗口操作 图形操作 显示策略 桌面风格 帮助

实时态 EACCS

图层信息 安全稳定评估—安全稳定极限

系统状态 安全 **详细信息** 电网安全稳定,不需要采取稳定控制措施,静态安全分析故障后潮流发散.

System Status: Safe **Detail:**

静态安全稳定极限
Steady State Safety Stable Limitation

断面时刻 2007/03/07 09:31:34 [→ 暂态极限](#) [→ 历史极限潮流查询](#)

单位: MW Unit: MW

断面名称	当前潮流	在线极限	离线极限
上盐线	897	1260	1200
任庄-上河5237线	547	1024	975
任庄-上河5238线	538	1024	975
肥西-繁昌	1104	1995	1900
任庄-上河	1085	2048	1950

Border Name The current flow High Line Limit

断面名称	当前潮流	在线极限	离线极限	离线极限说明	在线极限说明
1 上盐线	897	1260	1200	上盐线正常方式	受热稳限制,设置为离线的1.05倍
2 任庄-上河5237线	547	1024	975	任庄-上河5237线正常方式,阳城和苏北安控投	不受热稳限制,设置为离线的1.05倍
3 任庄-上河5238线	538	1024	975	任庄-上河5238线正常方式,阳城和苏北安控投	不受热稳限制,设置为离线的1.05倍
4 肥西-繁昌	1104	1995	1900	肥西-繁昌正常方式	不受热稳限制,设置为离线的1.05倍
5 任庄-上河	1085	2048	1950	任庄-上河正常方式,阳城和苏北安控投	不受热稳限制,设置为离线的1.05倍
6 三堡-双洮	1524	2520	2400	三堡-双洮正常方式,阳城和苏北安控投	不受热稳限制,设置为离线的1.05倍
7 上江双线	895	2100	2000	上江双线正常方式	不受热稳限制,设置为离线的1.05倍
8 上江-上盐	1792	3150	3000	上江-上盐正常方式	不受热稳限制,设置为离线的1.05倍

坐标:(1048, 143) 当前层次: 0 外高桥二厂 黄渡变 南桥变 田湾核电厂 东善桥 武南变 2007-03-07 09:38:37 星期三

- 1 Introduction – China Power Industrial
- 2 Why WAMAP
- 3 WAMAP System Requirements
- 4 WAMAP System Specifications
- 5 WAMAP Features & Comparisons**
- 6 Conclusion

From the user perspective,

The WAMAP system provides:

- A Multi-States Data Management Platform which consists of dynamic data from PMUs, steady data from EMS, and transient state data from the reaction of protection devices.
- An online prevention strategy and an emergency control strategy by using a rapid data processing and analysis.
- An add-on system service tool package for the power market such as the monitoring of frequency, voltage, and the evaluation of power plant contract execution.
- A rapid safety margin analysis of a power system.
- An efficient utilization of the transmission capacity and the generation capacity of a power system in order to meet economic interest of power companies.

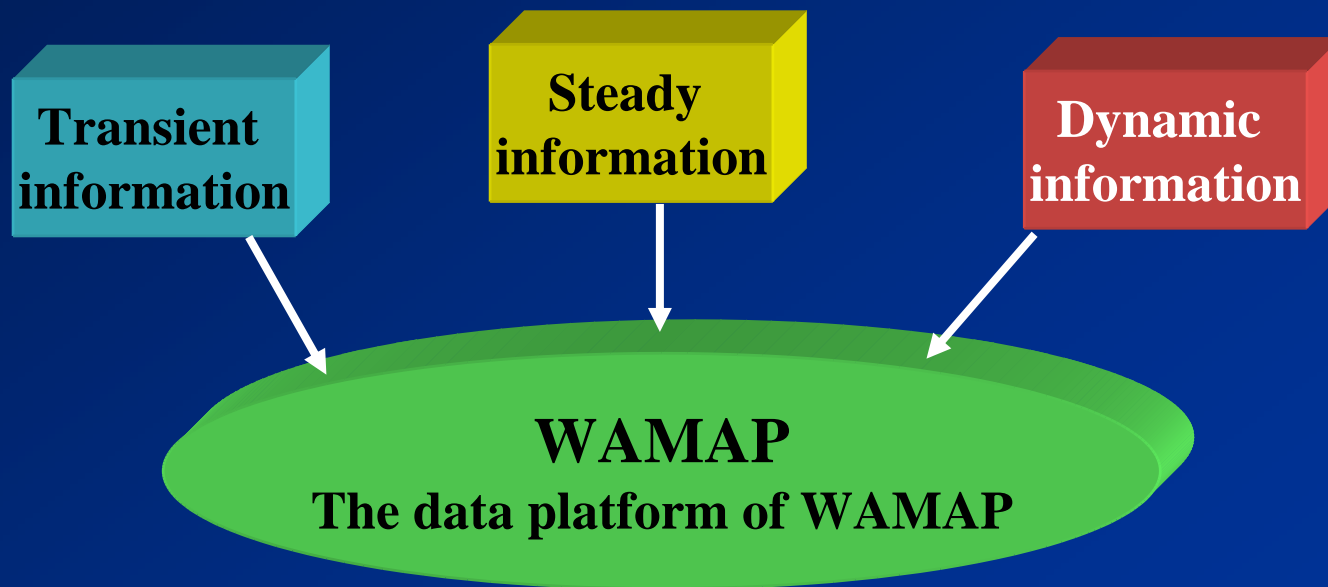
Overall, WAMAP vs. WAMS

- WAMS monitors system dynamics and logs data. In contrast to the SCADA system (in which only the steady state is monitored), WAMS made some improvement by the inclusion of system dynamics monitoring.
- WAMS analyzes only the transient states data provided by the independent protection device. As a result, the simulation of a power system is based only on a real local operation environment.
- The WAMAP system, however, advances its capability significantly over WAMS. Its goal is to achieve a power grid protection over a wide area. This is achieved by including all condition simulation of the power system, with its human-machine interface.
- WAMAP is a next generation system for power grid monitoring and controlling after WAMS.

Function	WAMAP	WAMS
Data Acquisition	3 States	Dynamic state only
Multiple States Data Management	Uniform timestamp and Management	NO
Characteristics of Online Analysis (Angle, frequency, voltage)	YES	NO
Assistance for post-contingency decision-making	YES	NO
On-line fault prevention and emergency control strategy	YES	NO
Fault finding and locating	YES	NO
Offline power system simulation model and parameter checking	YES	NO
Damping control and other process control	YES	NO
Online check of power system modeling parameters	YES	NO

WAMAP's Foundation: Triple state Data Platform

WAMAP uses all 3 kinds of information



The Triple-State Data Type

Device	Type of Data Output
PMU	Vector, state and wave records
SCADA/EMS System	Remote data, tele-signalization data, network and component modeling parameters.
Integrated Protection Relay Management System	Protection configuration, On/Off status, operation data, operation current and voltage, wave records.
Stability Control Devices	Configuration and operation information.
Fault Waveform Recording Devices	Recording fault current and voltage waveform.

Data sharing issue is resolved by WAMAP data management platform

When a problem occurs, the PMU real-time data acquisition unit shall be invoked to collect data such as frequency, voltage, current, active power, reactive power and switch status. At the same time, all of the action information from fault protection device, recording devices, auto-protect switches, and other stable control devices will be recorded and transmitted to the analysis center.

To power system researchers, the sharing of information from different time, different devices, states and areas is always an important topic. An additional benefit of a WAMAP system is that it is built to resolve this “critical” data sharing issue by using a unique data management platform.

The main functionality of the WAMAP's data management platform includes:

- Collecting,
- Logging,
- Sorting,
- Categorizing
- Real-time data Processing for all three states

Using these data, the WAMAP system will be able to perform system protection estimation, Sequence of Event (SOE), Post Disturbance Record (PDR), analysis of fault process, modeling and parameter checking as well as stability margin calculation

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How to do? what to do?

---- the most difficulties in five years of WAMAP development.

1, No idea, Thinking hard In the WAMAP beginning stage.

--- After 1 year WAMAP system study, we divided project to phase-1,2,3

2, Difficult to finalize WAMAP system requirements

--- After 2003 North America blackout, our goal is confirmed.

3, Big challenge in testing

--- Spent great effort to complete dynamic simulations, functional test, as well as the system level test. The same tests were repeated for multiple times.

4, The Interface issue was often a problem during integration

--- Issues are in the data sharing, communication within EMS, protection device, data acquisition and data logging devices.

5, Management challenges

--- “wide area grid” project needs “wide area” management method. A lot push, a lot patience and proper orders as well as rewards.



ECG Control Center



ECG Headquarter in Shanghai



Dynamic data from field



Master station computer Room



Design begin meeting >

< System Planning meeting



< Phase-1 Detail Design Meeting V



Final stage
WAMAP Design Meeting
V



< Problem Solving and Discussion





Meeting for finalizing of system design phase



WAMAP Feasibility Discussion Meeting

Project Contract Meeting with suppliers



Engineers in WAMAP Project Development





WAMAP System Application Function RTDS Test



2005.7.15--7.29
1st RTDS test

2005,10.8--10.22
2nd RTDS test

2006.3.8—3.28
3rd RTDS test

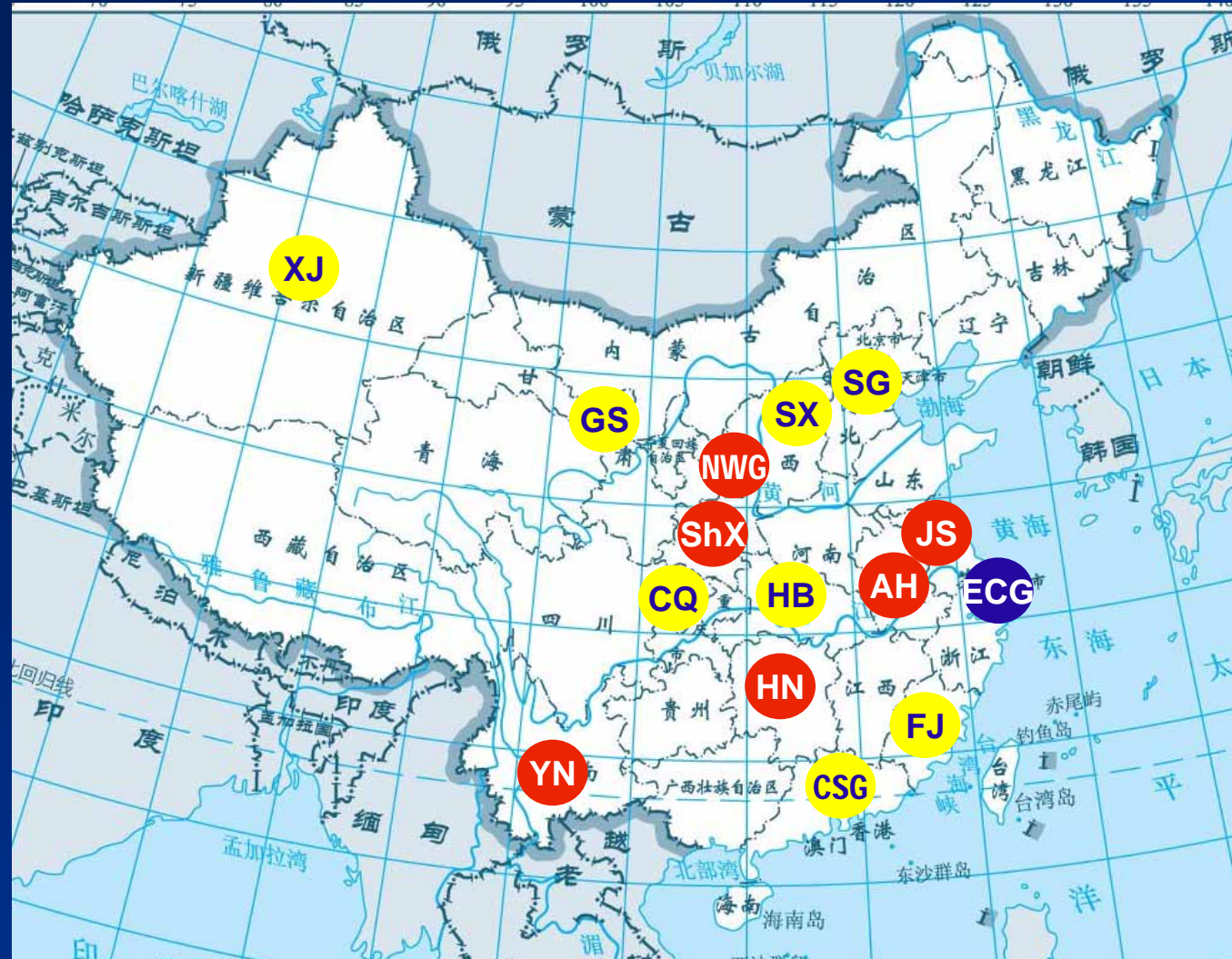


WAMAP System Developments in China Power Grid

ECG The WAMAP system of East-China is operating and stepping ahead in the China

● 6 systems in progress

● 8 systems In beginning stage



WAMAP, National wide Recognition

- Prize Award, Advanced Science and Technology in Electric Power , Society of Electrical Engineering, China (CSEE)
- 1st Place Prize Award, Advanced Science and Technology, China State Grid (CSG)
- 1st Place Prize Award, Advanced Science and Technology, East China Grid (ECG)



Conclusion

- Without a system-level data platform and the capability to analyze the triple-state data, our power system is not a robust system.
- Based on its unique “Triple-State Data Management Platform”, the WAMAP system is capable of a wide area power grid monitoring and control. It uses today’s the most advanced technologies to gather steady-state, dynamic-state, and transient- state data in order to provide a complete protection of a power system.
- The WAMAP system is currently being developed by the power engineers of East China Power Grid Co. The first two phases have been completed and it is now in its third phase. The system was able to detect LFOs in its early stage. In many cases, its online fault-simulators have prevented wide area power outages with satisfactory preliminary results.

Ms. Xianping Hong

- East China WAMAP project Manager
- CEO, East China Electric Consulting Co.,Ltd
- Member of IEEE
- Member of the standing council of Shanghai Society of Electrical Engineering (SSEE)
- Member of the standing council of Shanghai Electro _technical Society (SES)
- The council Member of Shanghai Women Engineers Association (SWEA)
- Graduated from the Electrical Engineering Department of Shanghai Jiao-tong University in 1982.

Welcome to ECG & Welcome to Shanghai, China

Thank You !

*If any questions, please contact me at
hong_xp@ec.sp.com.cn*

Xianping HONG, CEO

East China Electric Consulting Co.,Ltd

<http://www.ecec.sh.cn>; www.ecpgc.com