



Federal Ministry
for Economic Affairs
and Energy



Federal Ministry
of Education
and Research

SIEMENS
Ingenuity for life

Adaptive Protection System with On-line Protection Security Assessment in Distribution Systems with High Penetration of DERs

Ashok Gopalakrishnan

October 30, 2018

Presentation Overview

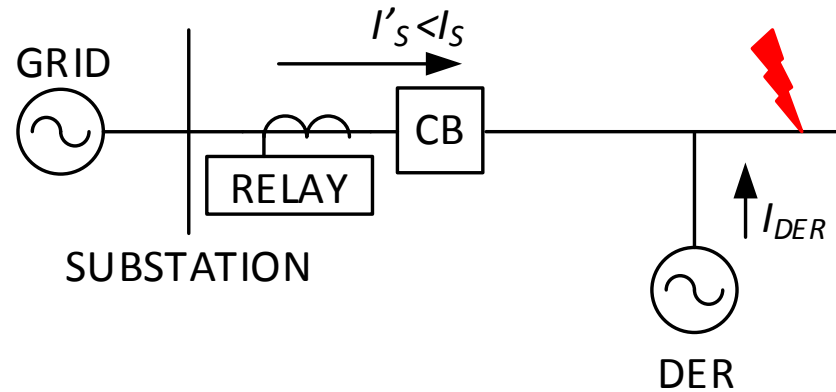
- Protection system challenges with DERs
- Adaptive Protection – a potential solution
- Protection Security Assessment
- Pilot Implementation

Protection Challenges

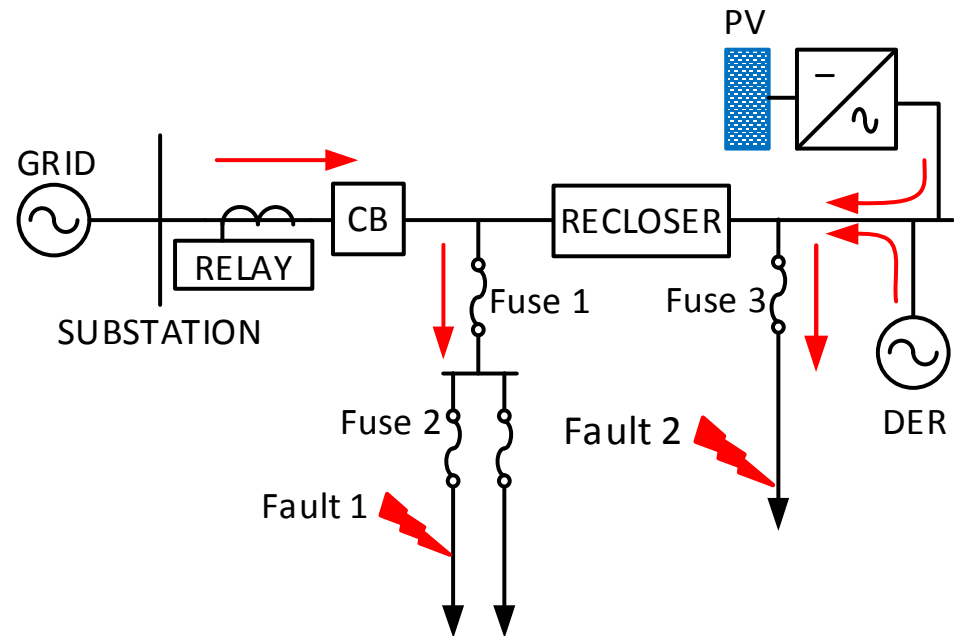
- DER Integration
 - Time and season-dependent generation
 - Traditional radial systems now exhibit bidirectional current flow under normal and short-circuit conditions
- Network configurations and operating conditions
 - DER on/off status
 - Distribution automation and resulting topology changes

Protection Challenges

- Desensitization

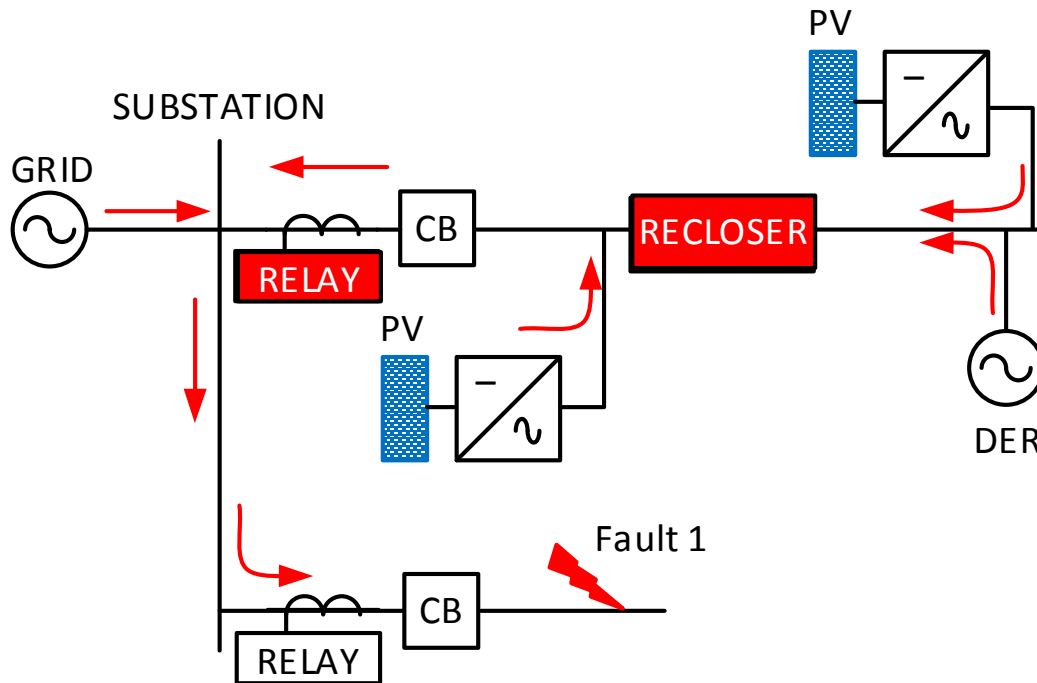


- Miscoordination



Protection Challenges

- False/Sympathetic tripping
- Failed auto-reclosing

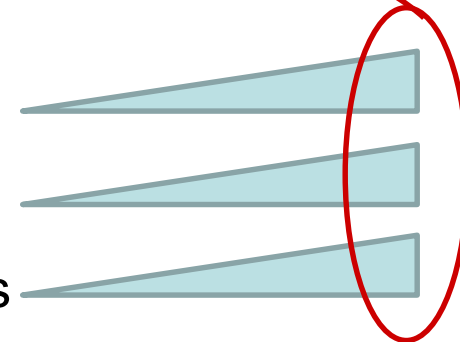


Automatic Reconfiguration

- Change in loading of circuits
- Change in short-circuit levels
- Potential system looping
- Change in zones of protection

Potential Solutions

- Customized logic to detect changing conditions and switch to different setting groups
- Communication-based protection schemes
- **Adaptive protection system**
- Proper solution depends on:
 - DER integration level
 - Number of network configurations
 - SC current flow changes due to DERs



Adaptive Protection System (APS)

- Capture network topology, DER status, generation levels
- Capture protection settings information
- Update the model
- Evaluate protection behavior under “no fault” and “fault” conditions
- Adapt settings to meet business rules
- Compromises?
- Deploy new settings

Protection Security Assessment

Benefits

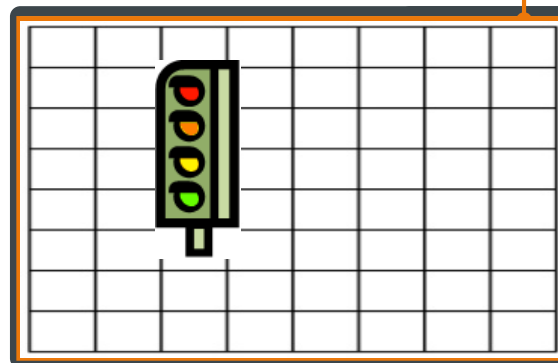
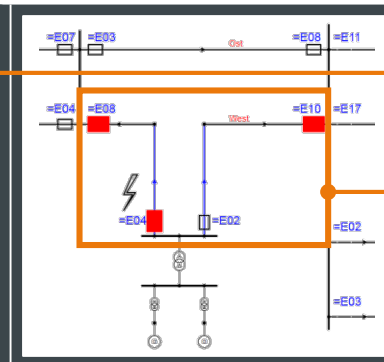
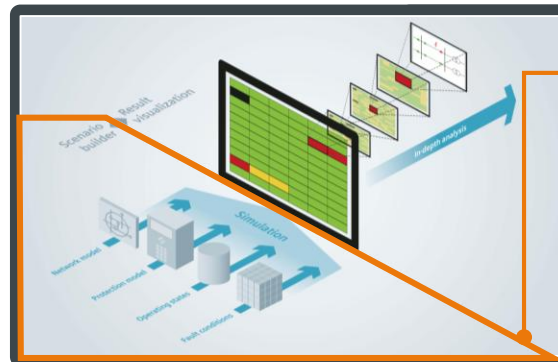
- Optimized system-wide protection coordination
- Increased system security
- Higher system utilization
- Adherence to technical, safety and regulatory standards
- The high degree of automation enables the efficient handling of complex tasks, and helps saving time and resources

Not Cleared
Protection system failed to clear a fault

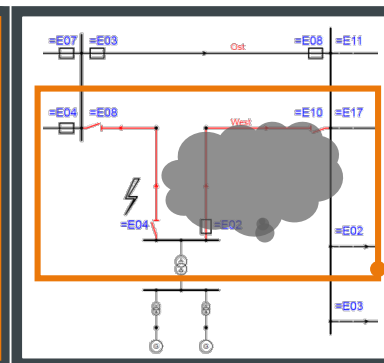
Over function
More trips than expected can isolate a fault

Under function
Less trips than expected can isolate a fault

Selective
Expected trips can correctly isolate a fault



System-Wide Result Matrix



Scenario builder

Automated system-wide protection simulation

In-depth fault clearing sequence evaluation

Concise result visualization

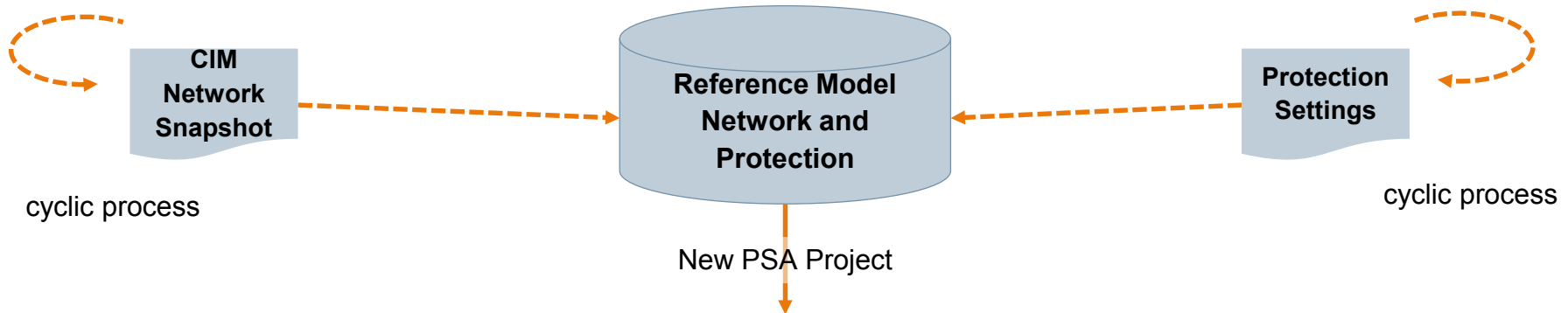
Weak spot identification by traffic light colors

Selectivity and impact analysis

Pilot Implementation

- Network/topology model at Univ. of Magdeburg
- Dynamic Grid Control Center (DGCC) at Univ. of Ilmenau
- Developed an online protection system security assessment to find protection vulnerabilities
- Implemented a workflow for APS in the DGCC

Workflow – Online Protection Security Assessment



Protection Security Assessment (PSA)

Protection engineer

all calculated results available

every 15 min. ↗

Color Code

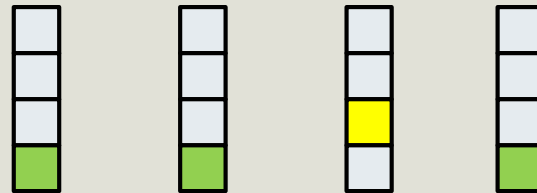
Selective	Green
Overfunction	Yellow
Underfunction	Orange
Not Cleared	Red



Operator

overall risk status displayed

observe and initiate detailed analysis

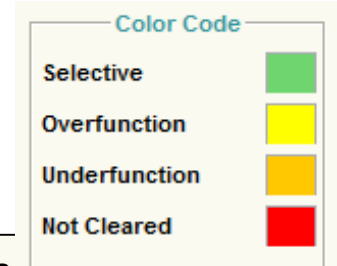



1:30 a.m. 1:45 a.m. 2:00 a.m. 2:15 a.m.

Online Protection Security Assessment



Overall Risk Status is reported to operators
Priority: Red, Orange, Yellow, Green



Selection: PSA_DGCC_02-12-18_11-05-09 > Power System Risk Status: 

Scenario: Normal Analysis; SC3; 0.8 D; 20.04.2018 12:55:11

Report

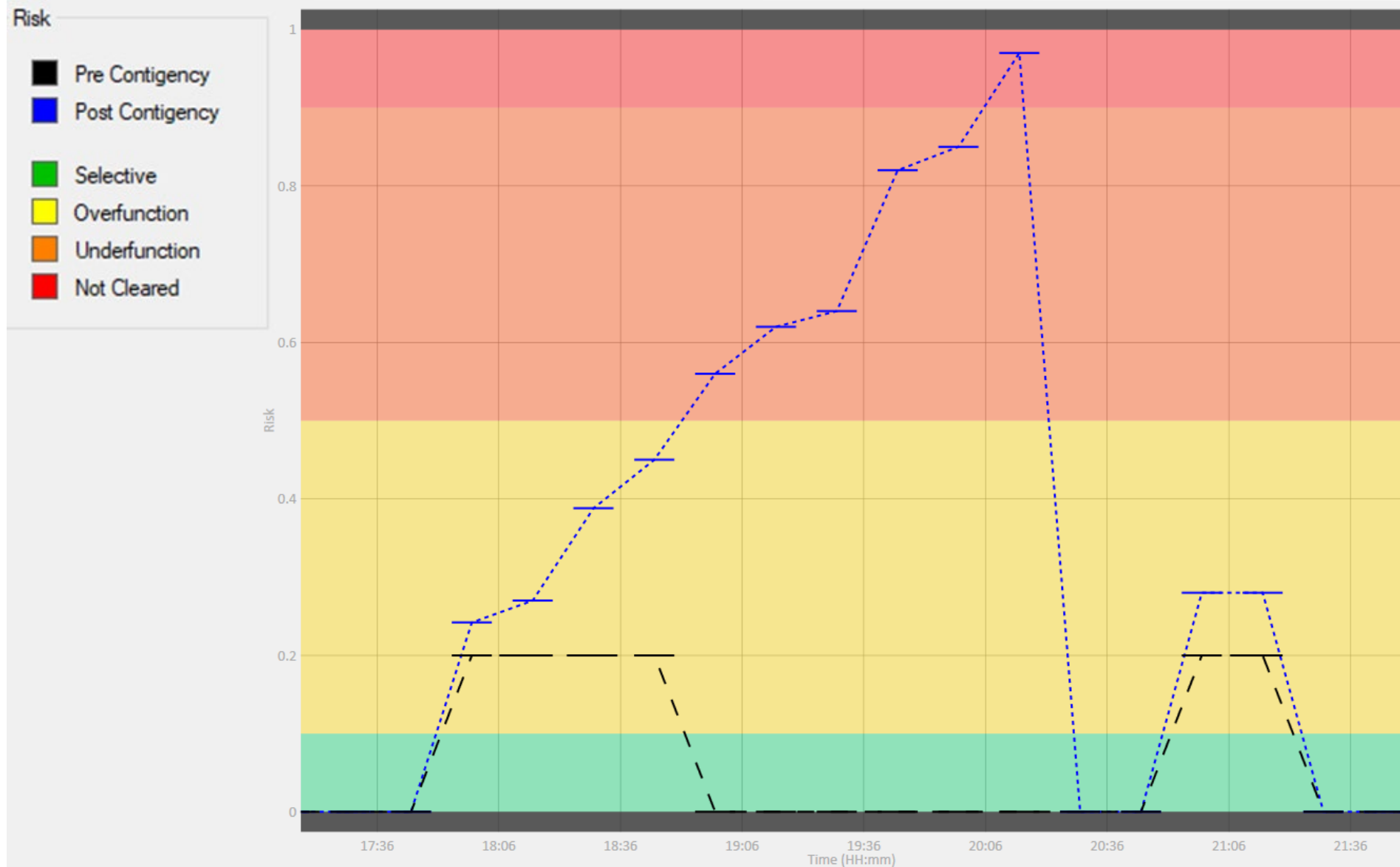
FC300.0.0

Feeders

Various fault locations

Fault	1%	20%	20%	30%	40%	50%	60%	70%	80%	90%	99%	ID
Zone111:6D206.N2-1-6D308.N2												111
Zone112:6D207.N2-1-6D309.N2												112
Zone113:6D208.N2-1-6D310.N2												113
Zone114:6D220.N2-1-AT01.N1												114
Zone115:6D221.N2-1-AT02.N1												115
Zone116:6D222.N2-1-7D201.N2												116
Zone117:6D223.N2-1-7D202.N2												117
Zone118:6D301.N2-1-FR16.N1												118
Zone119:6D302.N2-1-FR17.N1												119
Zone120:6D311.N2-1-CH03.N1												120
Zone121:6D312.N2-1-CH04.N1												121
Zone122:6D313.N2-1-CH05.N1												122
Zone123:6D314.N2-1-CH06.N1												123
Zone124:6D315.N2-1-CH07.N1												124
Zone125:6D316.N2-1-CH08.N1												125
Zone126:7D116.N2-1-7D303.N2												126
Zone127:7D117.N2-1-7D304.N2												127
Zone128:7D118.N2-1-7D305.N2												128
Zone129:7D119.N2-1-7D306.N2												129
Zone130:7D214.N2-1-AT03.N1												130
Zone131:7D215.N2-1-AT04.N1												131
Zone132:7D216.N2-1-7D301.N2												132
Zone133:7D217.N2-1-7D302.N2												133
Zone134:7D320.N2-1-AT05.N1												134
Zone135:7D321.N2-1-AT06.N1												135
Zone136:AT07.N1-1-CH09.N1												136
Zone137:AT08.N1-1-CH10.N1												137
Zone138:AT12.N1-1-0103.N1												138
Zone139:AT13.N1-1-0104.N1												139
Zone140:0E01.N1-1-0K06.N1												140
Zone141:0E02.N1-1-0K07.N1												141
Zone142:0E03.N1-1-0L05.N1												142
Zone143:0E04.N1-1-0L06.N1												143
Zone144:0E05.N1-1-FR03.N1												144
Zone145:0E06.N1-1-FR04.N1												145
Zone146:0E01.N1-1-CH16.N1												146
Zone147:0E02.N1-1-CH17.N1												147
Zone148:0E05.N1-1-0E05.N1												148
Zone149:0E06.N1-1-0E06.N1												149
Zone150:0E07.N1-1-0E05.N1												150
Zone151:0E08.N1-1-0E06.N1												151
Zone152:CH01.N1-1-FR14.N1												152

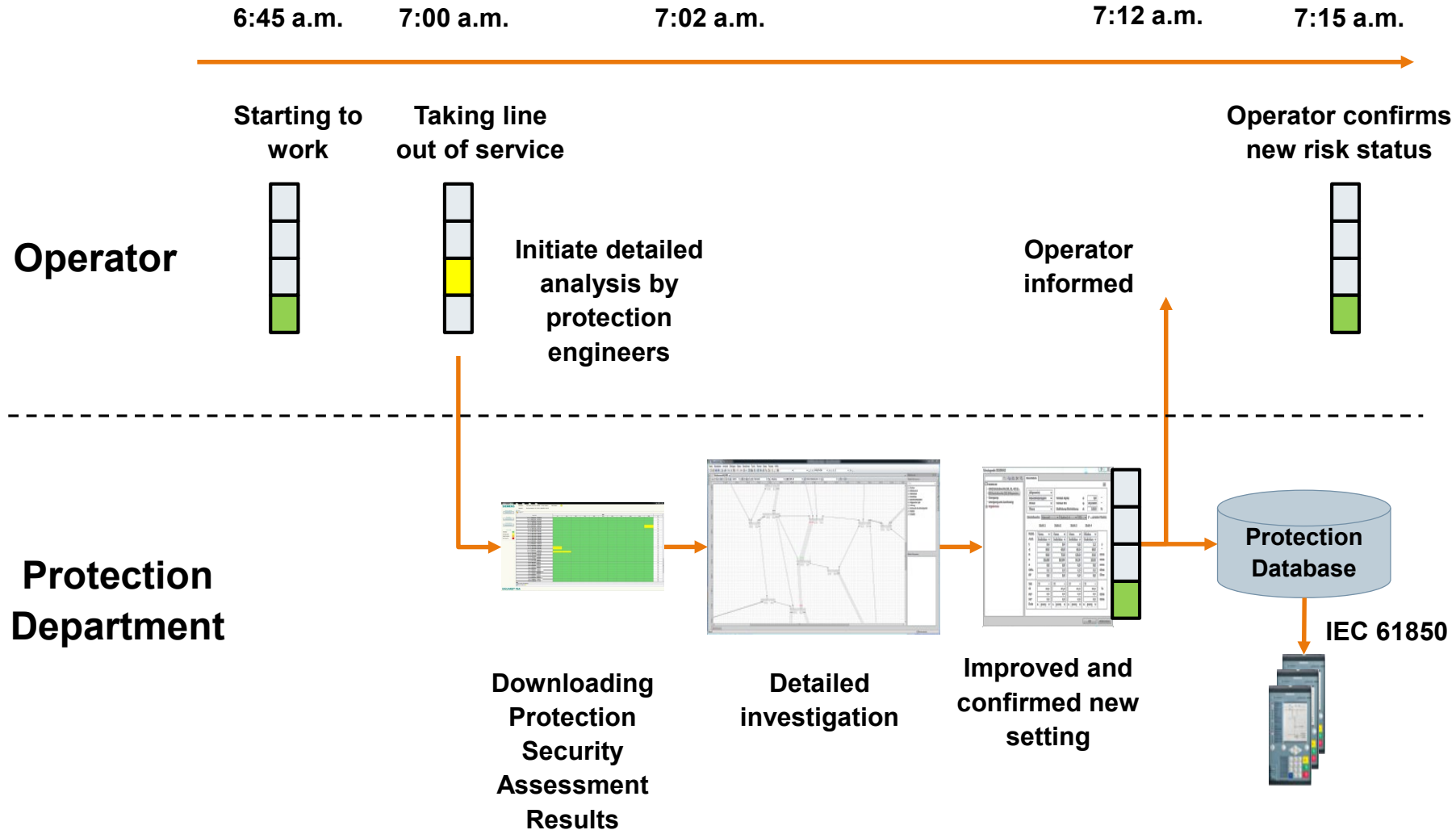
Risk Visualization for Operators



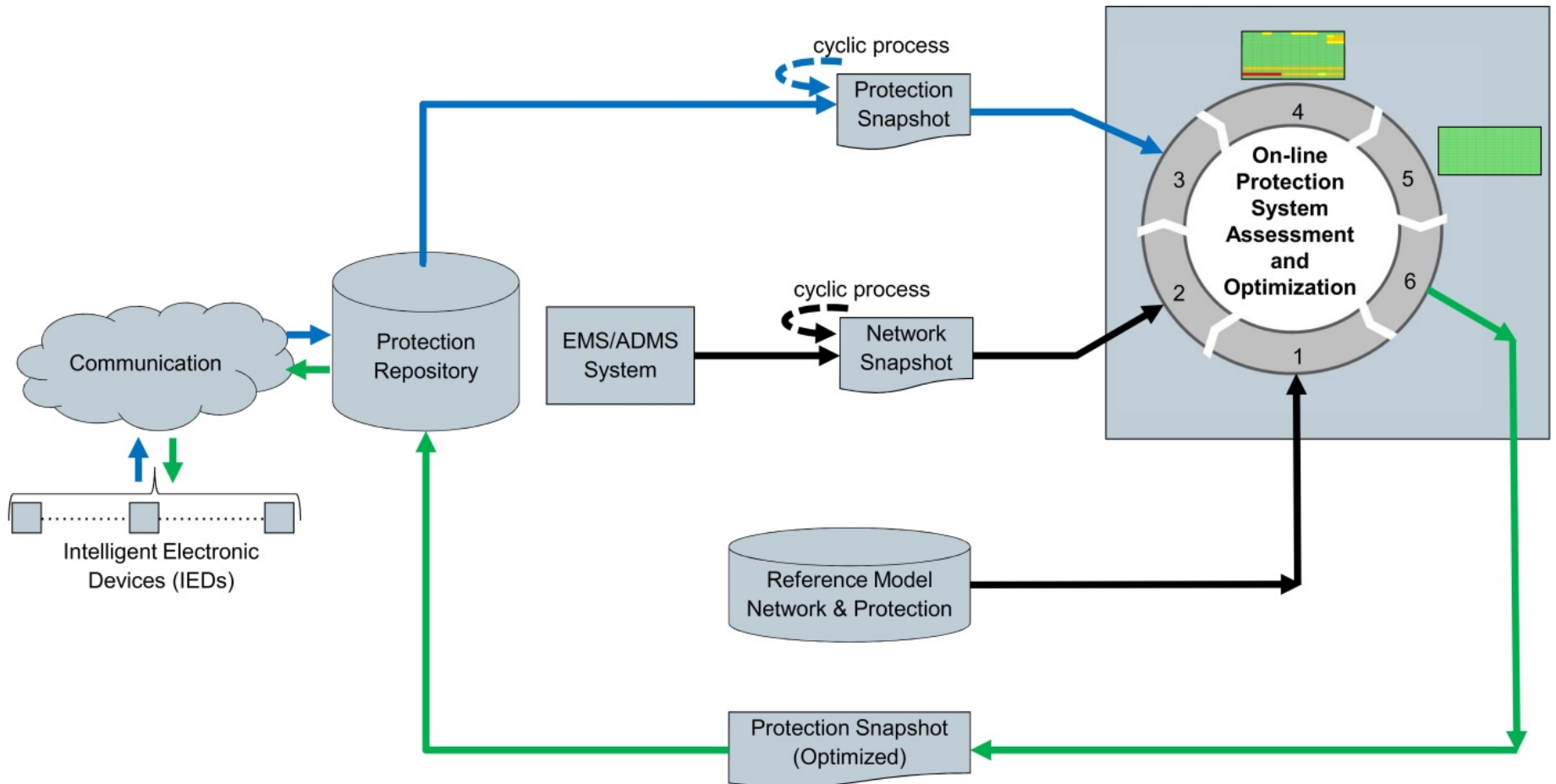
Visualization for Operators and Protection Engineers



Workflow – System Operator Timeline



Assessment, Optimization and Adaptation



Challenges

- Communications infrastructure upgrades
- Feeders have a mix of legacy and digital devices
- Protection IED updates
- Feedback from IEDs – were the settings pushed into the device actually applied?
- Communication failures – fail-safe mode of operation

Summary

- Pilot successfully completed
- Partnership with utilities for further research and implementation is on going

Thank You!