Power & Energy Society®

Reviewing the new IEEE C37.250 Guide for Engineering, Implementation, and Management of SIPS

Texas A&M Relay Conference, 2022

Gene Henneberg, Yi Hu, Robin Byun, Fernando Calero, Peiman Dadkhah, Alfredo de la Quintana, Ramakrishna Gokaraju, Erin Jessup, Vahid Madani, Mehrdad Majidi, Dean Miller, Wladimir Quishpe

PSRC Working Group C21

- Started September 11, 2013 and finished January 14, 2020
- Met 3 times a year in various locations in the USA
- Published the C37.250 standard in June 2020

Yi Hu, Chair Gene Henneberg, Vice Chair

Laura Agudelo	Kamal Garg	Alfredo de la Quintana
Eric Allen	Anthony Johnson	Zuyi Ren
Alex Apostolov	Vahid Madani	Tony Seegers
Phil Beaumont	Heather Malson	Bonian Shi
Robin Byun	Dean Miller	Roger Whittaker
Alla Deronja	Manish Patel	Yu Xia

SIPS DEFINITION

System Integrity Protection Scheme (SIPS): serves to enhance security and prevent propagation of disturbances for severe system emergencies caused by unacceptable operating conditions and is used to stabilize the power system by taking control action to mitigate those system conditions. It also encompasses Special Protection Systems (SPS) and Remedial Action Schemes (RAS) as well as underfrequency (UF), undervoltage (UV), and out-of-step (OOS) protection schemes.

Motivation for C37.250

- SIPS plays a vital role in power system reliability and resiliency
- A joint IEEE/CIGRE/EPRI global survey indicated wide application of various types of SIPS
  [Reports - IEEE PSRC (pes-psrc.org)]
- SIPS is a specialized area within power system protection and control

C37.250 Purpose and Scope

Purpose

Provide information to help properly engineer, implement, and manage SIPS.

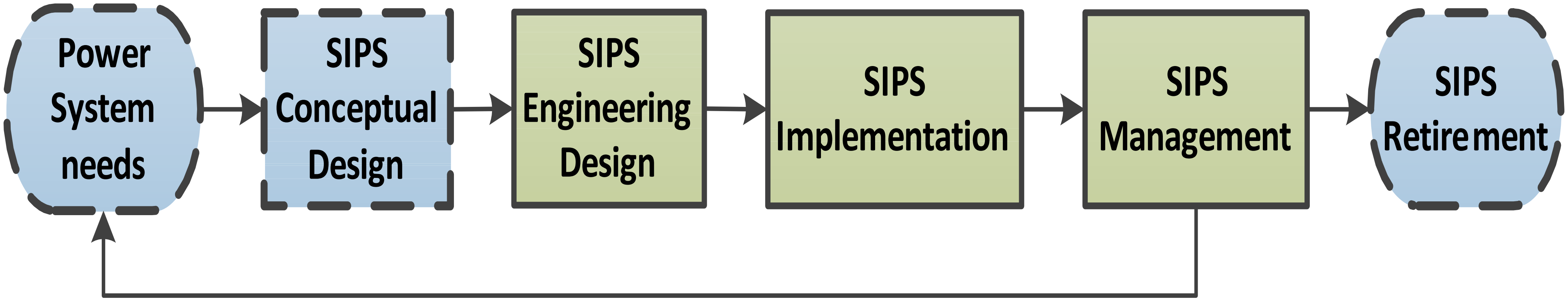
Scope

Provide guidance for engineering, implementation, and management of SIPS.

Address general concepts for architecture and communication design to achieve functionality and performance requirements.

Address principles for commissioning processes and strategies for life-cycle management.

SIPS Life Cycle

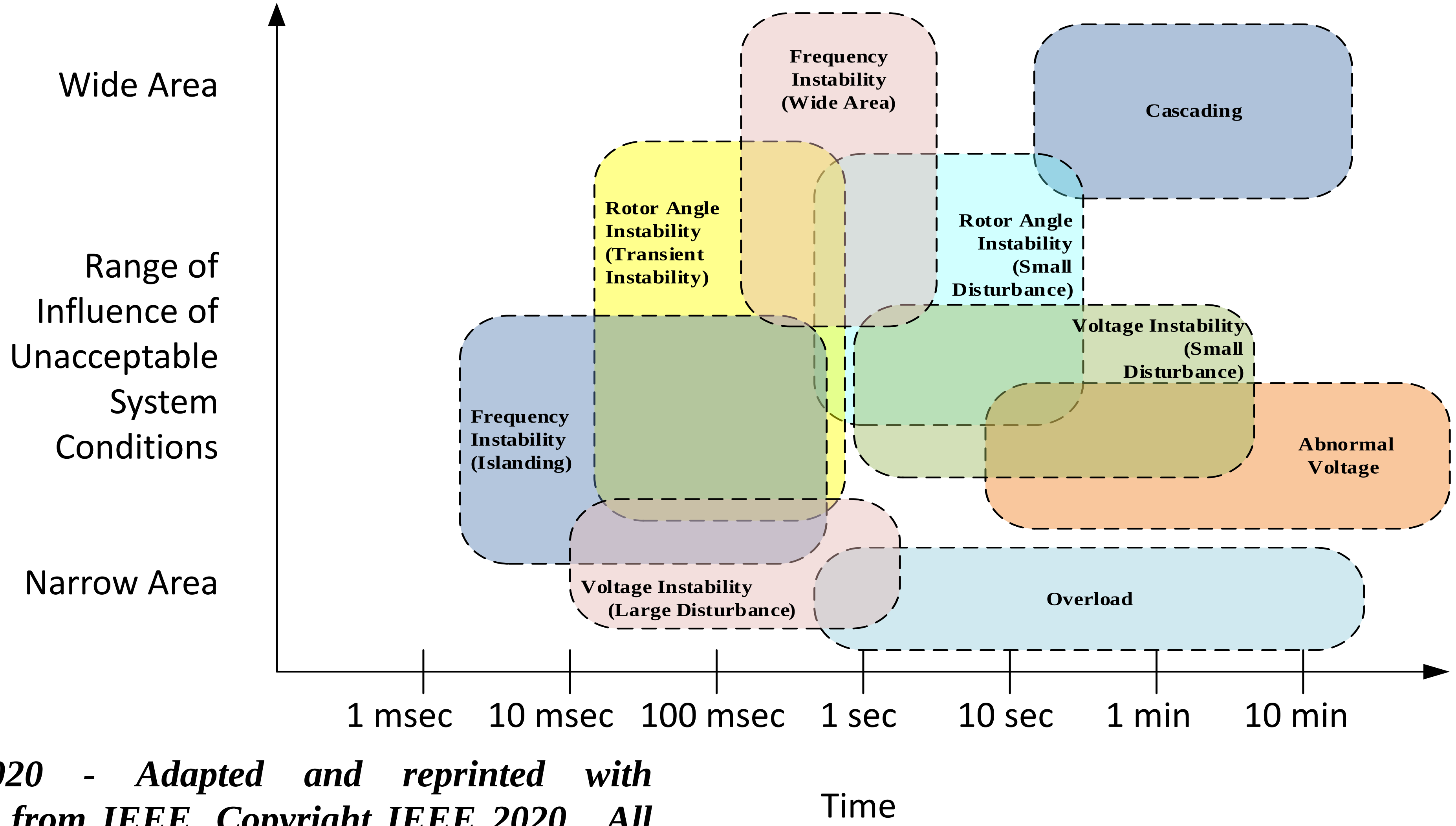


Need for SIPS

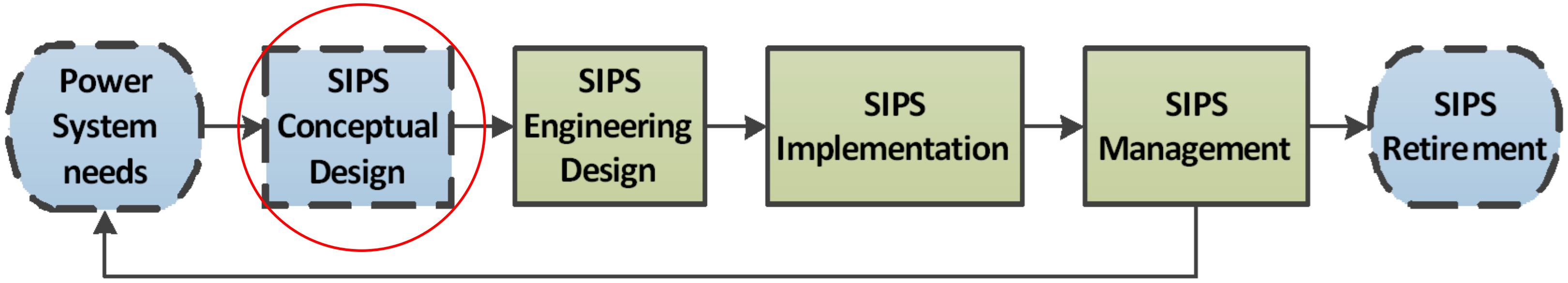
The need for a SIPS and the SIPS actions are usually determined through system planning studies such as power flow, stability, and/or other power system modeling.

- … contingencies
- … result in problems (violate performance requirements)
- … with vulnerability based on loads, generation, and system configuration (arming criteria)

OVERVIEW—Problems to Solve

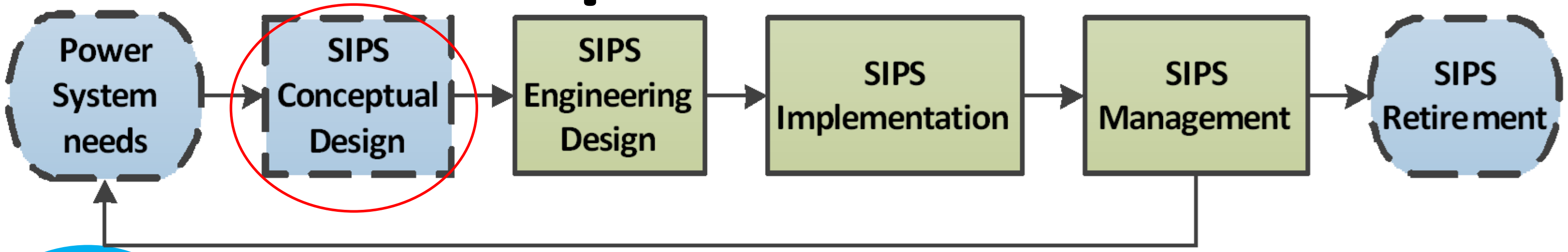


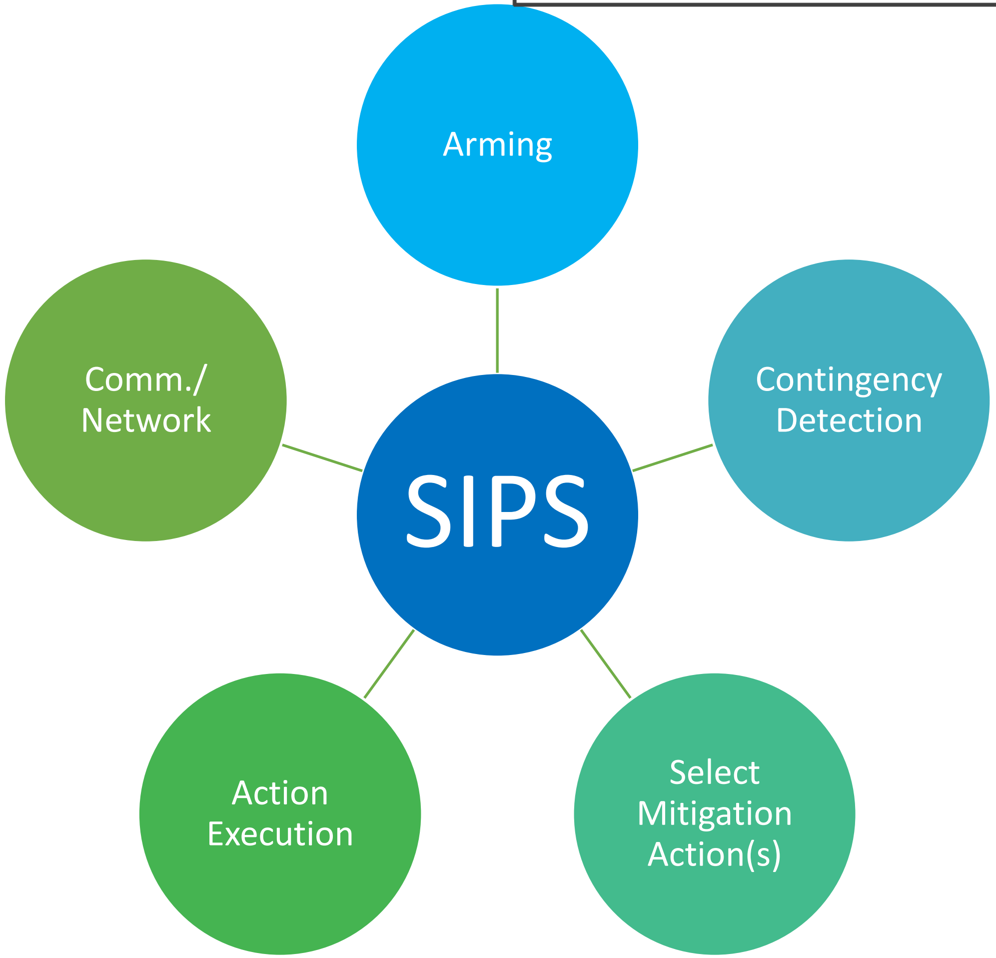
SIPS Conceptual Design



- Identify the system problem
- Determine arming conditions
- Identify mitigating actions
- Design the SIPS to perform these control actions

SIPS Basic Operational Elements





- **Arming** – Enable SIPS action when it may be needed
- **Contingency Detection** – Controller to determine if mitigation is needed
- **Select Mitigation Actions** – Select the right mitigation actions
- **Action Execution** – Take the selected actions
- **Communication / Network** – Connect all components together

SIPS Classifications

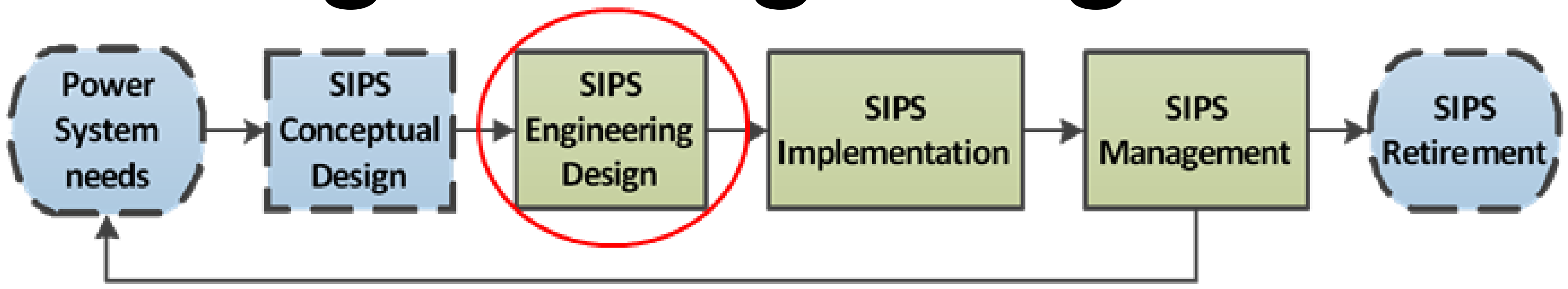
Multiple ways to classify SIPS:

- The contingency level for which mitigation is designed.
- The type of problem the SIPS mitigates.
- The geographic scale of the event that the SIPS mitigates.
- The electrical scale of the event that the SIPS mitigates.
- Event-based versus response-based SIPS operation.
- The type of action taken by the SIPS.

Common SIPS Actions

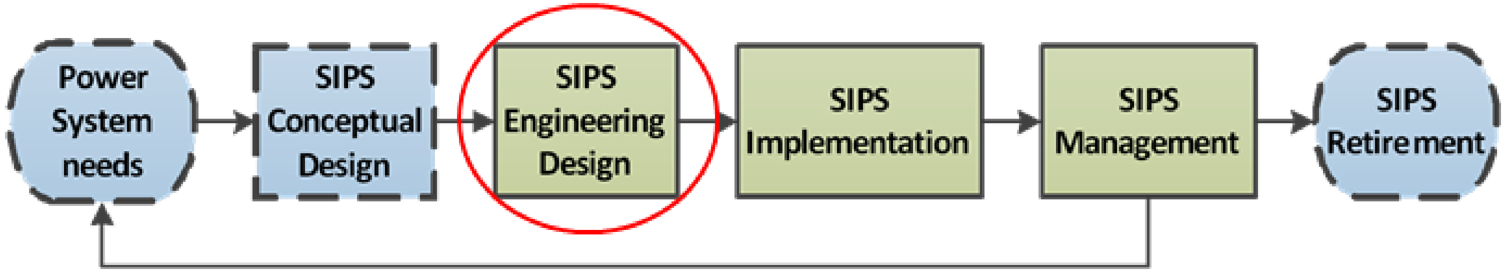
- Generator Rejection
- Load Shedding
- Underfrequency Load Shedding
- Undervoltage Load Shedding
- Adaptive Load Mitigation
- Out-of-Step Tripping
- Voltage Instability Advance Warning Scheme
- Angular Stability Advance Warning Scheme
- Overload Mitigation
- Congestion Mitigation
- System Separation
- Load and Generation Balancing
- Shunt Capacitor and Reactor Switching
- Tap-Changer Control
- SVC/STATCOM Control
- Turbine Valve Control
- High Voltage Direct Current (HVDC) Controls
- Power System Stabilizer Control
- Discrete Excitation
- Dynamic Braking
- Generator Runback
- Bypass Series Capacitor
- Black-Start or Gas-Turbine Start-Up
- AGC Actions
- Busbar Splitting
- System Reconfiguration
- Fast control to
  - photovoltaic inverters
  - wind turbine controllers
  - energy storage controllers
- Synchronous condenser control

SIPS Engineering Design Process



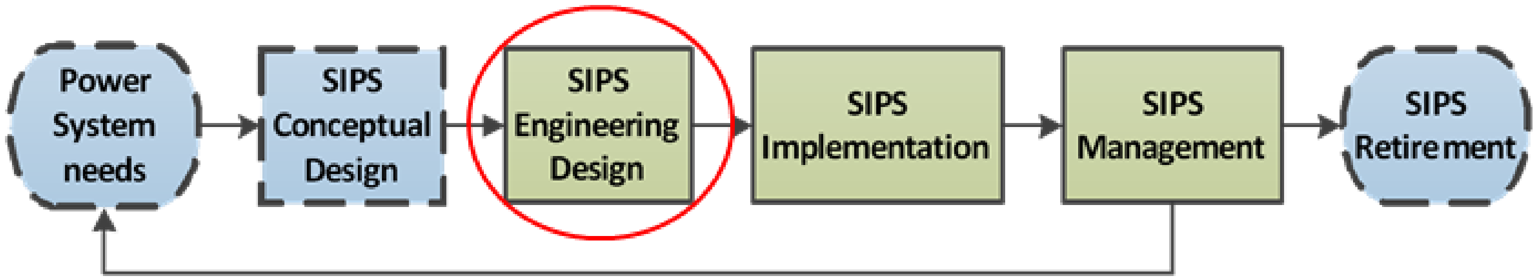
- System modelling questions should be answered before detailed SIPS implementation design.
- Determine the desired dependability and security level.
- Translate the conceptual SIPS design into detailed and specific engineering design requirements.

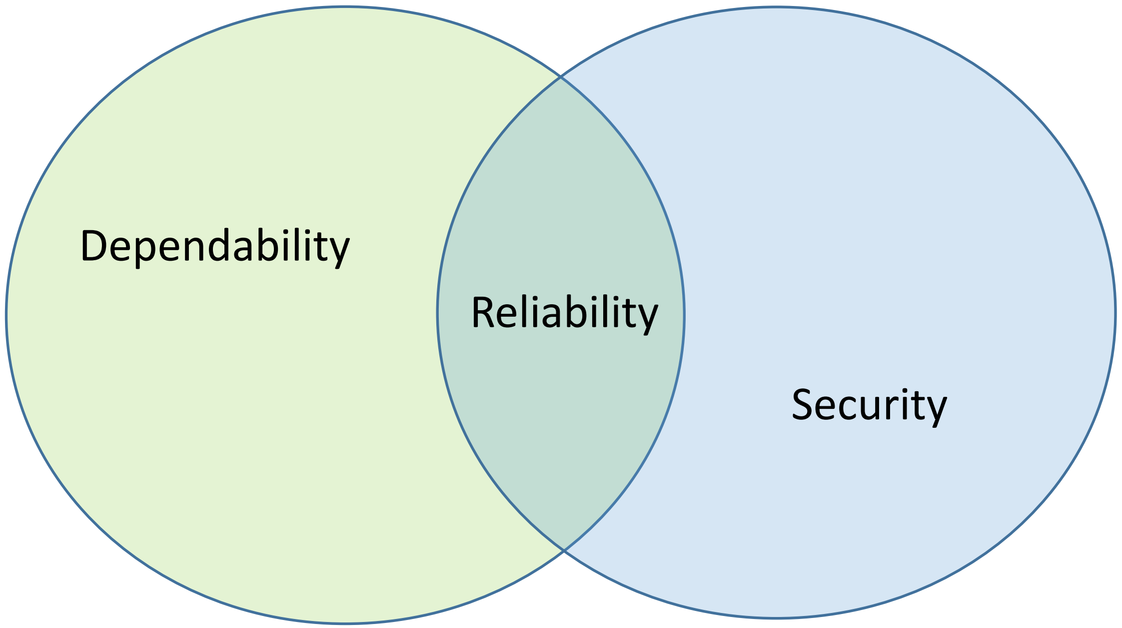
SIPS Design Considerations



- Data exchange between SIPS and EMS.
- Coordination of SIPS with other protection and control systems.
- Disturbance scale
  - If a system element is not monitored, assume the worst possible condition.
  - SIPS action consequence: generation trip--hydro, coal, or renewable; multi-unit plants.
- Breaker Failure
  - Desired action is usually different than for traditional BF operation

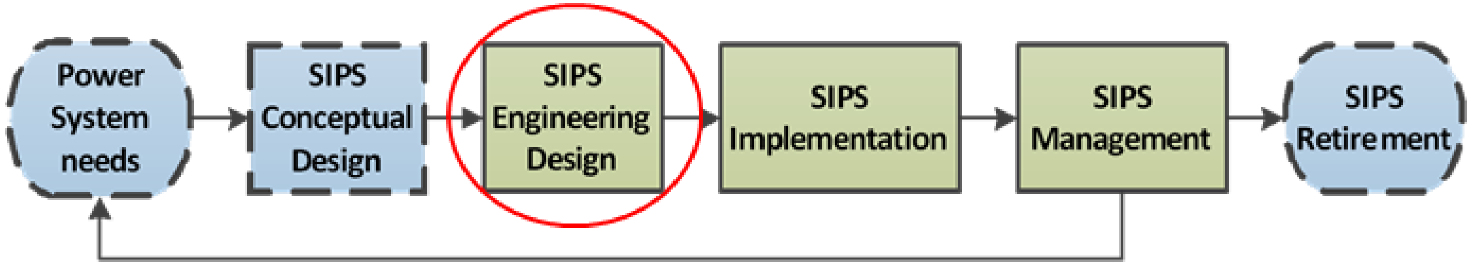
Design for Reliability





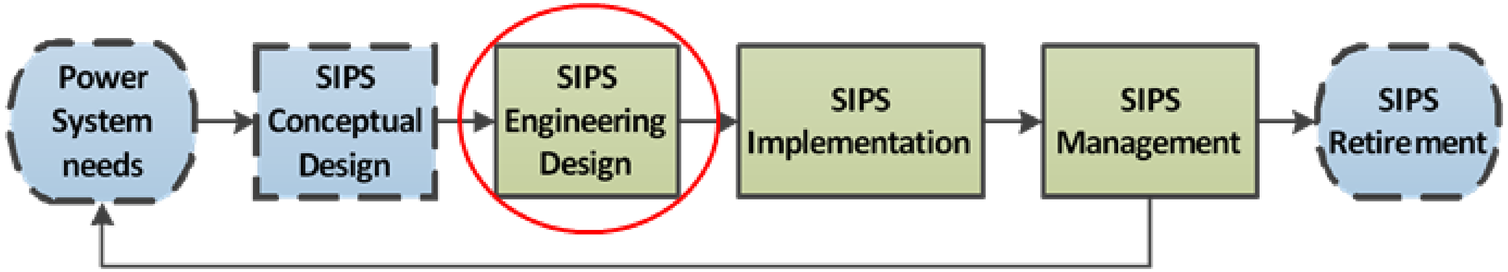
- Dependability: Operate when required.
- Security: Do no operate when not intended (unnecessary operations).
- Reliability: Dependability + Security.

SIPS Design for Testing



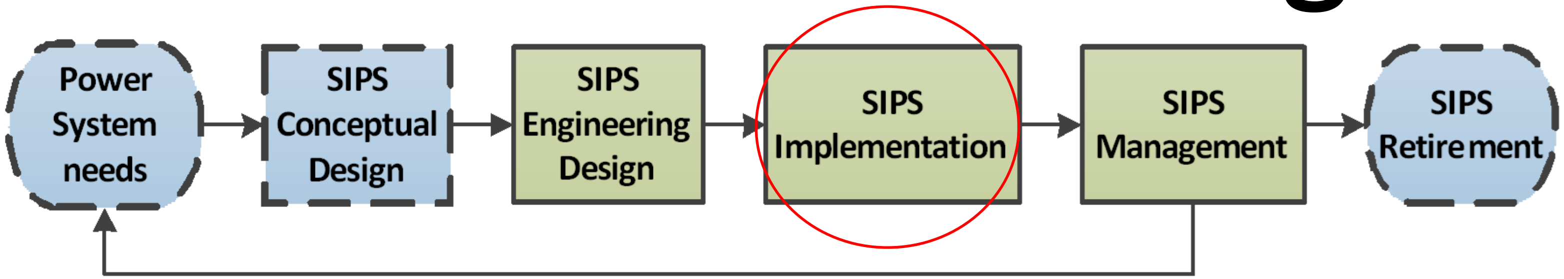
- Traditional test procedures for protective relays not addressed.
- The object should prove the functionality of the scheme for both the hardware and the software.
- Accommodate periodic testing without compromising the reliability of the power system or SIPS.
- Especially for more complex SIPS the scheme logic may be designed to include a test mode, allow playback of recorded events to the SIPS, and minimize the chances of human error.

SIPS Documentation



- Planning documents are less-detailed, high-level descriptions of the SIPS.
- Detailed design documents are needed for installation, commissioning, maintenance, periodic testing, as-built configuration, and long-term operations of SIPS equipment.
- Communication documentation illustrates information flow through the communication ports of SIPS devices.

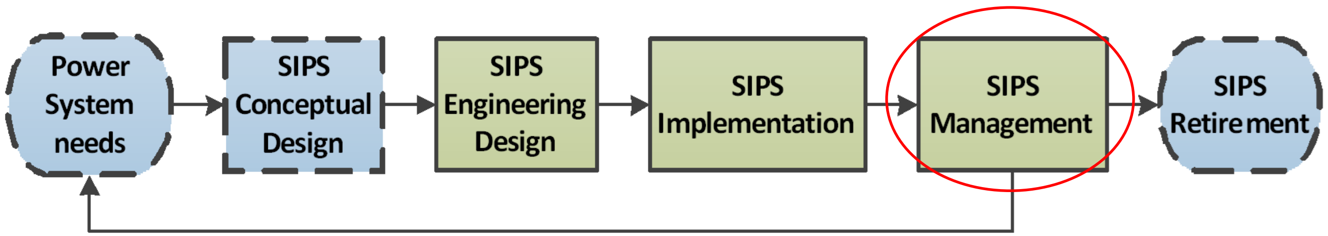
SIPS Commissioning



Commissioning tests all of the functionality of the SIPS.

- FAT primarily designed to test scheme logic with all I/O.
- SAT primarily designed to test the field connectivity of individual devices and confirm scheme logic.
- May be segmented
- During a trial run the SIPS will be live on the power system, but actions are blocked.

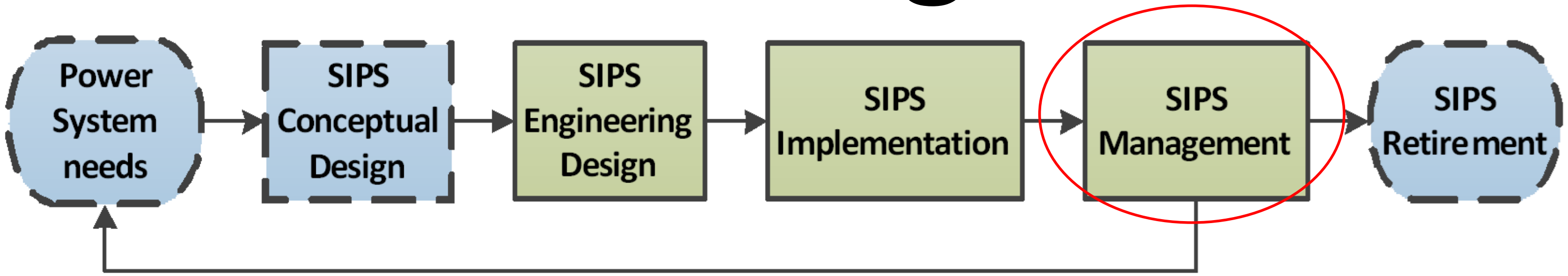
SIPS Training



Training must be tailored to the individual installation over the life of the SIPS.

- Multi-disciplinary skills required
- Complex logic, often unique to an individual SIPS.
- Pass on knowledge to the next generation.

SIPS Management



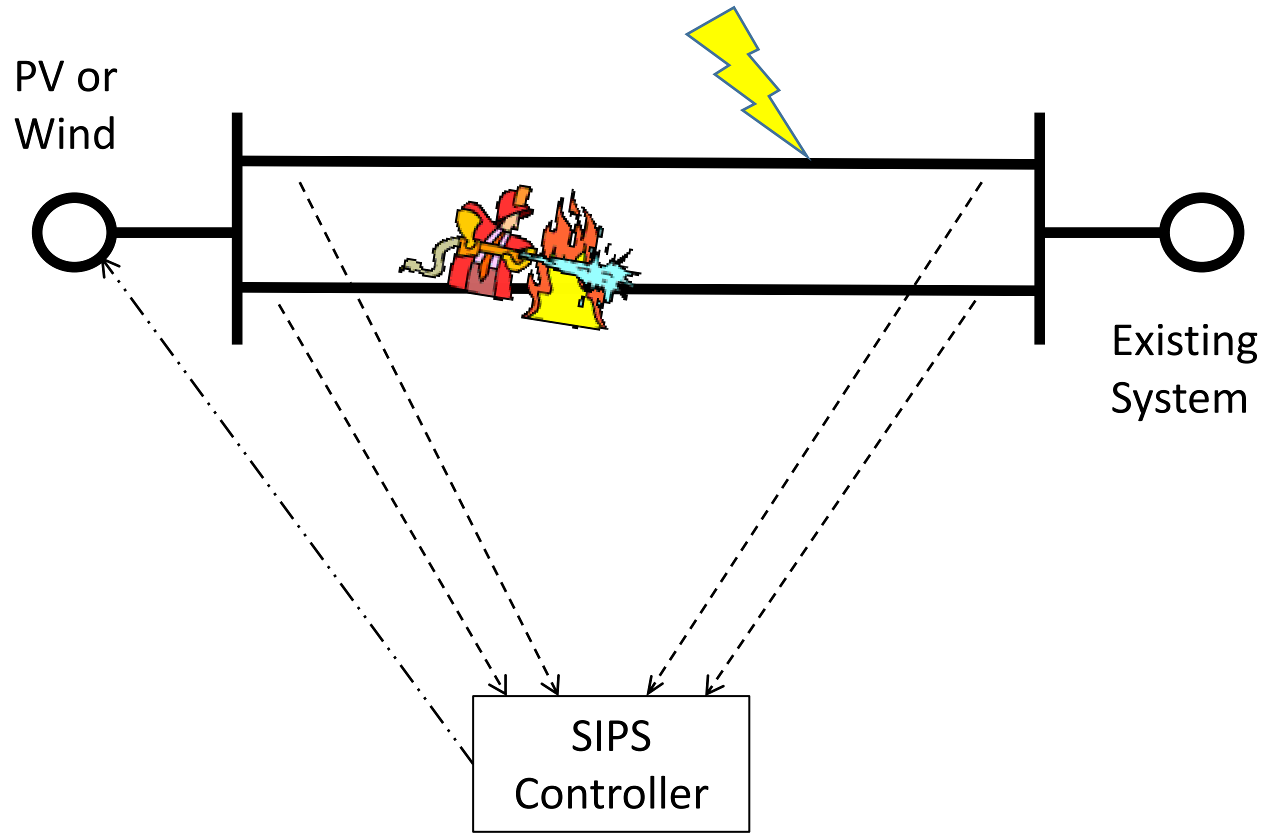
Longer Term Management Philosophy

- Operations Management
- Change management and maintenance
- Operational assessments
- Periodic planning assessments

Concluding Remarks

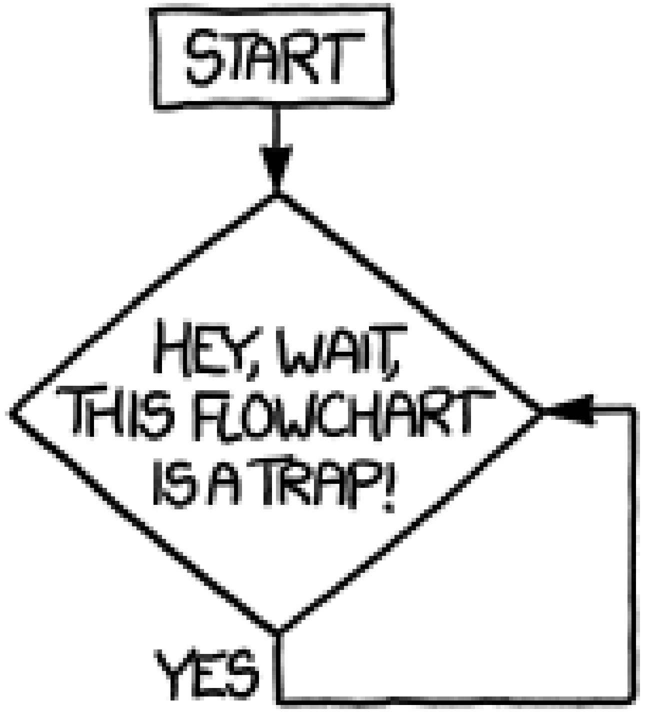
- SIPS engineering design is a complex process for turning a conceptual design into a detailed engineering design
- Follow a systematic approach
- SIPS needs an effective management program to maintain desired functionality and performance
- C37.250 could benefit anyone who is involved in SIPS engineering design, implementation, and management

A Simple SIPS Example



- The new PV or wind resource has higher capacity than the thermal capacity of either line alone.
- One line faults and the other overloads.
- Wind, solar, and some other resources can quickly reduce plant output.
- SIPS monitors both ends of both lines (status and flow).
- SIPS waits for the line reclose attempt (if used).
- SIPS determines a safe line load and sends a "ramp down" signal to the plant.
- SIPS keeps the generation ramping until the line is no longer overloaded.

SIPS Questions?



Gene Henneberg – Gene.Henneberg@nvenergy.com