Hybrid Testing on
Steel Panel Damper
Substructures using a
Multi-axial Testing System with
**Model Updating**

Recdex PISA3D Features

- **Arbitrary number of end nodes**

- **Damping and inertial effects numerically simulated**

- **One PISA3D can have many RecdexElement objects**

- **One PISA3D can work with many labs**

- **Many PISA3D can work with one lab**

- **Transmission of auxiliary signals / variables supported**

- **All analysis methods supported**

- **Interrupted tests resumable**

- **General-purpose analysis engine for hybrid simulation**

```
Element
  RecdexElement SPD-NW-3F 2 Node_I Node_J Stiff0.txt
  1 2 5462 NCREE ncree!
```
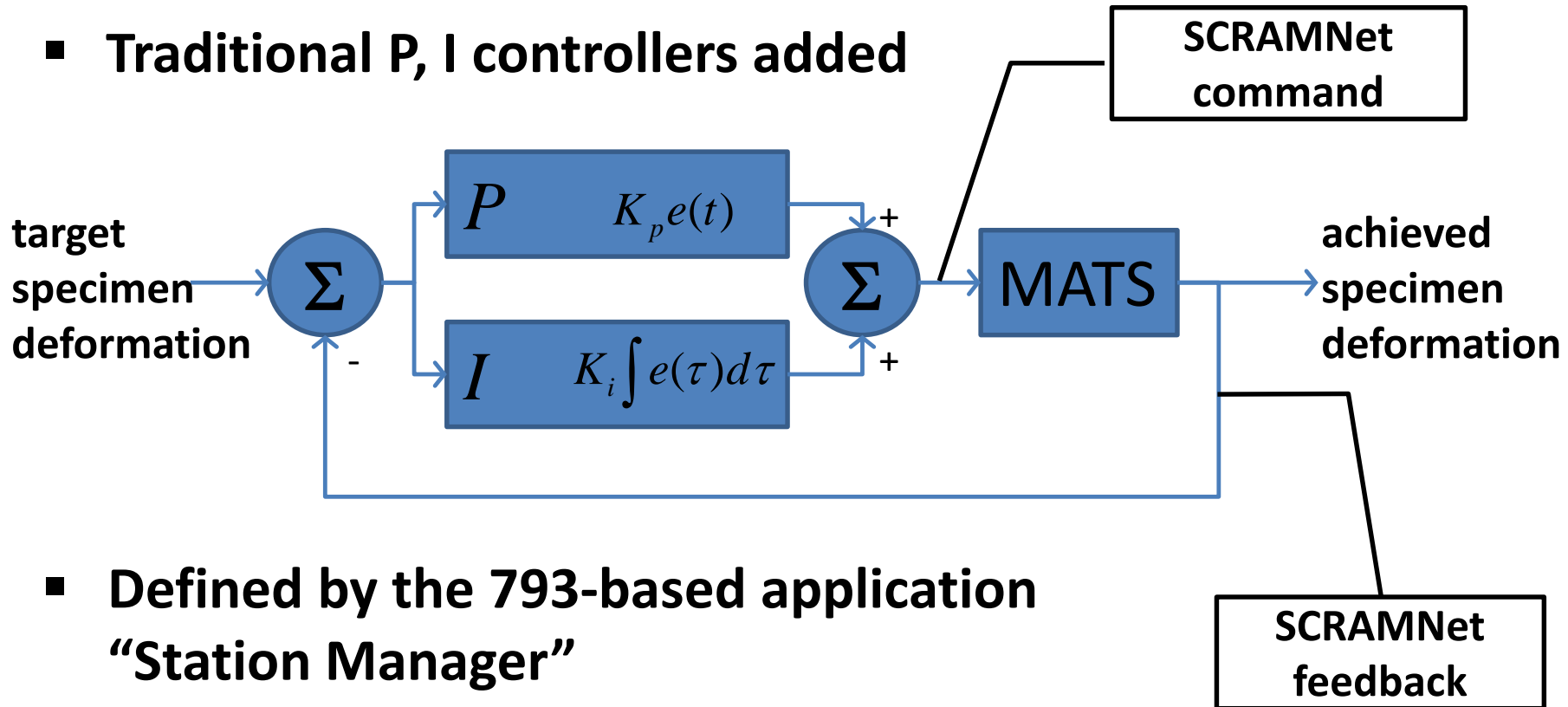
Multi-Axial Testing System (MATS)
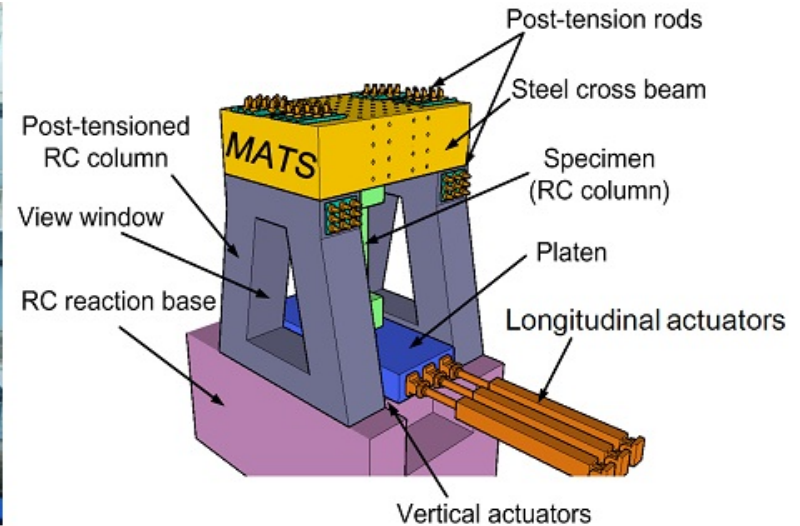
DOF	Type	Stroke	Velocity	Force
Longitudinal	Static	±1200 mm	±40 mm/s	-5.37~+7.62 MN
Lateral	Static	±100 mm	±20 mm/s	±3.8 MN
Vertical	Dynamic	±125 mm	±30 mm/s	+30 MN
Roll	Dynamic	±2 degree	±0.03 rad/s	±7.5 MN-m
Pitch	Dynamic	±2 degree	±0.03 rad/s	±27 MN-m
Yaw	Static	±2 degree	±0.015 rad/s	±5.28 MN-m

Instrumentation

External Control - Outer Loop

- **Traditional P, I controllers added**

| SCRAMNet command |

$$P \qquad K_p e(t)$$

target specimen deformation

Σ

$$I \qquad K_i \int e(\tau) d\tau$$

Σ +

+

MATS

achieved specimen deformation

| SCRAMNet feedback |

- **Defined by the 793-based application "Station Manager"**
- **Run by the "FT40" controller**

Facilities & Programs (SCRMANet)

External sensors

THS1100 FlexControl (C++) (*Recdex server*)

FT40

Compensated command SCRAMNet

469D

TCP/IP

TCP/IP

469D Host PC MATS Control (Alltalk)

FT40 Host PC FlexControl (C++) Station Manager (MTS) (*Recdex client*)

PISA3D (C++) (*Recdex server*)
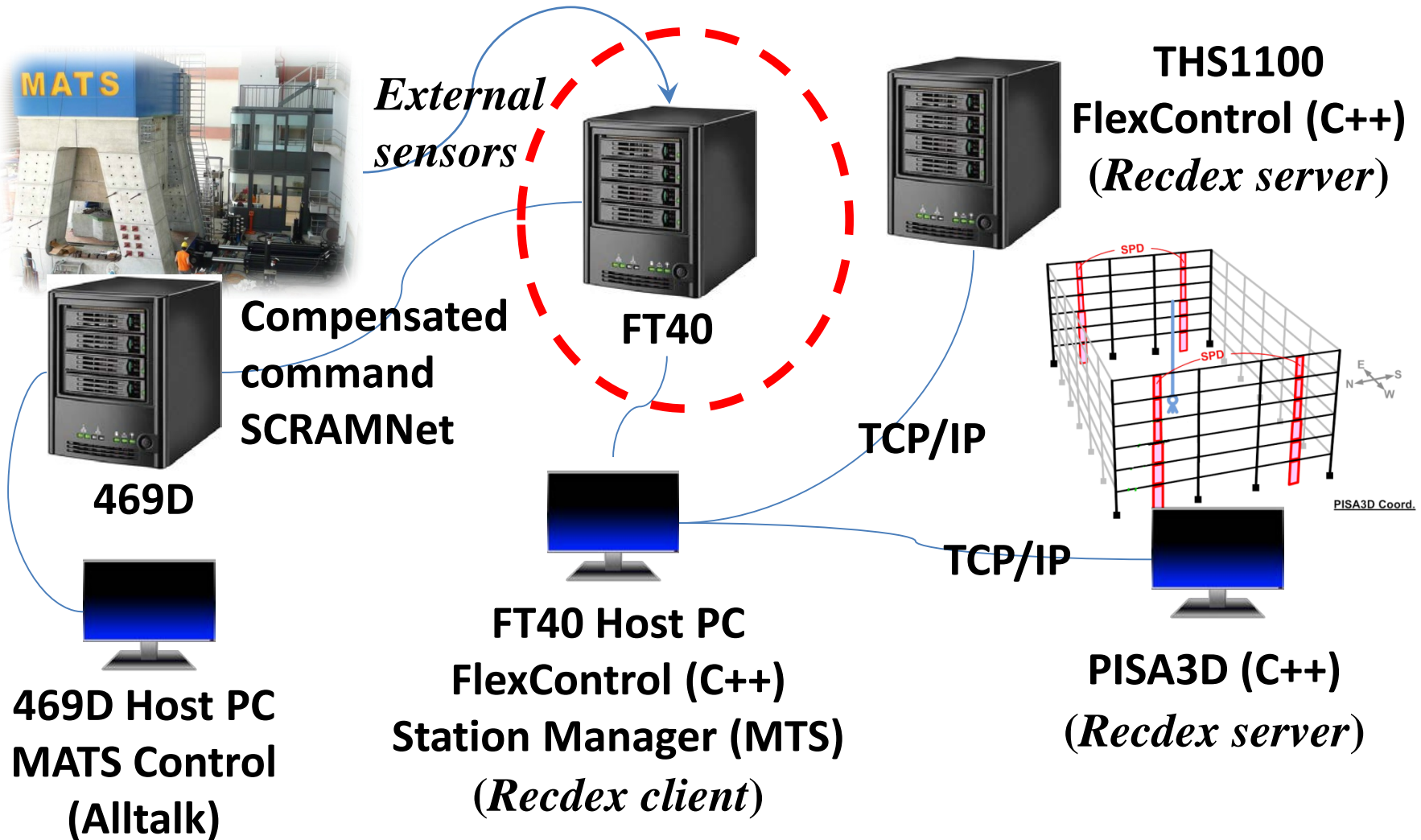
Control Modes & Resisting Force

SPD DOF	MATS DOF	Control	Resisting force
In-plane translation	Longitudinal	Ext. disp.	Experimental measurement
In-plane rotation	Pitch	Ext. disp.	Experimental measurement
Out-of-plane translation	Lateral	Ext. disp.	Elastic calculation
Out-of-plane rotation	Roll	Int. disp.	Elastic calculation
Axial translation	Vertical	Int. disp.	0 (constant)
Axial rotation	Yaw	Int. disp.	0 (constant)

No hard coding for: ext. control, calculation & adoption
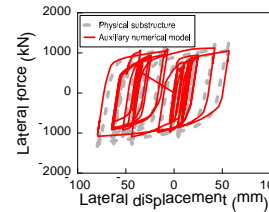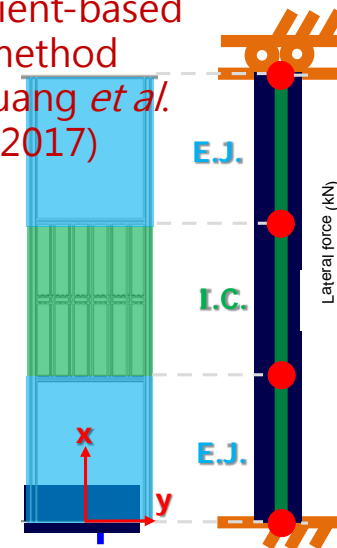
Online Model Updating

Numerical Substructure (NS) + Recdex Elements (REs)

Physical Substructure (PS)

Auxiliary Numerical Model (ANM)
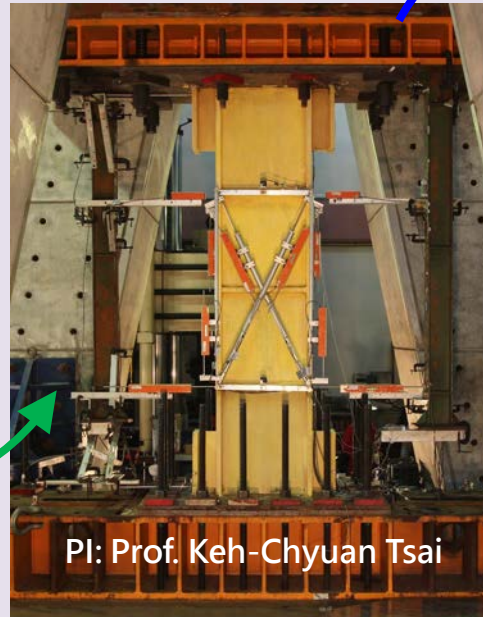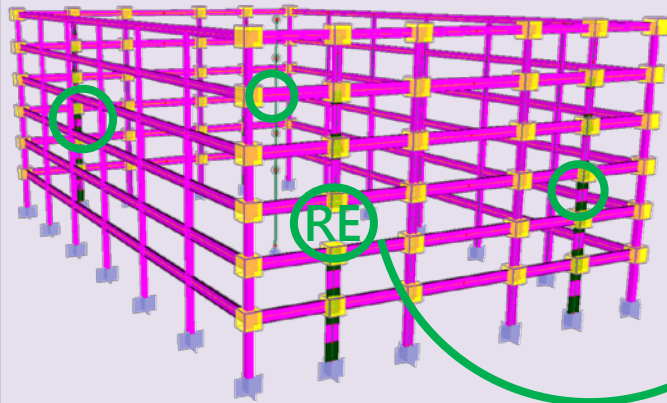
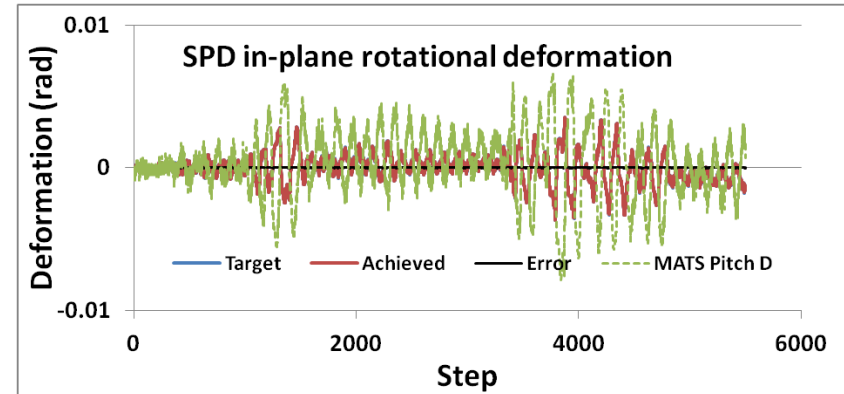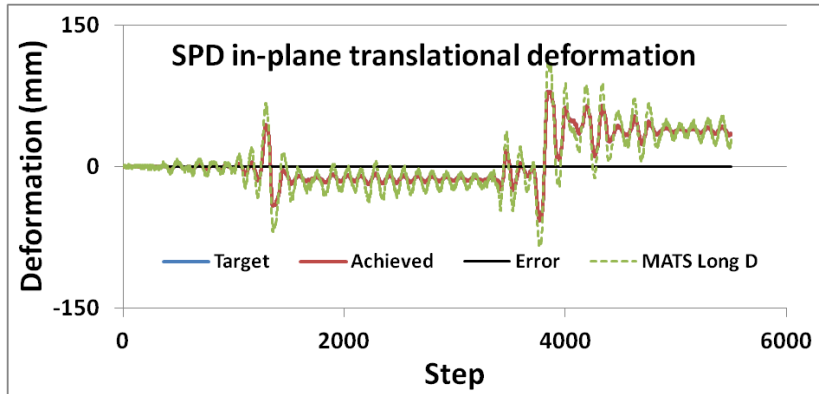Parameter identification with the gradient-based method (Chuang *et al.* 2017)
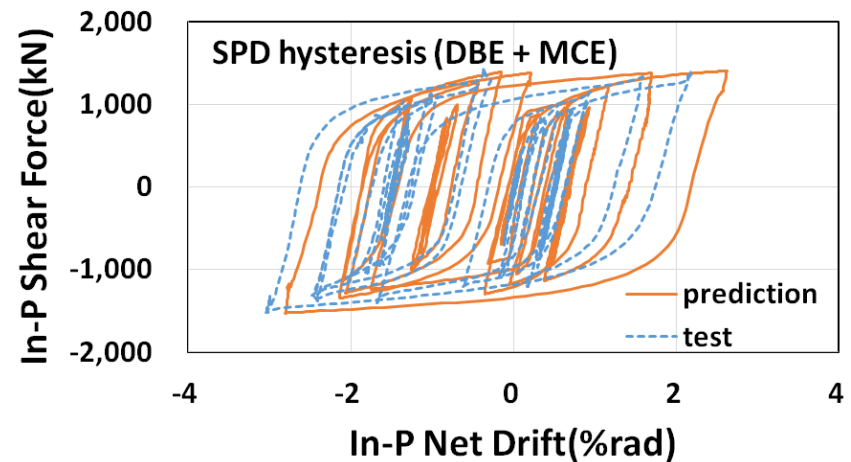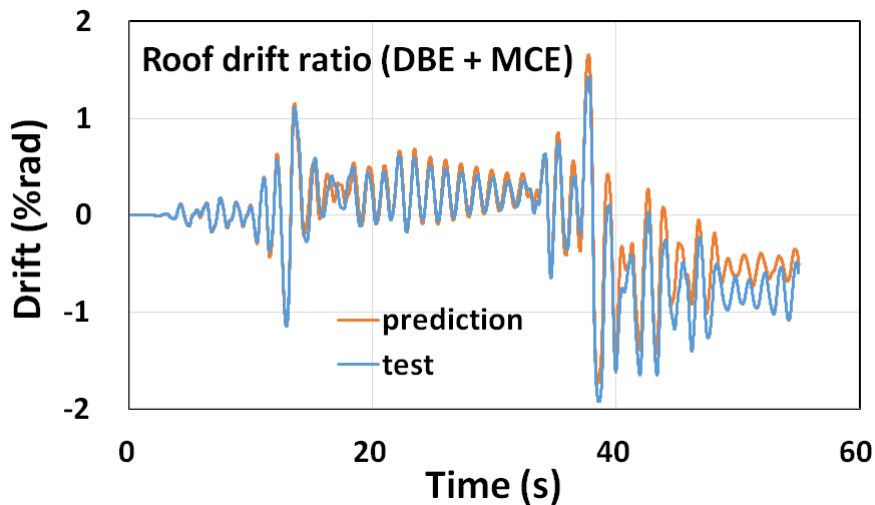
Conduct hybrid simulation

PI: Prof. Keh-Chyuan Tsai

E.J.

I.C.

E.J.

1. Update relevant models (8 SPD ICs of 1F and 2F)
2. Update the **12 x12** stiffness matrix (Kt) via static condensation

Test Results

- ## External control

- ## Structural responses

Future

- **Keywords**
  near-fault, high velocity, large deformation, real-time

- **Conventional geographically distributed HS**
  MATS + reaction wall + BATS

- **Real-time HS**
  BATS + south table + south reaction wall

- **HS for SSI**

Thank you for your kind attention.