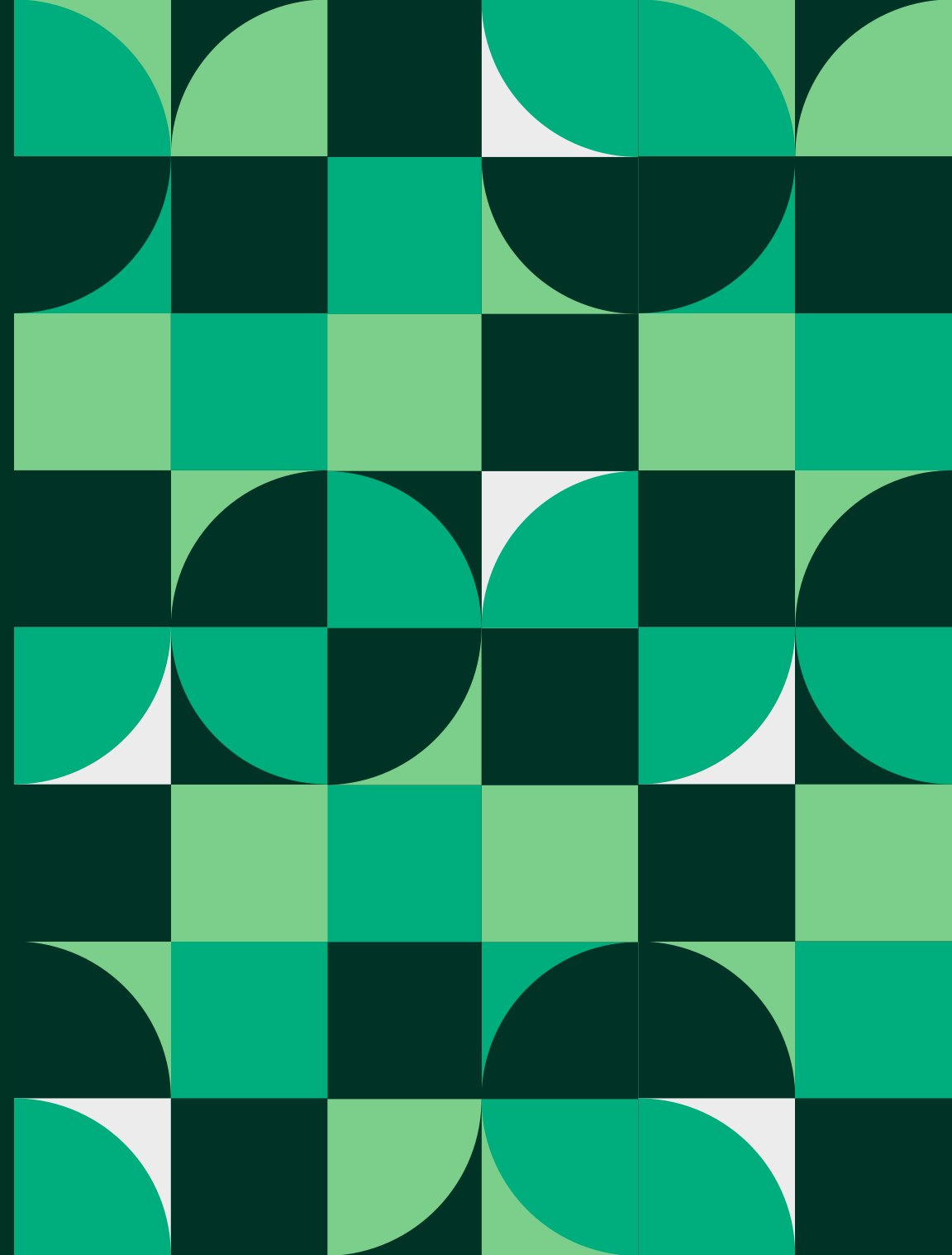


The Big Refactor: A Technological Challenge and Business Outcomes

Kenny Kreitzer, CLA

Paul Holzrichter, CLAD



Outline

Who is Badger Meter?

Current State of Test Software

Assessment through NI Professional Services

Selection of Third Party

Future State

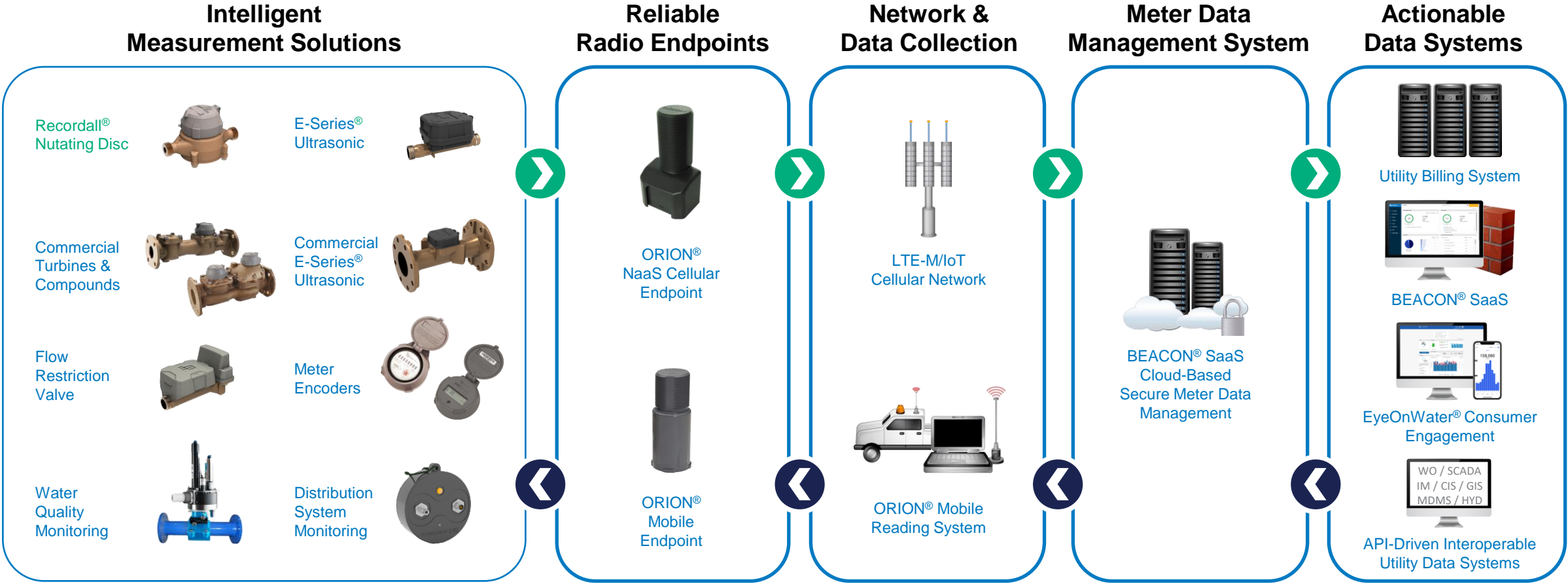
Q & A

Badger Meter - A Global Company

- 118+ Years of Operation
- Present in over 50 Countries
- 9 Global Manufacturing Sites
- 2,000+ Employees
- 5 Global R&D Centers



Smart Water Solution Offerings



Proven Solution: Reliability



Less than 0.5% failure rate over 20-year life. Over 10 million ORION® endpoints deployed at more than 3,000 Utilities since 2002.

Current State of Test Software



A Technology Shift

Large adjustment when moving from testing Mechanical versus Electronic Meters

- Long lead time for modifications to the meter to be introduced (mechanical) versus multiple possible changes per year (electronic)
- One or two options (mechanical) versus "infinite" configurability for electronic
- Order Specific programming



What Language should I use now?

Previously Test Engineer/Design Engineer could choose programming language

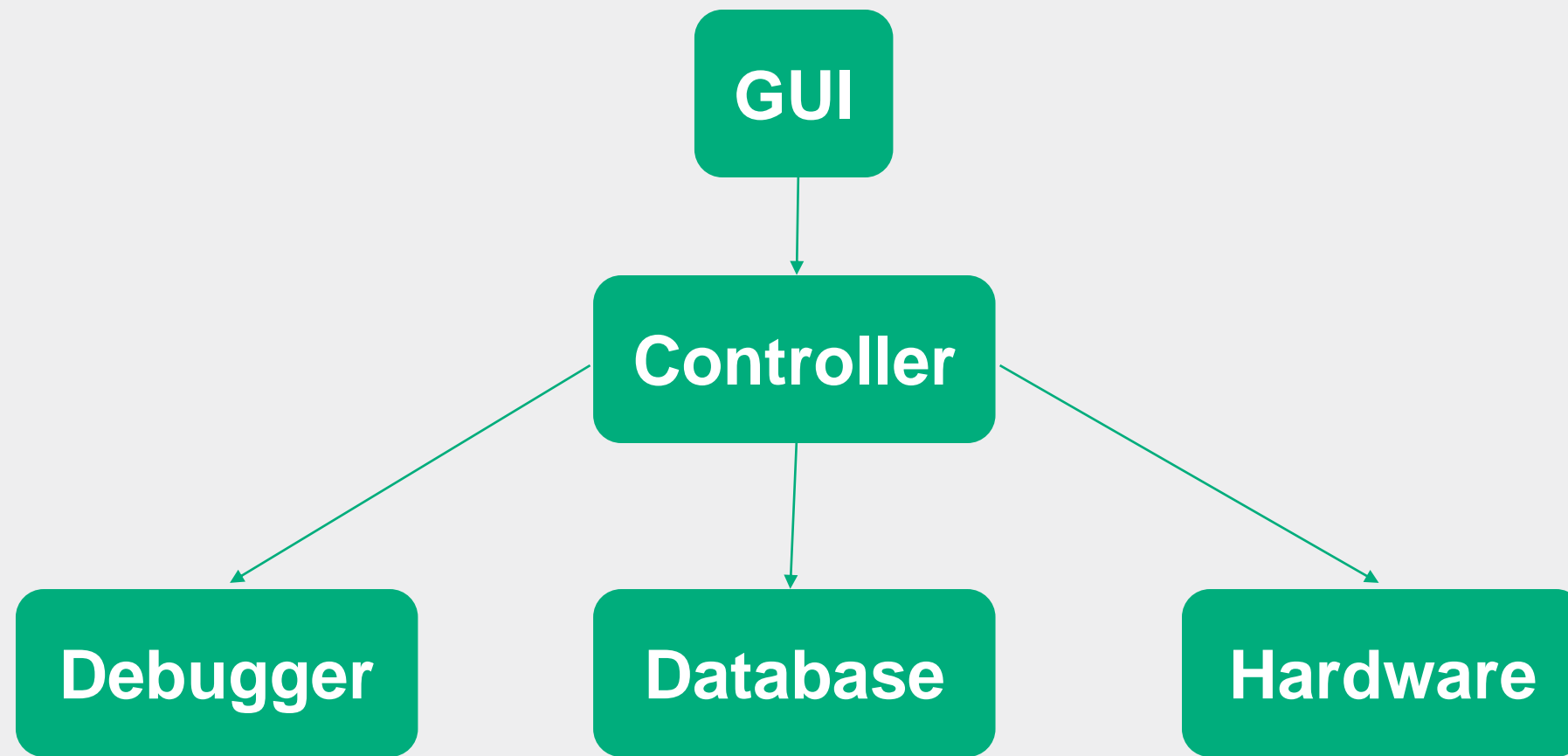


Baby Steps

Standardizing on LabVIEW

- Easier to create UIs
- New Software – Must be written in LabVIEW
- Legacy Software – Ported/rewritten in LabVIEW as needed (ROI/business needs)
- Code Reuse
 - VIPM – Distributing reuse source code
 - Project Templates – Shell of program auto-generated (~50% complete)

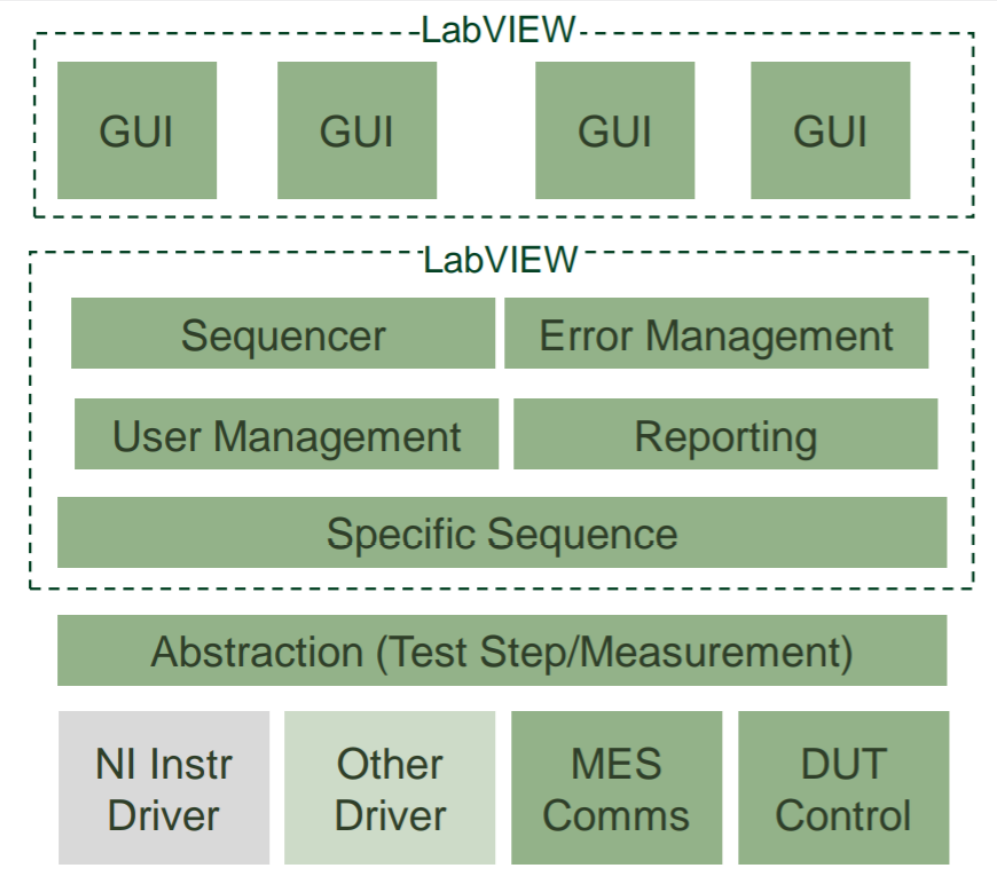
LabVIEW Architecture



Compiled into a single EXE

1 to N Controllers, based on # of UUTs

Results in...



- Mostly custom code
- Similar but unique GUIs

No Code
Limited Coding
Custom Code

The screenshot displays a complex LabVIEW test interface. On the left, a configuration panel includes a 'Menu' button, 'Scan Shop Order #' field, 'Get Order' button, 'Scan Accuracy Tag' field, 'Start' and 'Abort' buttons, and an 'Exit' button. Below this is a 'Shop Order Configuration' section with fields for Shop Order #, ItemNum, Order QTY, QTY Tested, Size, Unit of Measure, FWD Totalizer, Pulse Output?, Pressure Sensor?, Encoder?, ISO Standard MID?, Analog Output?, Wireless Config?, Wired Config?, Lid Color, and Part to be Tested. A 'Shop Order Customer Serialization Summary' table and a 'Device Specific Yield' section are also present. The main area features four test cells (Cell 1, Cell 2, Cell 3, Cell 4) with 'Start' and 'Abort' buttons, and a 'Settings' button. Each cell has a 'Test Description' table with columns for Min, Actual, Max, Result, and Exec Time. The bottom of the interface shows a 'SCAN SHOP ORDER TO BEGIN.' message.

And.....Another Sequencer!

The Good

- Changes without recompile*
- Password Protected
- Standard comparison
- Developer does not have to worry about formatting results into internal database format

The Bad

- A lot of maintenance
 - Debugging, Documentation updates, keeping up with VI scripting changes to "auto-upgrade"
- Lacked features like looping steps, branching, etc.

NI Professional Services

Best Practices and Code Review

Some Issues with Current Process

- Current framework is not scaling fast enough
- Too much QA validation for each update
- Onboarding is taking longer than desired
- Harder to find advanced LabVIEW knowledge locally

Is moving to TestStand the correct move?

Customer Feedback

Talk to ALL Stakeholders

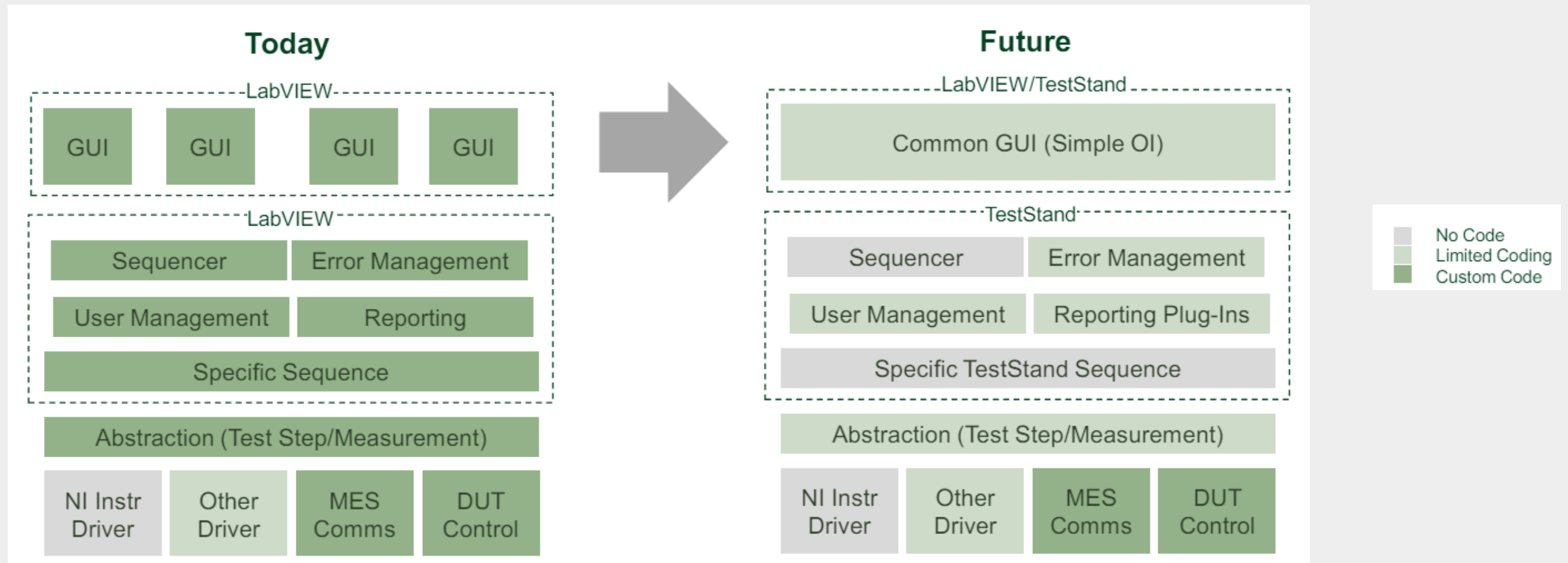
- Meet with all teams that interact (direct and indirectly) with the software
 - Quality Engineering
 - Manufacturing Engineering
 - Test Engineering
 - Operators
- What do they like?
- Dislike?
- What do they wish for?

Recommendations

- Try to use the standard process models
 - Custom Process Models make it harder to update to newer TS versions
 - PPLs CAN be useful to prevent missing file issues
 - Would also help with validation, since PPLs are compiled code
 - Make measurements or “test steps” reusable to allow code sharing
 - Utilize NI tools for Soft Front Panels (think InstrumentStudio or MeasurementLink)

Recommendations

Less code needed to "startup" a tester



Third Party Assistance

Just because you can do it....

We knew we could create UI, but at what cost?

- Time and effort to complete internally was too great
- Engaged third party to "jump start" our development
 - Experience in creating TestStand UI
 - Allow BMI to own source code when complete
 - DQMH and TestStand
 - DQMH Consortium was a HUGE help here
 - Chose NeoSoft as the partner



Documentation

- Requirements Gathering
 - Even if you think you have enough detail to explain your project, you likely need more!
 - We (Test Group) knew several things (and assumed others did) but were not communicated properly.
- Stale documentation can cause confusion
 - There are MANY good presentations and tools on LabVIEW documentation on YouTube (and here!)
 - Documentation can be a pain in the butt, but worth it in the long run.

Outcomes

Using More PPLs

Refactor some of the DQMH Modules

- "Teststand-ify" the DQMH Modules before making into PPL
 - Free tool from NeoSoft that will convert all DQMH responses to Request and Wait for Reply, among other changes.
- Testing out Plugin based PPLs
 - Some challenges with 32/64 bit PPLs and where to put them on disk
- Trying to keep compatibility between LabVIEW code and TS
 - PPLs in the same location on disk
- Protect code changes (pre-compiled)

Custom Step Type

- Due to requirements of internal database, the name of the parameter needs to be pre-defined in the BMI database.
- Only supports Pass/Fail instead of Passed, Failed, Error, Aborted, Terminated.
- Only the custom Step Type is used to generate text to be sent to database.

The UI

Login

Logout

Settings

Health Monitoring

LOGs

Quit Application

UUTs 01-04

Serial Number...

Start

Start Tests

Abort All

Shop Order Configuration

ItemNumber

Shop Order QTY

QTY Tested

Device Specific Yield

Good Cycles

Bad Cycles

Yield %

UUT 1

Idle

Abort

Serial Number...	STEP	DESCRIPTION	SETTINGS	STATUS
------------------	------	-------------	----------	--------

Timestamp	Message	Category
-----------	---------	----------

Serial Number...

Start

UUT 2

Idle

Abort

Serial Number...	STEP	DESCRIPTION	SETTINGS	STATUS
------------------	------	-------------	----------	--------

Timestamp	Message	Category
-----------	---------	----------

X

...

1 UUT

Login

Logout

Settings

Health Monitoring

LOGs

Quit Application

Shop Order Mode

2103578

Start All

Abort All

Active Database

Development

Shop Order Configuration

ItemNumber

40-03-06

Shop Order QTY

10

QTY Tested

2

Device Specific Yield

Good Cycles

107

Bad Cycles

386

Yield %

21.7

Serial Number...

Start

00:00:05

UUT 1

SN : 100110538

Passed

Open Report

Abort

CycleQty	Passed	1.00			
CycleTimeUom	Passed	s			
ConfirmationId	Passed	2103578230			
TestDate	Passed	2024-05-07T12:56:50			
DeviceName	Passed	LM-61NKN73			
ItemNum	Passed	40-03-06			
WATs Header: Set PartNumber	Done				
WATs Header: Set BatchSerialNumber	Done				
WATs Header: Set StationName	Done				
Validate Previous Process	Passed	Passed	Passed		
Set Production Code (3)	Passed	3.00			
Validate Current Process	Passed	Previously Tested	Previously Tested		
Set ItemNum from Transaction Data Returned	Done				
Get ARM Firmware (Expected)	Done				
Get ASIC Firmware (Expected)	Done				
Simulate Actual Values	Done				
Verify Firmware: ARM	Passed	1.0.4501	1.0.4501		
Verify Firmware: ASIC	Passed	1.0.4491	1.0.4491		
Set PCBA & Hardware Rev Actual	Done				
Verify Part Number	Passed	68688-004	68688-004		
Verify Hardware Revision	Passed	16	16		
Verify Power Level	Passed	-11.56	-13.00	4.00	GELE dB
Verify Carrier Frequency	Passed	4000.00	3500.00	4500.00	GELE kHz
Verify Carrier Power	Passed	-11.56	-12.00		GT dB
Spectral Frequency Response	Passed	10.50	9.00	11.00	GELE
Attribute: Record Unit of Measure	Done				
Attribute: Record MeterType	Done				

Timestamp	Message	Category
5/7/2024 12:56:50 PM	UUT Serial Number: 100110538	info
5/7/2024 12:56:50 PM	Test Start Time: 2024-05-07T12:56:50	info
5/7/2024 12:56:50 PM	PC Name: LM-61NKN73	info
5/7/2024 12:56:51 PM	Validate Previous Process: Pass	Result
5/7/2024 12:56:51 PM	UUT Test Starting	info
5/7/2024 12:56:51 PM	Validate Current Process: Previously Tested	info
5/7/2024 12:56:52 PM	Database Result for PCBA Transaction: SN: 100110538 ItemNum: 68688-004 Socket: 1	Info
5/7/2024 12:56:53 PM	Expected Values from Database ARM: 1.0.4501, ASIC: 1.0.4491 Socket: 1	Info
5/7/2024 12:56:55 PM	Begin Logging Data...	info
5/7/2024 12:56:56 PM	Log Data "PASS"	Result
5/7/2024 12:56:56 PM	Debug File Complete	Info
5/7/2024 12:56:56 PM	Connect UUT and Press 'Start' to begin	info

2 UUTs

Shop Order Mode

2103578

Start All

Abort All

Active Database

Development

Shop Order Configuration

ItemNumber

40-03-06

Shop Order QTY

10

QTY Tested

1

Device Specific Yield

Good Cycles

108

Bad Cycles

387

Yield %

21.8

UUTs 01-04

Start

00:00:10

UUT 1
SN : 100110538
Passed

Open Report

Abort

Step Name	Status	Result	Low Limit	High Limit	Attribute
CycleQty	Passed	1.00			
CycleTimeUom	Passed	s			
ConfirmationId	Passed	2103578230			
TestDate	Passed	2024-05-07T14			
DeviceName	Passed	LM-61NKN73			
ItemNum	Passed	40-03-06			
WATs Header: Set PartNumbe	Done				
WATs Header: Set BatchSerial	Done				
WATs Header: Set StationNam	Done				
Validate Previous Process	Passed	Passed	Passed		
Set Production Code	Passed	3.00			
Validate Current Process	Passed	Previously Test	Previously Test		
Set ItemNum from Transaction	Done				
Get ARM Firmware (Expected)	Done				
Get ASIC Firmware (Expected)	Done				
Simulate Actual Values	Done				
Verify Firmware: ARM	Passed	1.0.4501	1.0.4501		
Verify Firmware: ASIC	Passed	1.0.4491	1.0.4491		
Set PCBA & Hardware Rev Act	Done				
Verify Part Number	Passed	68688-004	68688-004		
Verify Hardware Revision	Passed	16	16		
Verify Power Level	Passed	-11.56	-13.00	4.00	GELE dB
Verify Carrier Frequency	Passed	4000.00	3500.00	4500.00	GELE kHz
Verify Carrier Power	Passed	-11.56	-12.00		GT dB
Spectral Frequency Response	Passed	10.50	9.00	11.00	GELE
Attribute: Record Unit of Meas	Done				
Attribute: Record MeterType	Done				

Timestamp	Message	Category
5/7/2024 2:07:44 PM	UUT Serial Number: 100110538	info
5/7/2024 2:07:45 PM	Test Start Time: 2024-05-07T14:07:45	info
5/7/2024 2:07:45 PM	PC Name: LM-61NKN73	info
5/7/2024 2:07:46 PM	Validate Previous Process: Pass	Result
5/7/2024 2:07:46 PM	UUT Test Starting	info
5/7/2024 2:07:51 PM	Validate Current Process: Previously Tested	info
5/7/2024 2:07:53 PM	Database Result for PCBA Transaction. SN: 100110538 ItemNum	Info
5/7/2024 2:07:53 PM	Expected Values from Database ARM: 1.0.4501, ASIC: 1.0.4491 S	Info
5/7/2024 2:07:56 PM	Begin Logging Data...	info
5/7/2024 2:07:57 PM	Log Data "PASS"	Result
5/7/2024 2:07:57 PM	Debug File Complete	Info
5/7/2024 2:07:57 PM	Connect UUT and Press 'Start' to begin	info

Serial Number...

Start

00:00:06

UUT 2
SN : 100110538
Failed

Open Report

Abort

Step Name	Status	Result	Low Limit	High Limit	Attribute
CycleTimeUom	Passed	s			
ConfirmationId	Passed	2103578230			
TestDate	Passed	2024-05-07T14			
DeviceName	Passed	LM-61NKN73			
ItemNum	Passed	40-03-06			
WATs Header: Set PartNumbe	Done				
WATs Header: Set BatchSerial	Done				
WATs Header: Set StationNam	Done				
Validate Previous Process	Passed	Passed	Passed		
Set Production Code	Passed	3.00			
Validate Current Process	Passed	Previously Test	Previously Test		
Set ItemNum from Transaction	Done				
Get ARM Firmware (Expected)	Done				
Get ASIC Firmware (Expected)	Done				
Simulate Actual Values	Done				
Verify Firmware: ARM	Passed	1.0.4501	1.0.4501		
Verify Firmware: ASIC	Passed	1.0.4491	1.0.4491		
Set PCBA & Hardware Rev Act	Done				
Verify Part Number	Passed	68688-004	68688-004		
Verify Hardware Revision	Passed	16	16		
Verify Power Level	Failed	-19.23	-13.00	4.00	GELE dB
Verify Carrier Frequency	Passed	4000.00	3500.00	4500.00	GELE kHz
Verify Carrier Power	Passed	-11.56	-12.00		GT dB
Spectral Frequency Response	Passed	10.50	9.00	11.00	GELE
Attribute: Record Unit of Meas	Done				
Attribute: Record MeterType	Done				
FailureReason	Passed	Verify Power L			

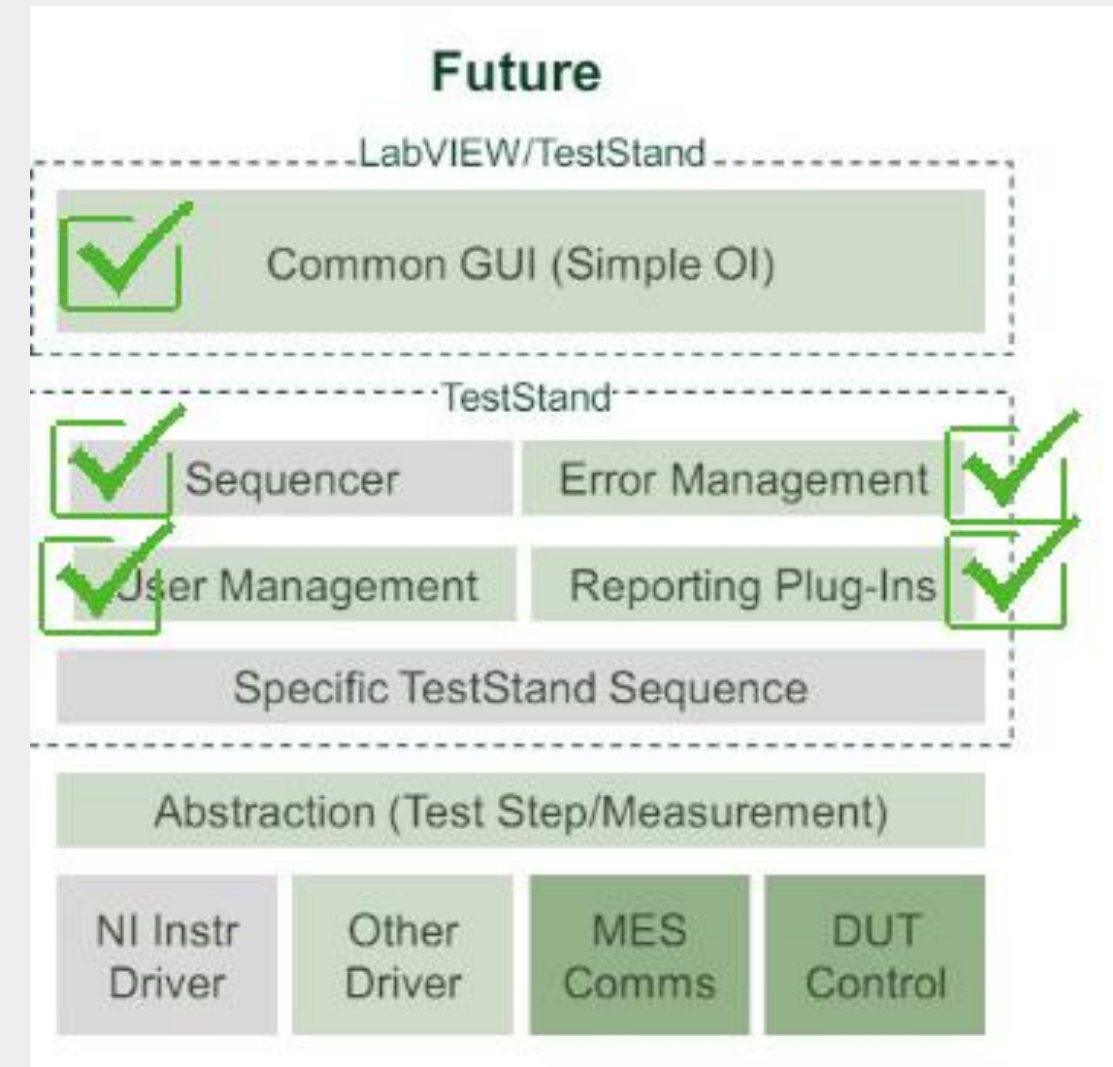
Timestamp	Message	Category
5/7/2024 2:07:53 PM	UUT Serial Number: 100110538	info
5/7/2024 2:07:53 PM	Test Start Time: 2024-05-07T14:07:53	info
5/7/2024 2:07:53 PM	PC Name: LM-61NKN73	info
5/7/2024 2:07:54 PM	Validate Previous Process: Pass	Result
5/7/2024 2:07:54 PM	UUT Test Starting	info
5/7/2024 2:07:56 PM	Validate Current Process: Previously Tested	info
5/7/2024 2:07:57 PM	Database Result for PCBA Transaction. SN: 100110538 ItemNum	Info
5/7/2024 2:07:58 PM	Expected Values from Database ARM: 1.0.4501, ASIC: 1.0.4491 S	Info
5/7/2024 2:07:59 PM	Test Complete: Failed	Result
5/7/2024 2:07:59 PM	Failure Reason: Verify Power Level	info
5/7/2024 2:07:59 PM	Begin Logging Data...	info
5/7/2024 2:08:00 PM	Log Data "PASS"	Result
5/7/2024 2:08:00 PM	Debug File Complete	Info
5/7/2024 2:08:00 PM	Connect UUT and Press 'Start' to begin	info

Reporting

- TestStand allows Test Result reporting to multiple data repositories
 - Internal Database
 - Can use existing DQMH module after "TestStandify-ing"
 - Module compiled into PPL
 - Internal Database data must be synchronous reporting
 - Cloud production analytics (WATs)
 - WATs provides TestStand Plugin to automatically import data
 - LabVIEW API is open source, but usually requires some customization to add all features
 - Or create DIY post processor to generate output into one of 3 possible file formats

What does Developer need to do?

- Process Model and Callback overrides take care of most of the setup
- Developer can focus more on just the tests/measurements (as originally intended)
- Uses Parallel Model by default
- Can adjust from 1 to 16 UUTs via configuration file setting
- Send messages to UI



Q and A
