



SEA-BIRD
SCIENTIFIC

Present and Future State of SBE 41 Argo CTD

Sea-Bird Scientific

Float / Sensor Workshop
University of Washington
September 2017

SBE 41: Topics to be covered

The Past

- Family tree

The Present

- Current product versions
- Comparison of specifications and capabilities
- Product versions that are no longer in production

The Future

- Product consolidation

Not covered:

- SBE 61
- Navis (see Daryl Carlson's talk, Wednesday afternoon)

SBE 41: Nomenclature

- SBE 41
 - Spot samples
 - No internal memory -> polled sampling only
 - Fixed pump rate
 - Optional sensors: Dissolved oxygen
- SBE 41CP
 - Designed to perform continuous profiles, storing data internally
 - Typically spot samples below 1000 dbar
 - Samples at 1 Hz from 1000 dbar to near surface
 - bin averaged into 2 dbar bins before transmitted to float controller
 - Variable pump rate
 - Optional sensors: Dissolved oxygen, STS

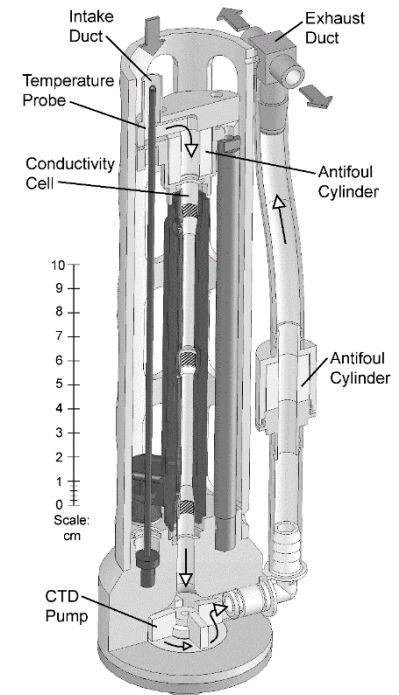
SBE 41: The Beginning

Originally developed for PALACE floats (Profiling Autonomous Lagrangian Circulation Explorer) to provide highly accurate & stable salinity over the lifetime of the float (3+ years)

SBE 41



1997



2017

2018

SBE 41: The Beginning

Success of SBE 41 CTD with PALACE floats led to ARGO Program

Goal: 3000 floats providing near-real time temperature and salinity from upper 2000m of the ocean

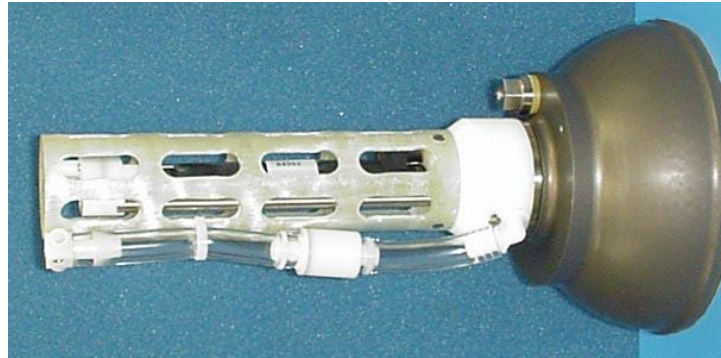
Accuracy: $\Delta T = \pm 0.002^{\circ}\text{C}$
 $\Delta S = \pm 0.01 \text{ psu}$
 $\Delta P = \pm 2.4 \text{ dbar}$



SBE 41: The Past

SBE 41CP

Standard



Coriolis



41 ARGO 41CP



1997 1999 2000

2018

SBE 41: The Past

SBE 41/41CP

- Integrated DO
- other sensors



41 ARGO 41CP



1997 1999 2000

41/41CP IDO



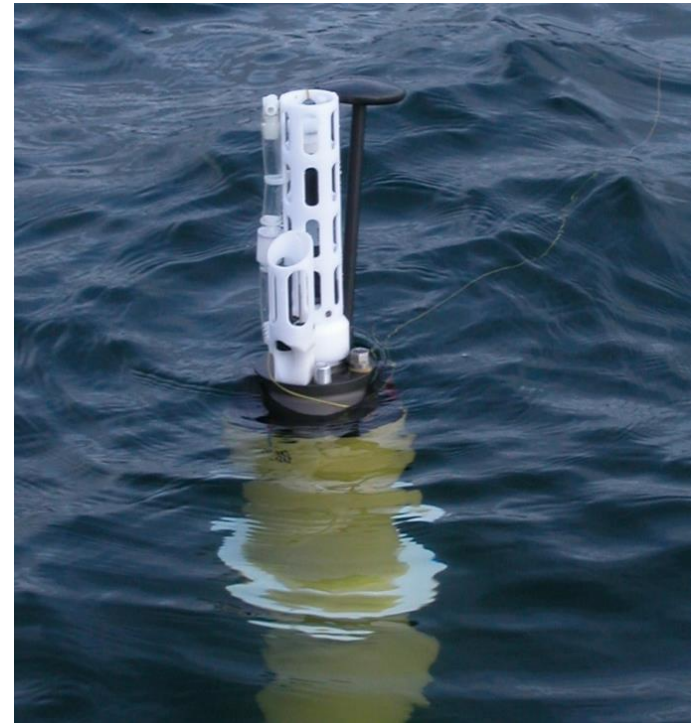
2003

2018

SBE 41CP Surface Temperature Salinity (STS)

- Free-flushed sensor, shorter C-cell
- Samples through surface and near park depth (980-960 dbar) at 1 Hz
- Drift due to fouling from surface films

Goal: $S \sim 0.1$ psu
 $T \sim 0.01^{\circ}\text{C}$



41 ARGO 41CP IDO 41CP STS



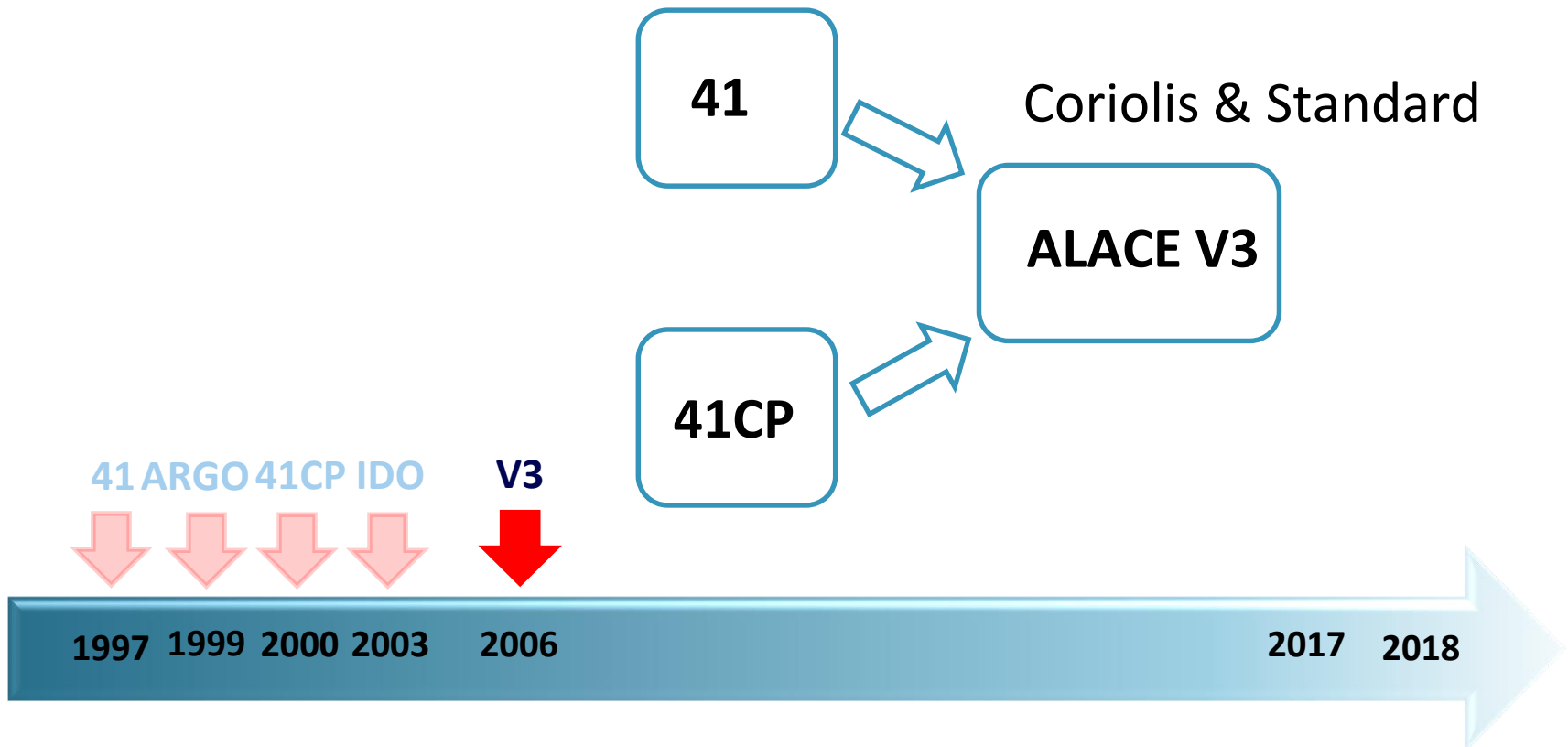
1997 1999 2000 2003 2006

2018

SBE 41: The Recent Past

Hardware Consolidation (2006)

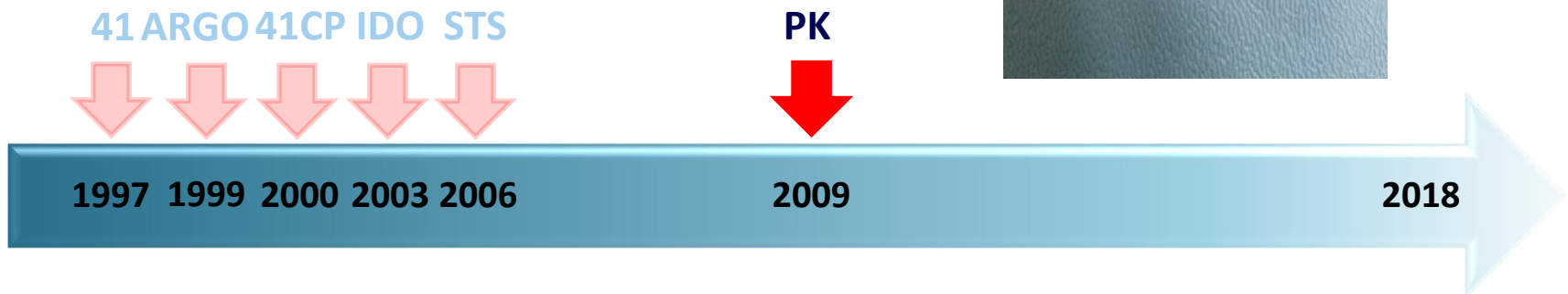
ALACE V3 used either as 41 or 41CP (single board, different FW)



SBE 41: The Past

Kistler Pressure Sensors (PK)

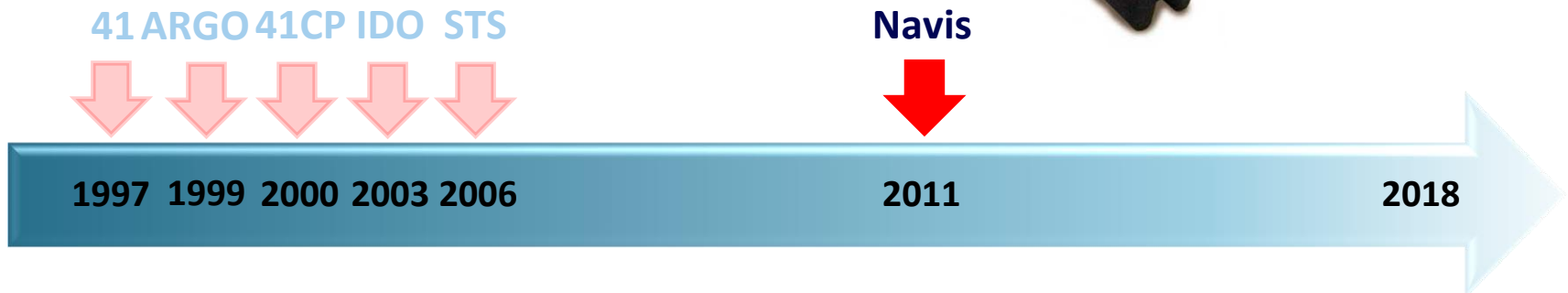
- Microleaks on Druck sensors



SBE 41: The Past

Navis

- Initially with 41CP ALACE V3



SBE 41: The Past

Navis

- 41N CTD
- ALACEplus (41+) derived from 41N



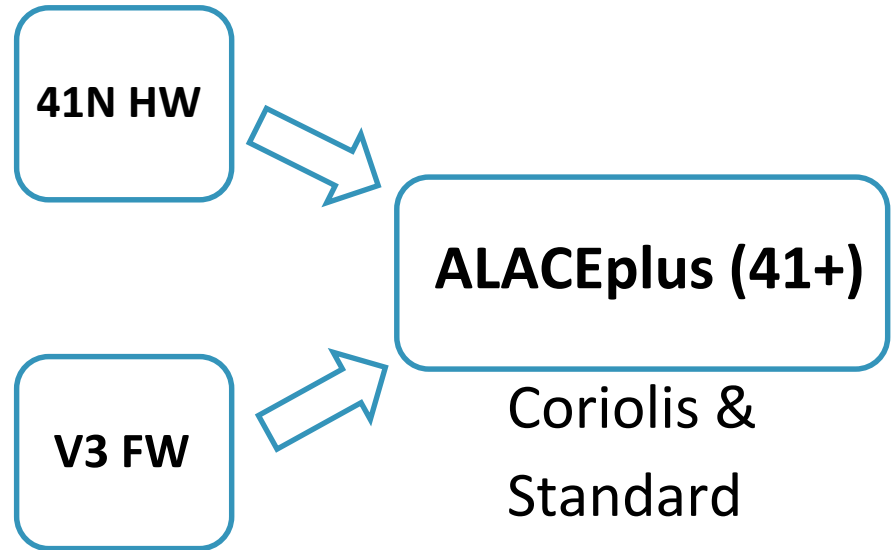
Hardware Consolidation

Reason: parts obsolescence

41+ science hub capable

- AD interface
- Serial interface

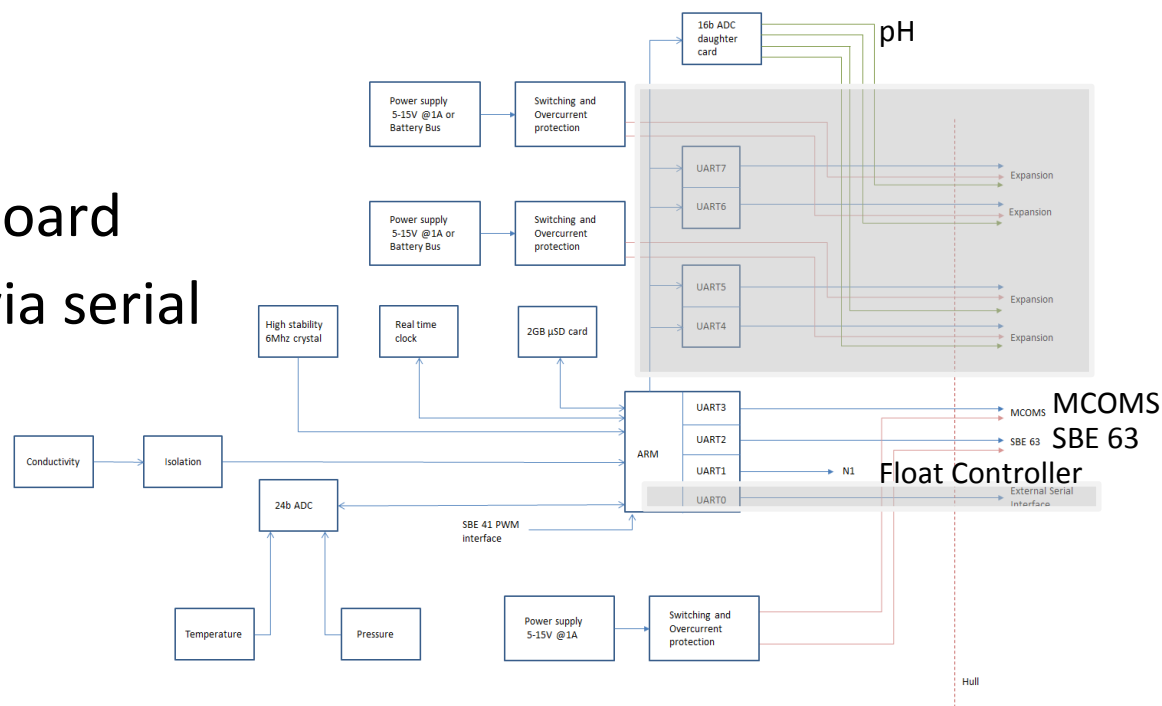
SBE 41: The Recent Past



SBE 41: The Recent Past

ALACEplus (41+)

- pH via daughter board
- SBE 63, MCOMS via serial



41 ARGO 41CP IDO STS 41N PK



1997 1999 2000 2003 2006 2008 2009

41+ (~ S/N 7500)



2015

2017 2018

SBE 41: The Recent Past

Firmware Consolidation

41

Standard V3.0
APL-CT V2.0
APL-SSAL V1.0
IDO-Webb V3.0

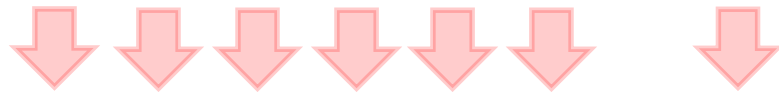
41CP

Standard V3.0C
Metocean V2.0
UW 2.0
McLane 3.0
IDO-McLane 3.1
SSAL-UW V1.0b
IDO-Seascan 2.0a
IDO-UW 2.0b

41 ARGO 41CP IDO STS 41N

41+

ALACE V3



1997 1999 2000 2003 2006 2008

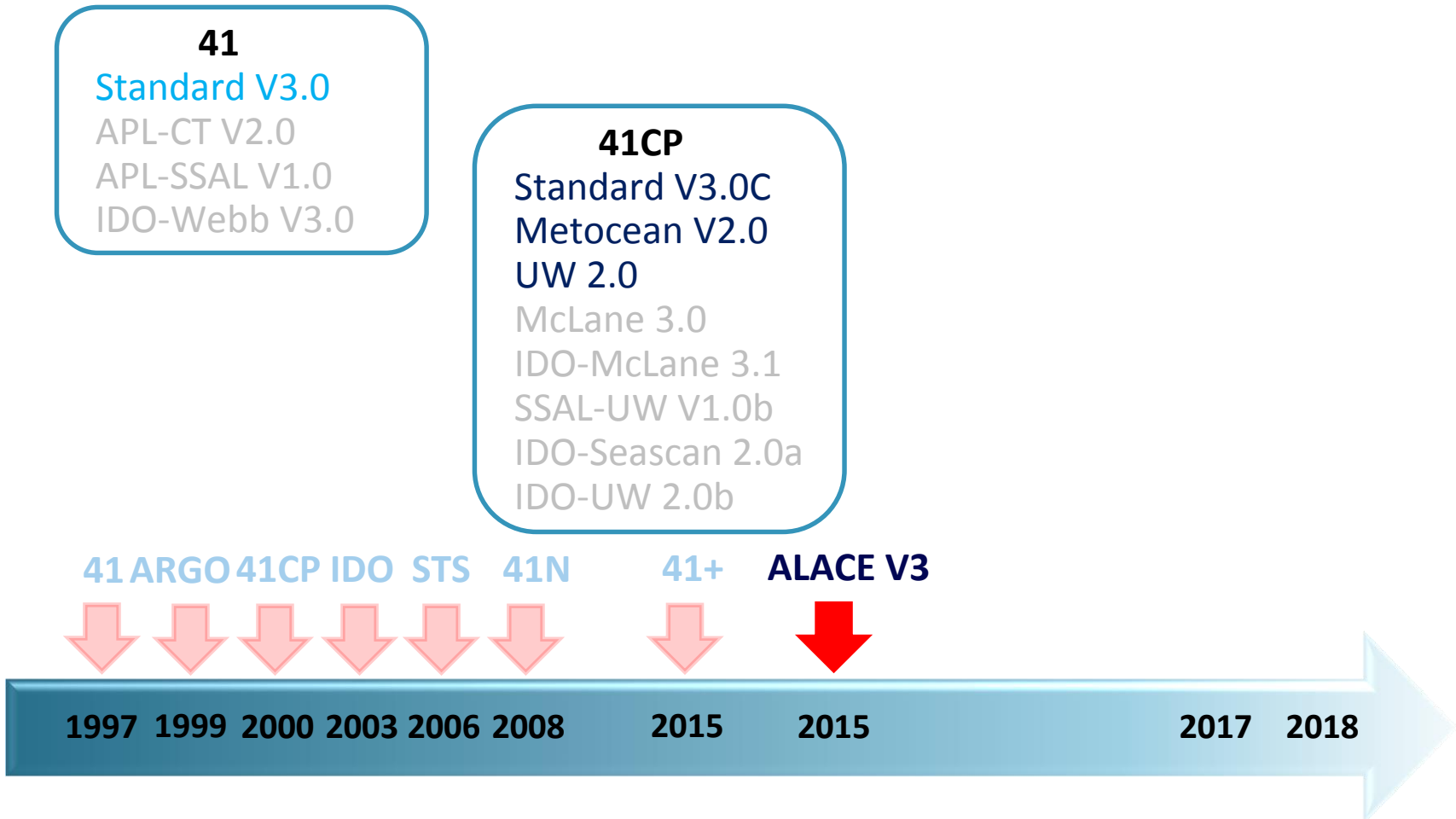
2015

2015

2017 2018

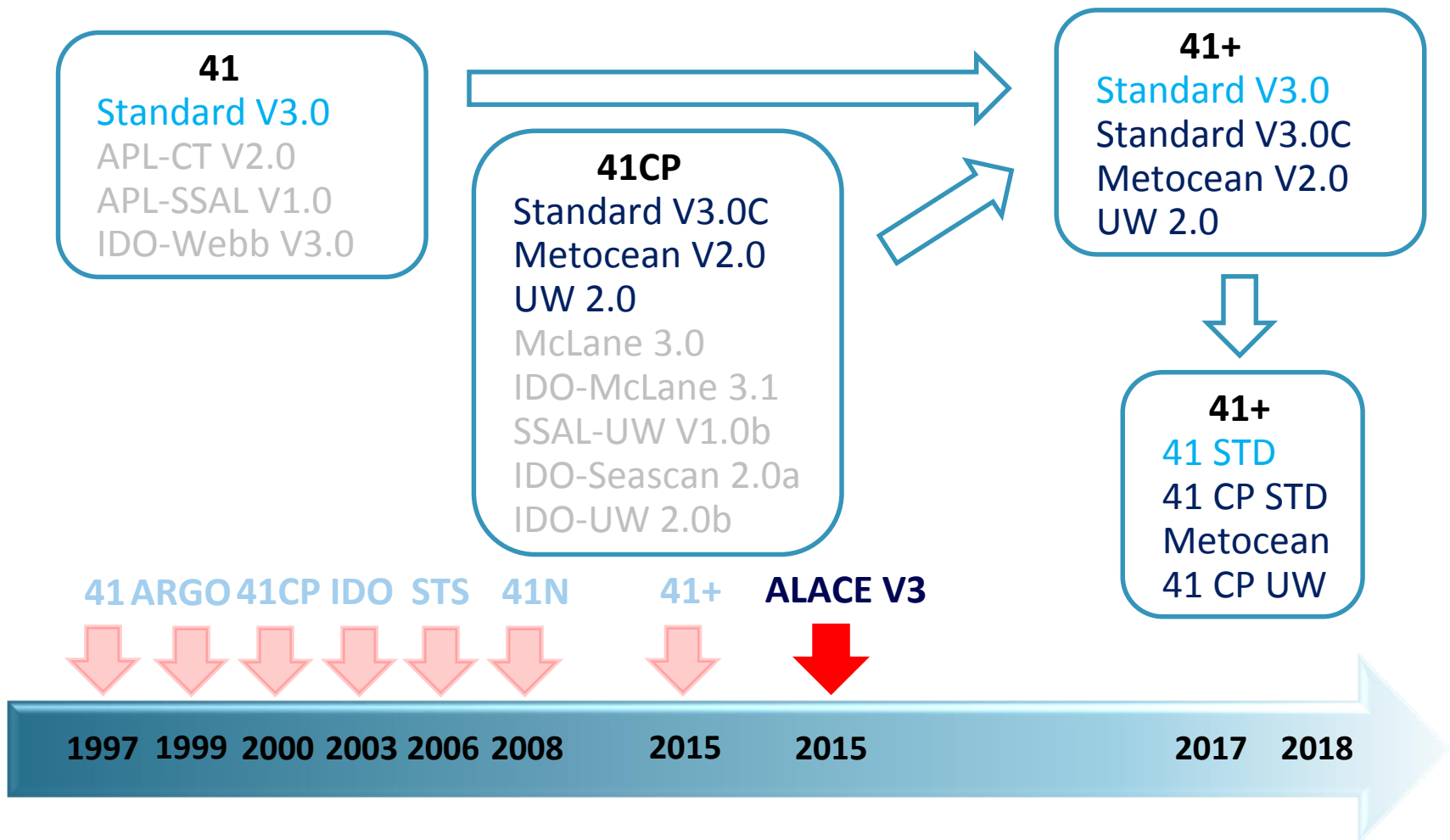
SBE 41: The Recent Past

Firmware Consolidation



SBE 41: The Recent Past

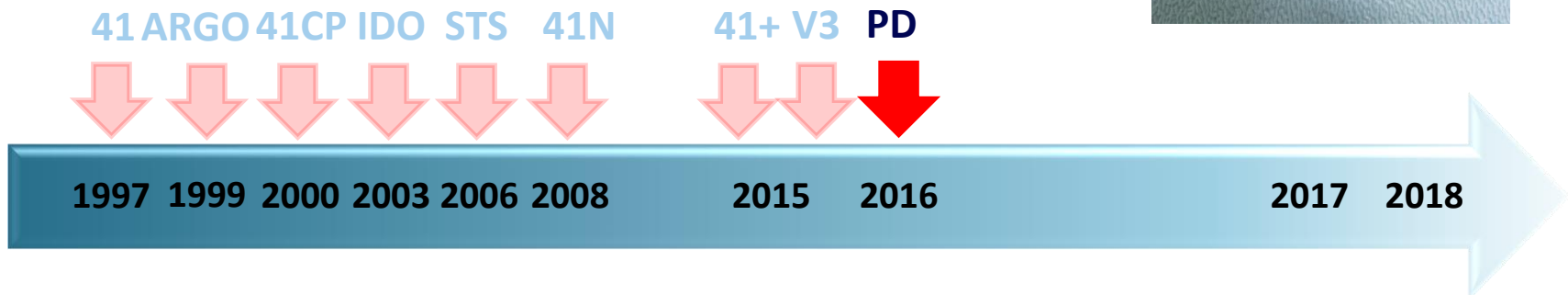
Firmware Consolidation



SBE 41: The Recent Past

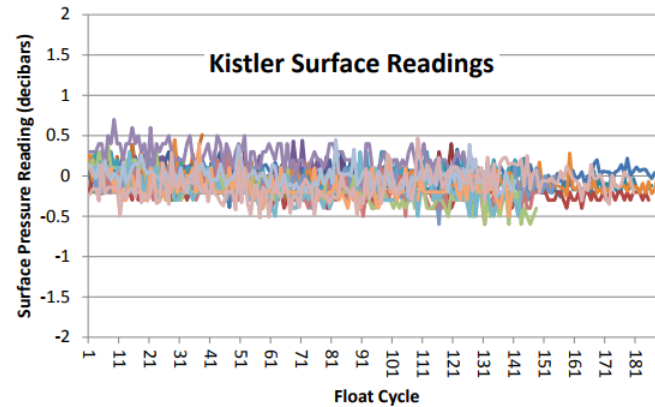
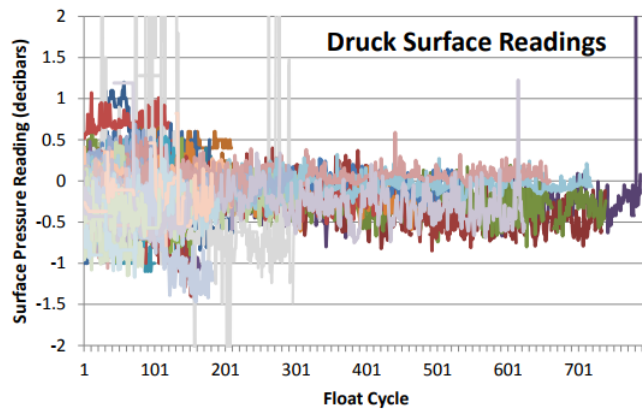
Switch to Druck P sensors

- Kistler transitioning to RoHS 2
- Kistler P sensor issues can cause shift in slope calibration
- Faulty sensors identified in QA
- Kistler resolved the manufacturing problem



SBE 41: The Recent Past

P Sensor Performance: Drift



41 ARGO 41CP IDO STS 41N

41+ V3 PD



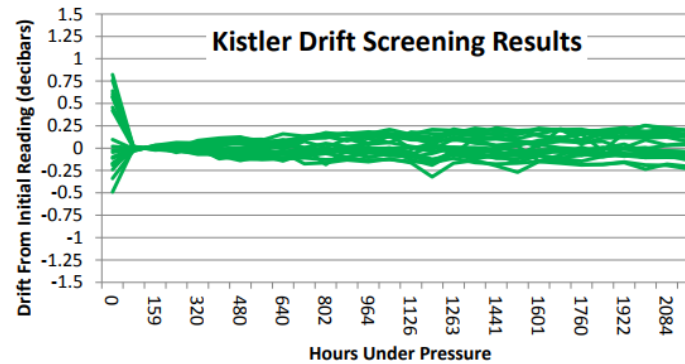
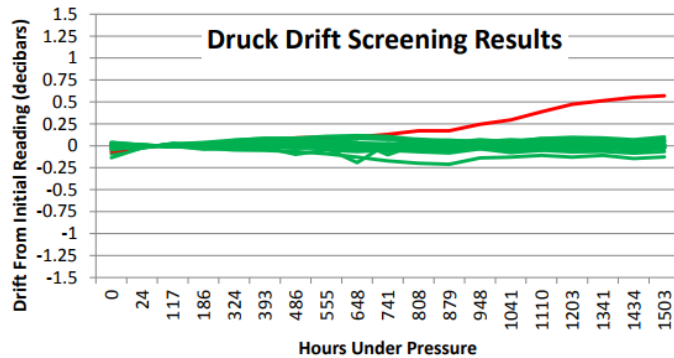
1997 1999 2000 2003 2006 2008

2015 2016

2017 2018

SBE 41: The Recent Past

P Sensor Performance: Screening



41 ARGO 41CP IDO STS 41N



41+ V3 PD



1997 1999 2000 2003 2006 2008

2015 2016

2017 2018

SBE 41: The Recent Past

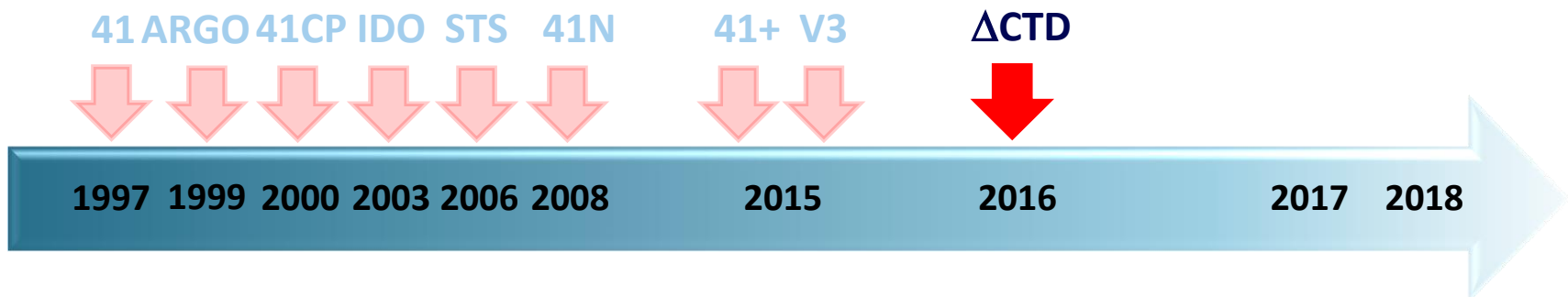
Longterm Accuracy of ARGO CTDs (Sea Technology, Janzen et al.)

- 5 yr record of calibrations for SBE 41 and 41CP designs; including periodic freezing of sensors to -20°C air temperature
- Post-calibration of six Argo float CTDs

Conclusions:

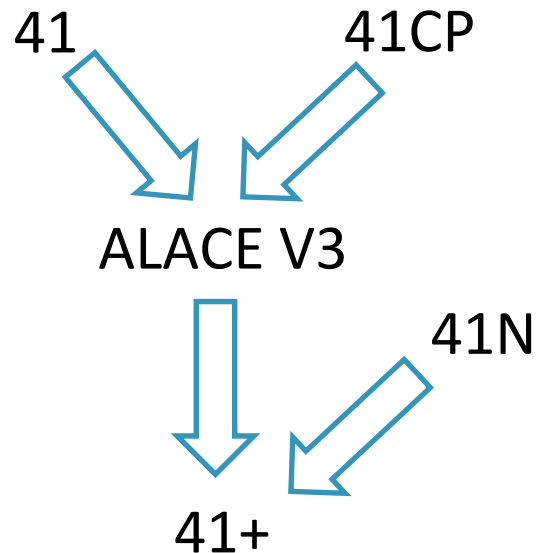
- Laboratory calibrations agree within 0.005 psu; T drift of less than 0.002°C and repeatability of $\pm 0.001^{\circ}\text{C}$
- low drift for Argo floats from the field (< -0.003 psu, -0.002°C)

Best Practices (AN97)

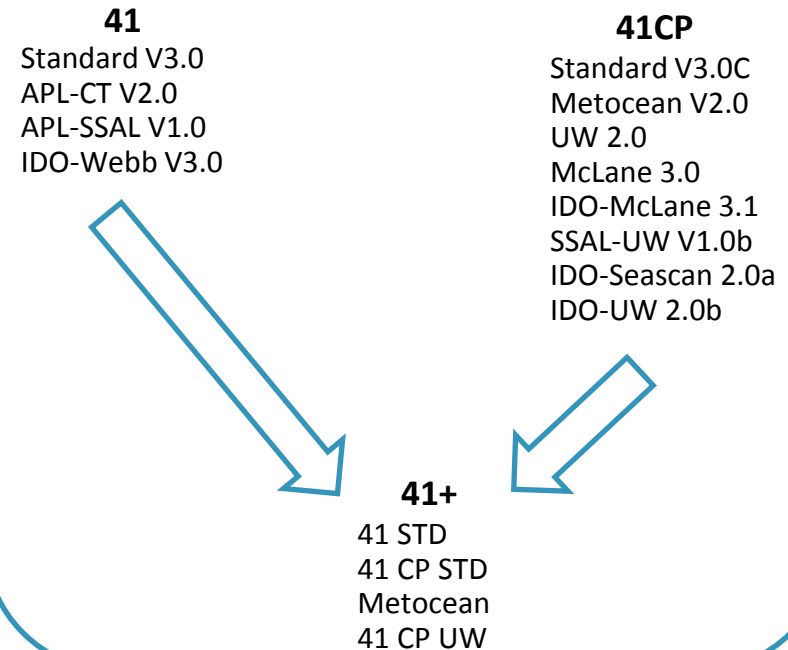


SBE 41: Evolution

Hardware



Firmware



41 ARGO 41CP IDO STS 41N

41+ V3

ΔCTD

S/N > 10000



1997 1999 2000 2003 2006 2008

2015

2016

2017 2018

SBE 41: Summary

41+

Firmware: 7.2.5

41 STD

41CP STD (serial)

Metocean (CP, HW)

41CP UW (HW)

Sensors: CTD

Currently not supported:
IDO STS

41N (only Navis)

Firmware: 5.3.0

5.4.0 (Tilt via PAR)

Sensors: CTD

SBE 63

MCOMS

pH

PAR

Tilt, Humidity

SUNA (via N1/N2)

41 ARGO 41CP IDO STS 41N



1997 1999 2000 2003 2006 2008

41+ V3



2015

Δ CTD



2016

S/N > 10000



2017 2018

SBE 41: The Present

41 STD

Webb UW
NOTC
Optimare

41CP STD

SIO/WHOI (SOLO)
MRV (SOLO-II)
MRV (ALAMO)
MRV (S2-A)
Metocean (NOVA)
Optimare (NEMO)

41CP UW

Webb/UW (APEX)
SBE (Navis)
MBARI (SOLO)

Metocean

NKE (Arvor)
NKE (Provor)

Druck 2k: 85%
Kistler 2k: 15%

Deep Ninja (TSK)
Deep Arvor (NKE)

41 ARGO 41CP IDO STS 41N

41+

Δ CTD

S/N > 10000



1997 1999 2000 2003 2006 2008

2015

2016

2017

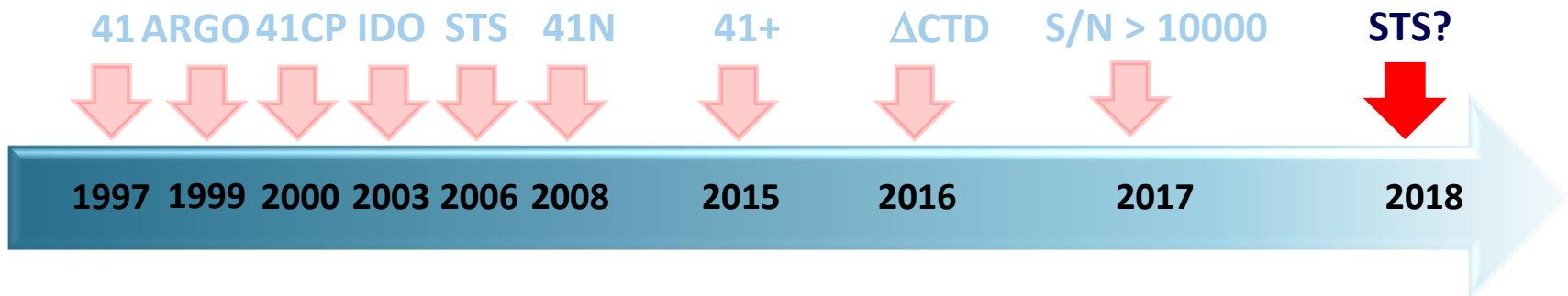
2018

SBE 41: The Future

41+

Firmware: 7.3.0
1 binary
>4 configurations

Sensors: CTD
STS
?



Questions?

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