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A Framework for Identifying and Managing New Operational Requirements during Naval Vessel Batch-Building Programs

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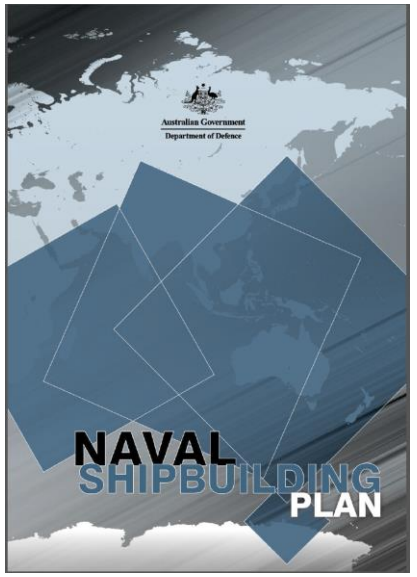
Naval Group

www.incose.org/symp2021

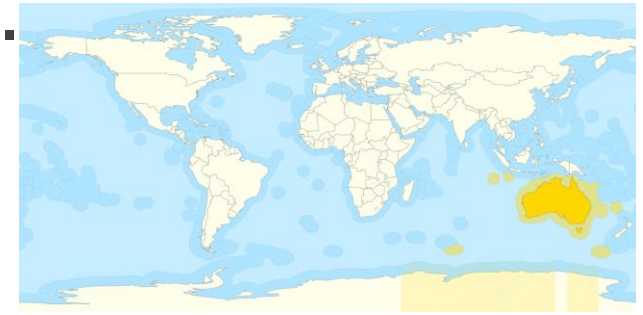
Outline

- Introduction:
  - Context
  - Domain
  - Research Question
- Investigation:
  - Naval vessel batch-building
  - Evolutionary systems development
  - Test and Evaluation in evolutionary acquisition
- Proposed high-level framework
- Conclusions

Introduction – Context

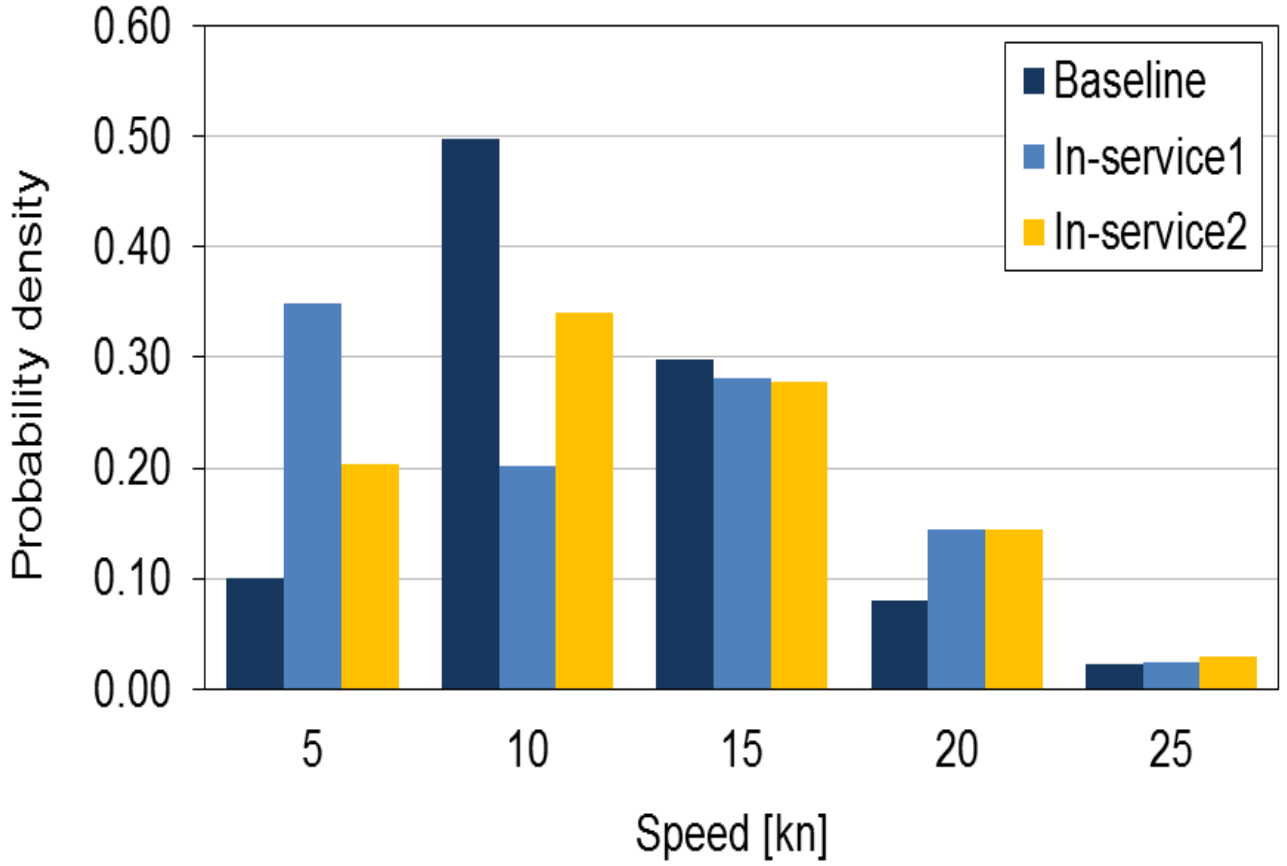


- Continuous Shipbuilding Policy:
  - Opportunity to implement batch-building.
- Batch-building:
  - Design updated during the build program.
  - Supports a (somewhat) adaptable Navy.
  - Potential benefits; costs, efficiency, time.
  - Analogous to Evolutionary Systems Development.



Introduction - Domain

- Naval Vessels:
  - Complex systems
  - Long lifecycles
- Potential sources of batch design updates:
  - Strategic circumstances
  - Technology maturation
  - Operational experience



*Graph kindly provided by Dr. Teresa Magoga

Introduction – Research Question

How can new operational requirements be identified, managed and integrated into the design of follow-on batches of vessels in a naval vessel batch-building program?

Naval Vessel Batch-Building

- Some Examples:

USN – Arleigh Burke Class

www.meta-defence.fr

- 4 Flights
- Hangars + Helos
- Additional VLS cells + sensors
- Crew increased
- Displacement 8300 → 9800t

USN – Ticonderoga Class

en.wikipedia.org

- 2 Batches (plus parent)
- Large margins!
- AEGIS
- Missile launchers replaced with VLS

RN – River Class

www.navalnews.com

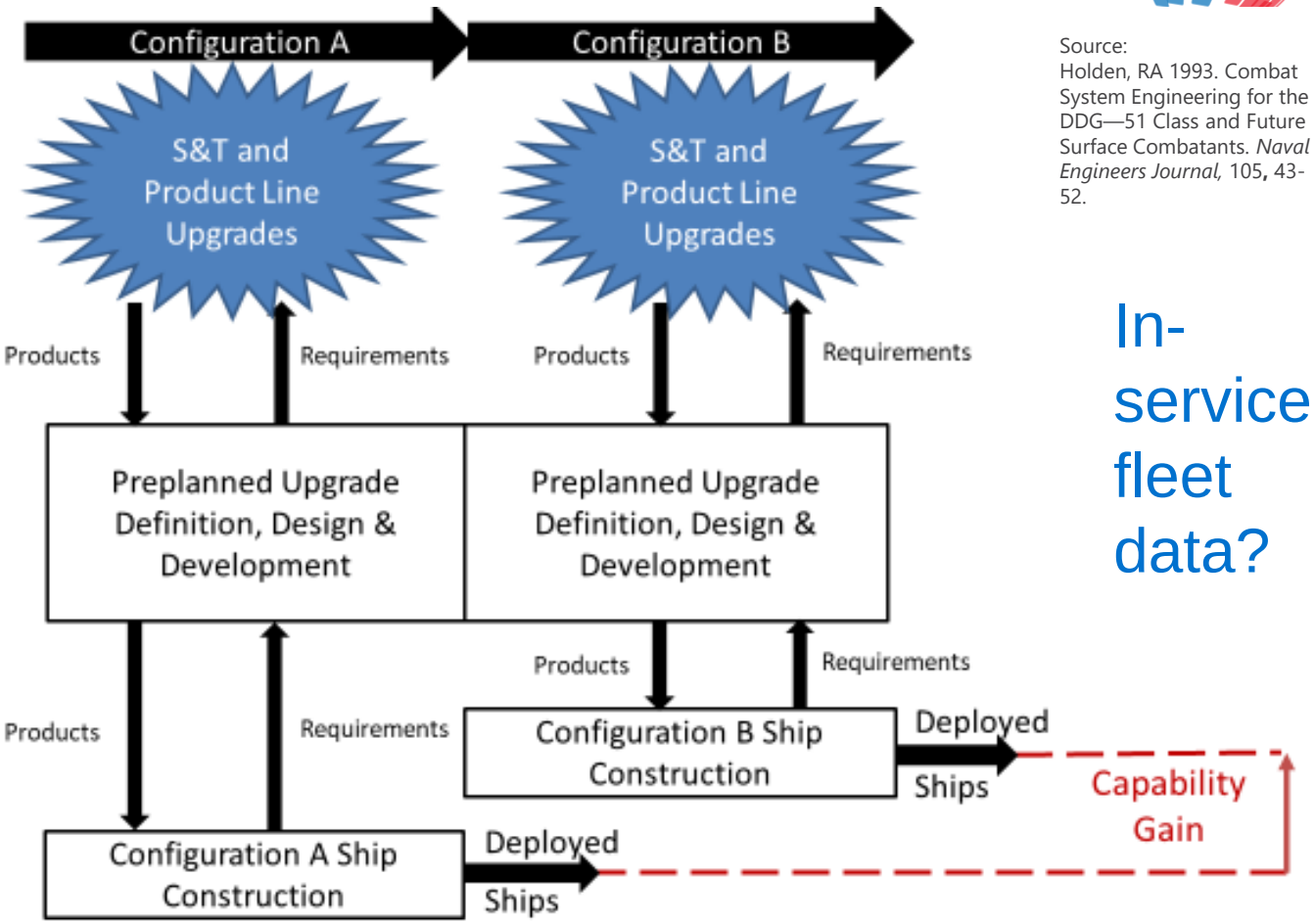
- 2 Batches
- Vessel length 80 → 90 meters
- Displacement 1700 → 2000t
- Larger flight deck + gun
- Higher sprint speed + endurance

Naval Vessel Batch-Building

Arleigh Burke Class:

- Batches to permit technology insertion.
- A funded ongoing engineering design capability is critical.
  - Not catered for in the typical linear, single pass capability lifecycle!

*Batch-building is not without issues…



Source:
Holden, RA 1993. Combat System Engineering for the DDG—51 Class and Future Surface Combatants. *Naval Engineers Journal,* 105**,** 43-52.

In-service fleet data?

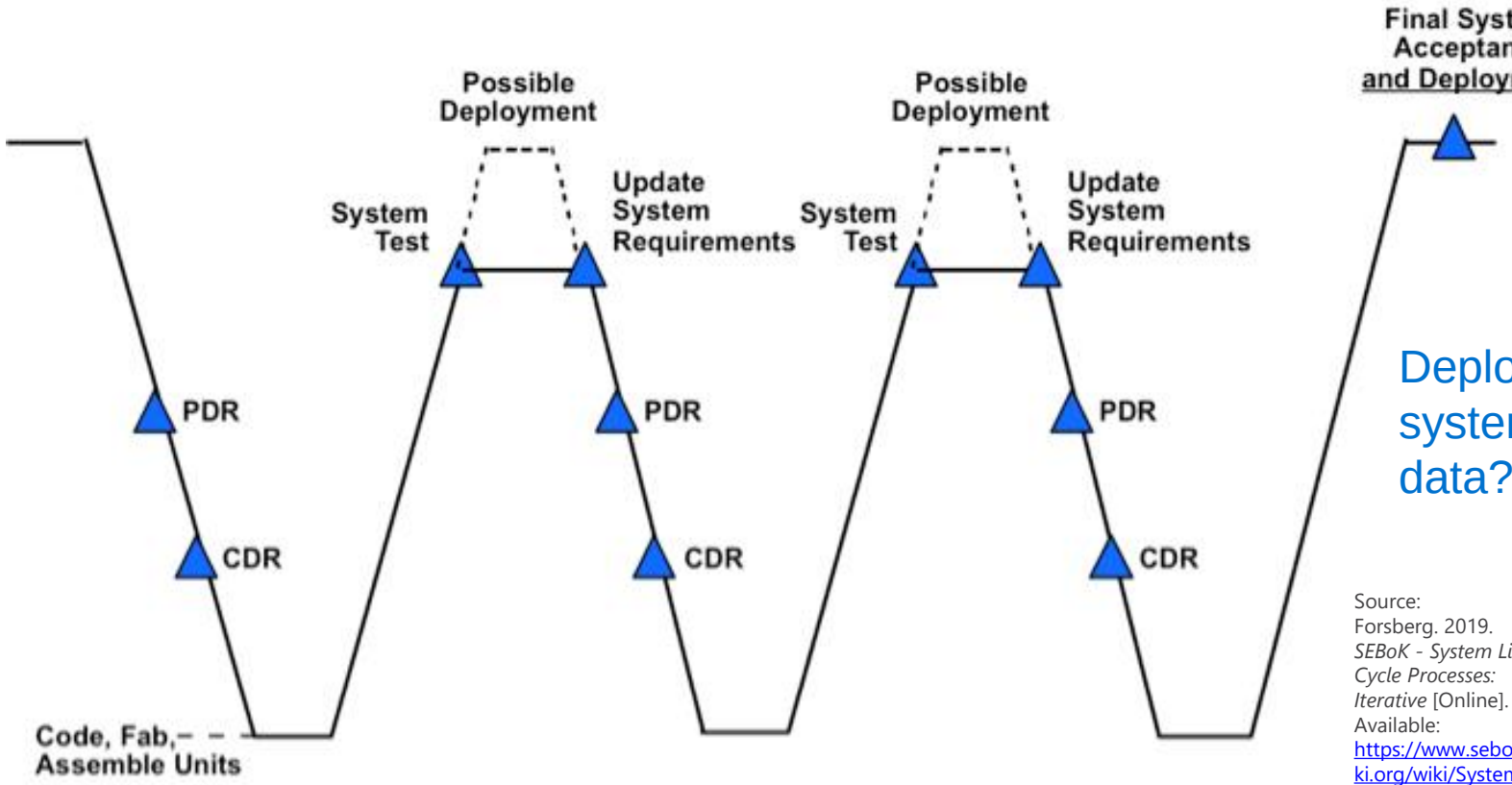
Engineering Process for naval vessel batch-building programs

Takeaways (Batch-building):
1. Parent design margins. 2. A funded, ongoing, engineering and design capability is required.

Evolutionary Systems Development

Evolutionary development – "successive improvement of solution versions based on experience with prior versions"

Source:
Mooz, H & Forsberg, K 2004. 8.3.1 Clearing The Confusion About Spiral/Evolutionary Development. *INCOSE International Symposium Proceedings,* 14**,** 1675-1688.



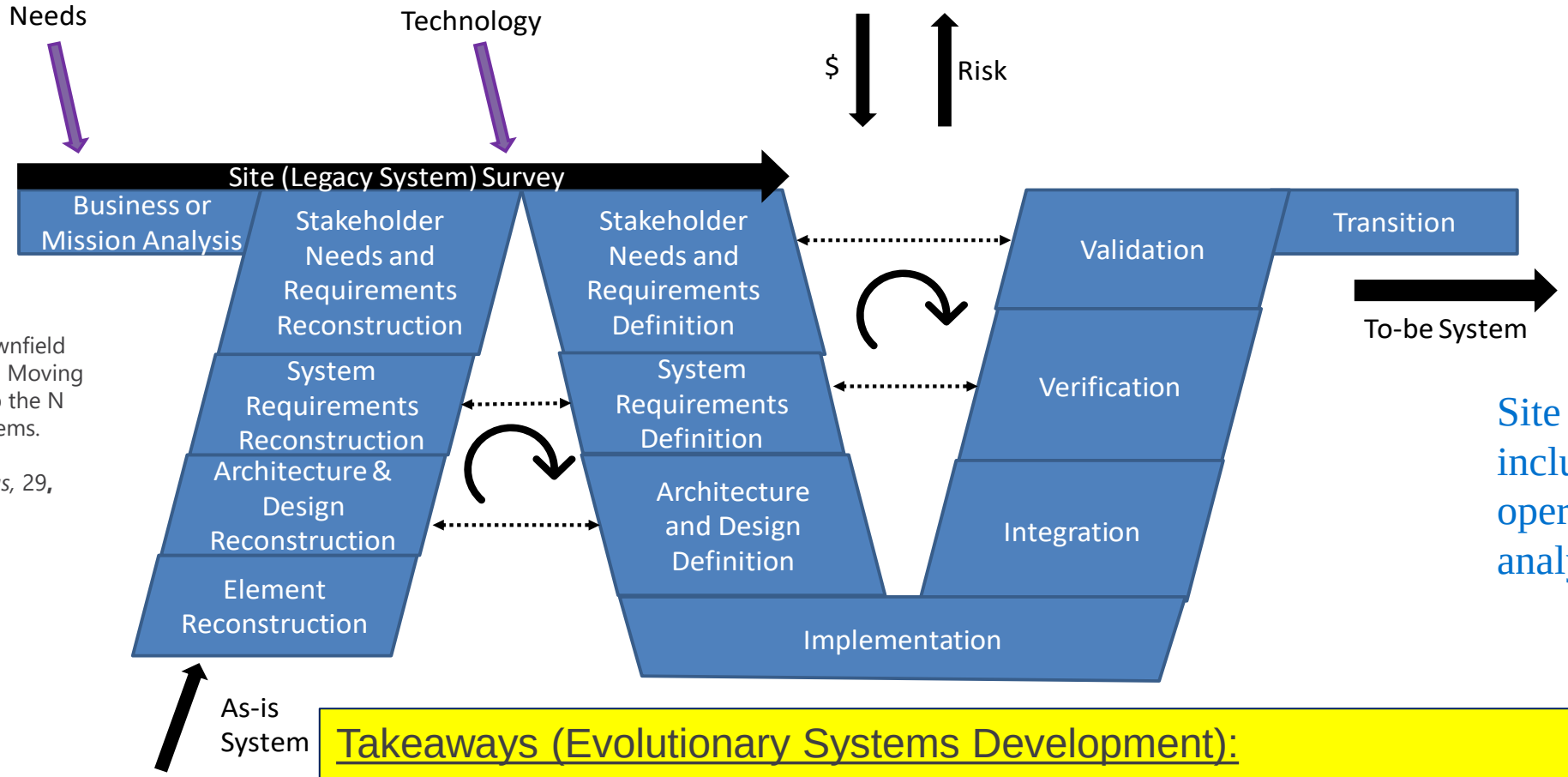
Evolutionary Development with multiple deliveries.

Deployed system data?

Source:
Forsberg. 2019. *SEBoK - System Life Cycle Processes: Iterative* [Online]. Available: https://www.sebokwiki.org/wiki/System_Life_Cycle_Process_Models:_Iterative [Accessed 24/03/2020 2020].

Evolutionary Systems Development

The “N” model for Legacy System Development



Source:
Walden, DD 2019. Brownfield Systems Development: Moving from the Vee Model to the N Model for Legacy Systems. *INCOSE International Symposium Proceedings*, 29, 1084-1092.

Site survey includes an operational data analysis?

Takeaways (Evolutionary Systems Development):

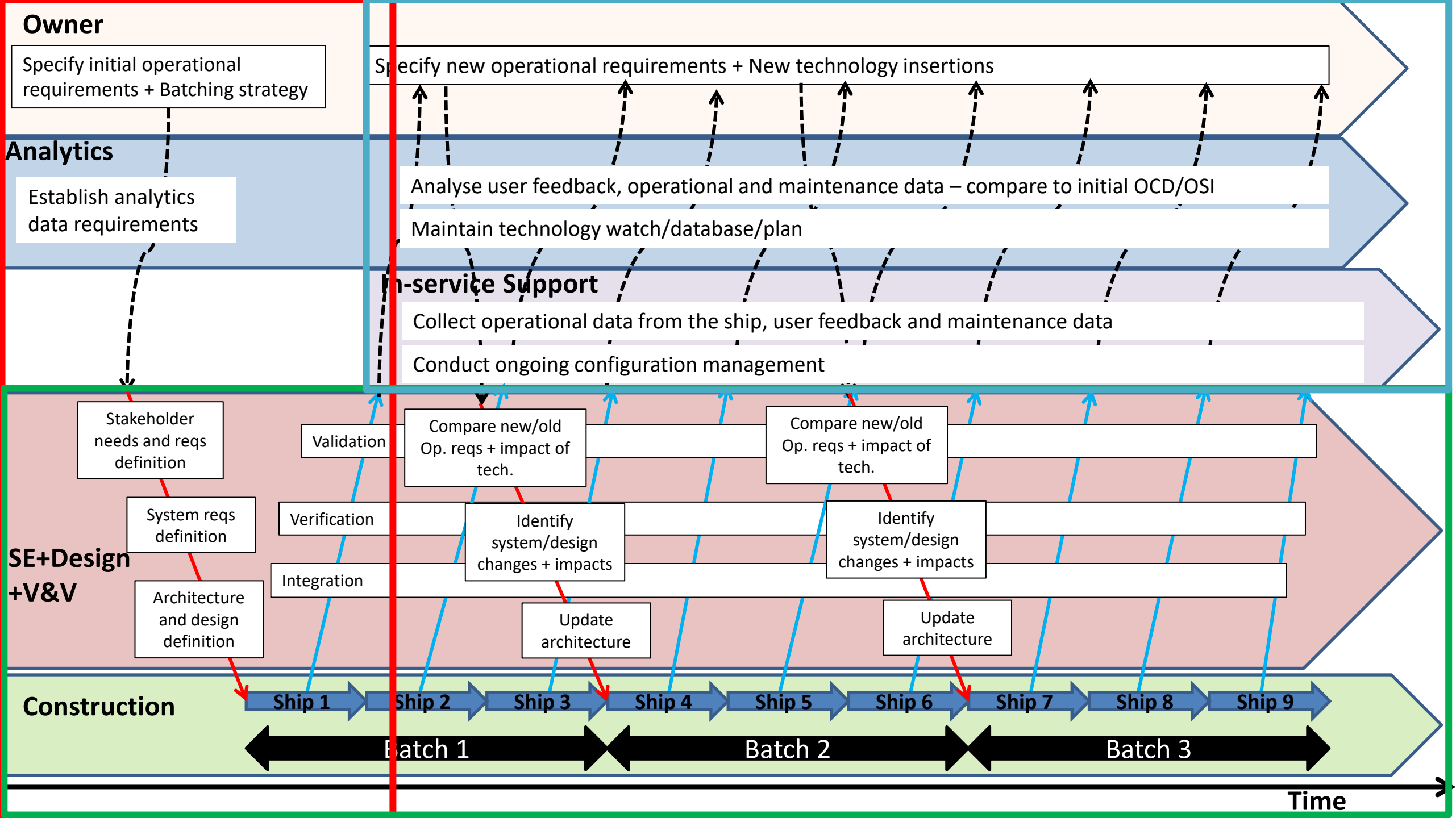
1. Ongoing need to analyse and characterise legacy/deployed system.
2. How to capture and analyse the deployed system’s data in a robust manner?

T&E in Evolutionary Acquisition

- Incremental rather than linear acquisition.
- User feedback + Operational T&E (OT&E) data an input for requirements of later increments.
- Naval Vessel Formal OT&E → Continuous OT&E
- A continuous OT&E capability is resource intensive!
  - Data collection, Statistics, M&S, Data Analytics,…

Stocktake

- Naval Vessel batch-building provides an opportunity to identify and manage new operational requirements for later batches.
- This necessitates a change to the typical linear, single pass defence capability lifecycle.
- Existing evolutionary development approaches are helpful, but a domain specific approach is required.


Owner
Specify initial operational requirements + Batching strategy
Specify new operational requirements + New technology insertions
Analytics
Establish analytics data requirements
Analyse user feedback, operational and maintenance data – compare to initial OCD/OSI
Maintain technology watch/database/plan
In-service Support
Collect operational data from the ship, user feedback and maintenance data
Conduct ongoing configuration management
SE+Design +V&V
Stakeholder needs and reqs definition
System reqs definition
Architecture and design definition
Validation
Verification
Integration
Compare new/old Op. reqs + impact of tech.
Identify system/design changes + impacts
Update architecture
Compare new/old Op. reqs + impact of tech.
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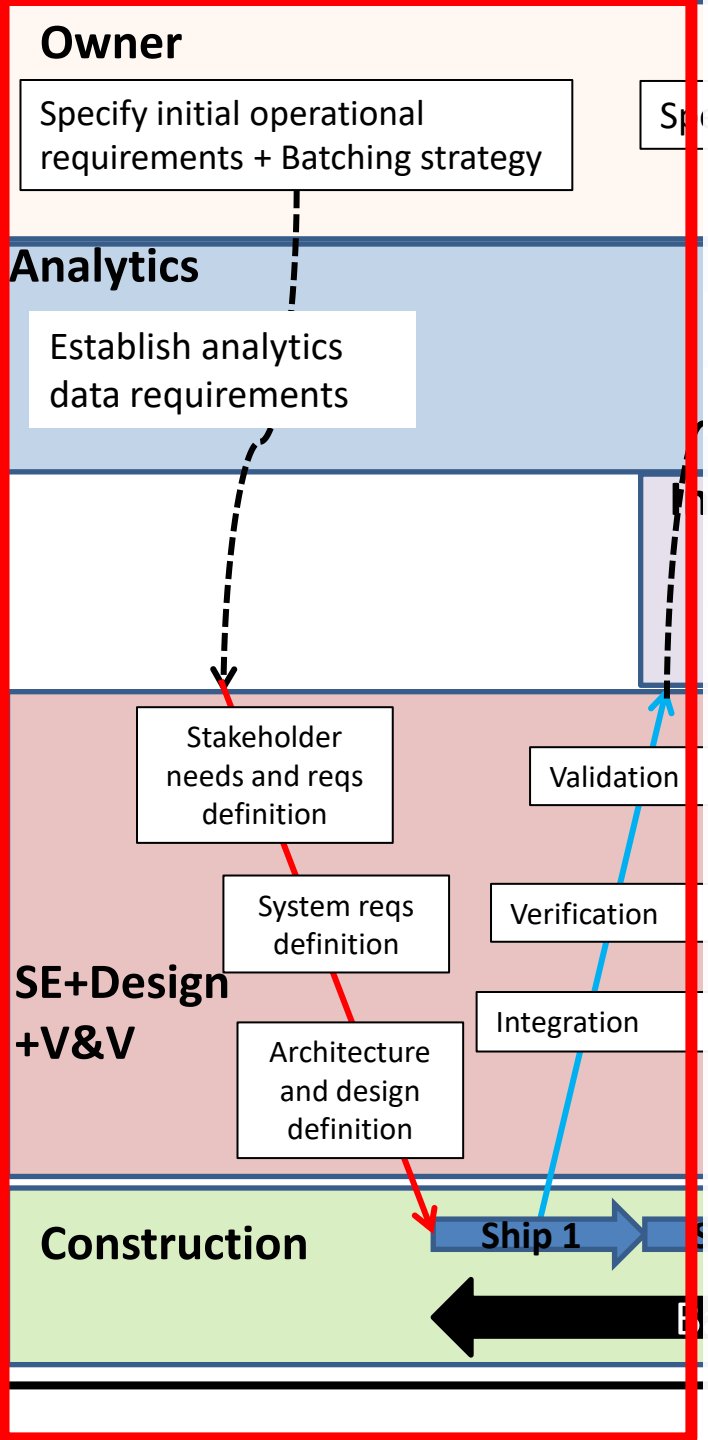
Update architecture
Construction
Ship 1
Ship 2
Ship 3
Ship 4
Ship 5
Ship 6
Ship 7
Ship 8
Ship 9
Batch 1
Batch 2
Batch 3
Time

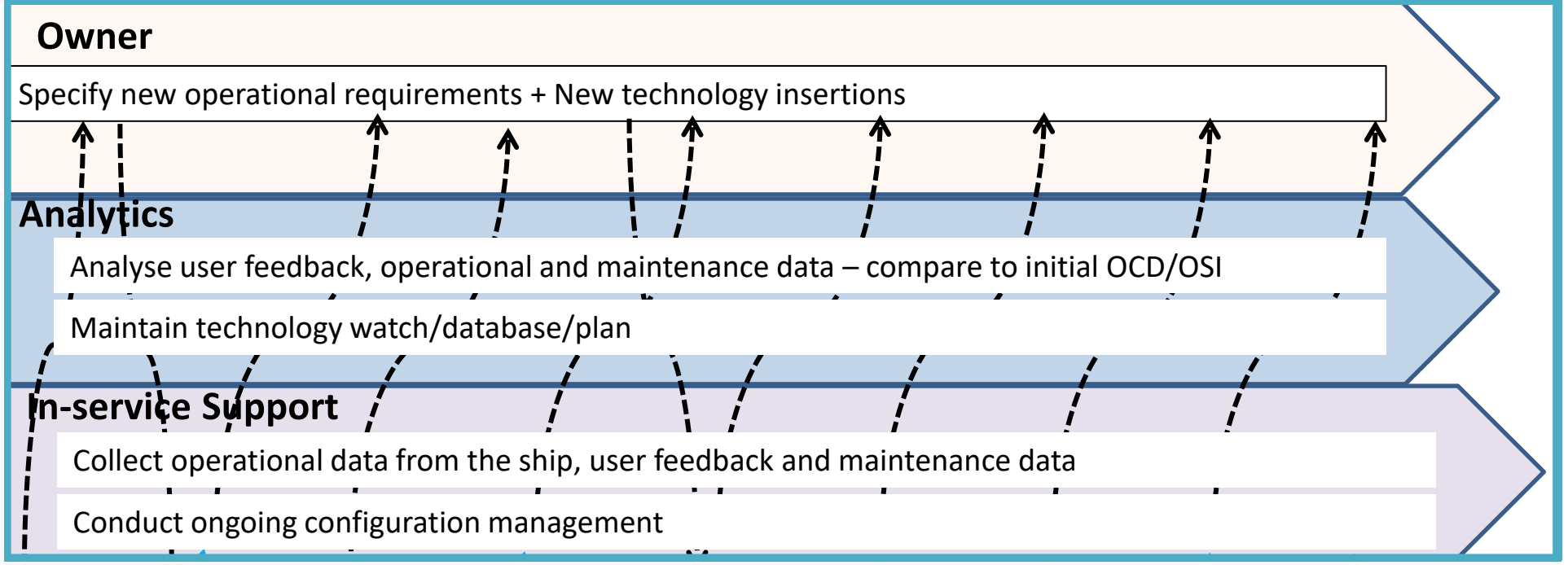


Focus on Process

- Starts with an OCD + Batching strategy.
- Batching strategy drives margins and commonality requirements.
- Establish data requirements:
  - From vessels.
  - Maintenance + other data.
- SE, design and integration activities similar to single pass for first batch.

Focus on Process

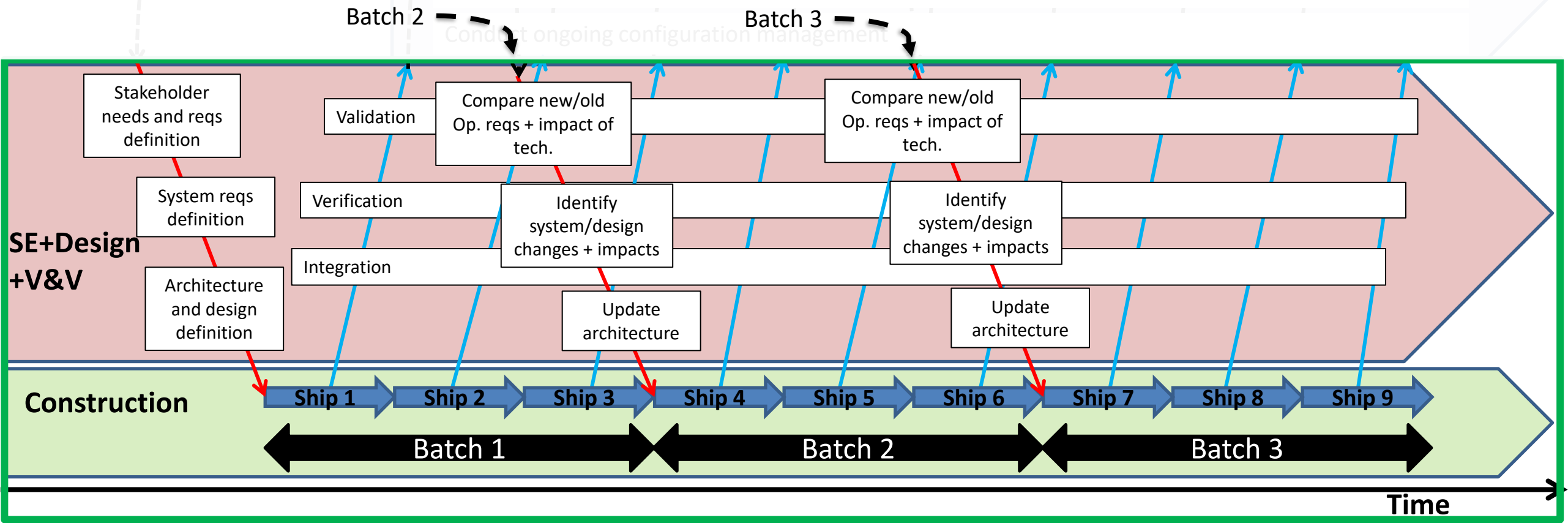
- In-service support:
  - Ongoing fleet support.
  - Collects data.
- Analytics:
  - Identify actual vessel usage.
  - Technology Plan.
- Owner:
  - Considers results of analytics activities.

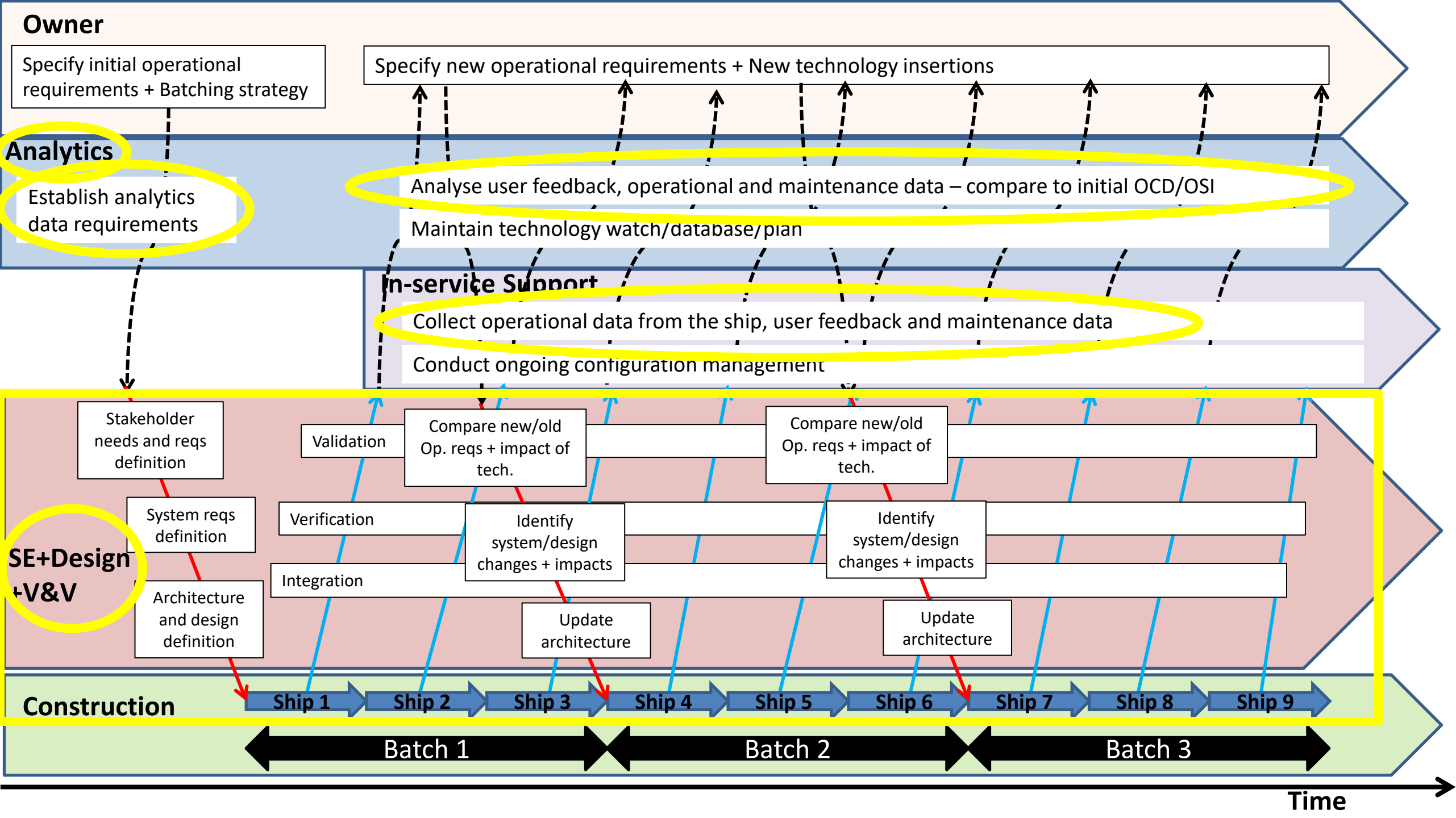


- Specify new op. requirements + technology (3 potential sources) → can trigger new batch.

Focus on Process

- New Op. requirements can trigger a new batch.
- SE+Design activities change!

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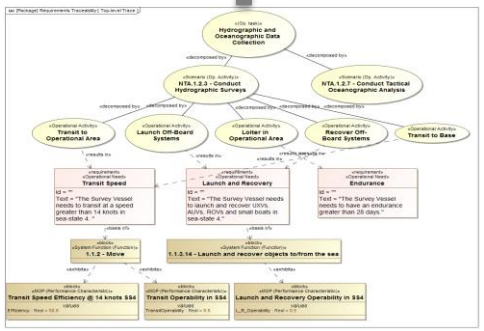
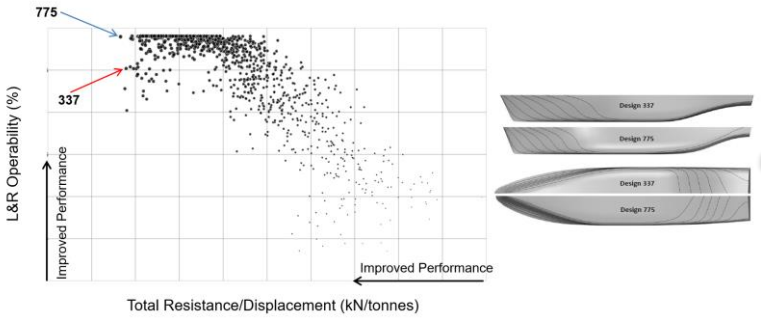
Batch 1
Batch 2
Batch 3
Time

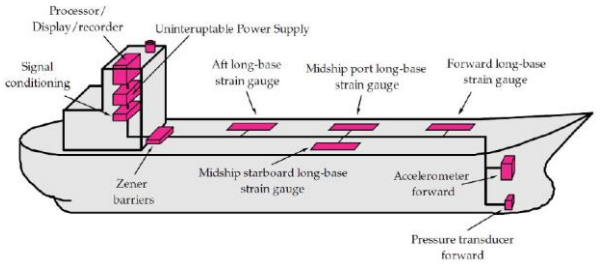
Supporting the Framework with MBSE and Digital Engineering

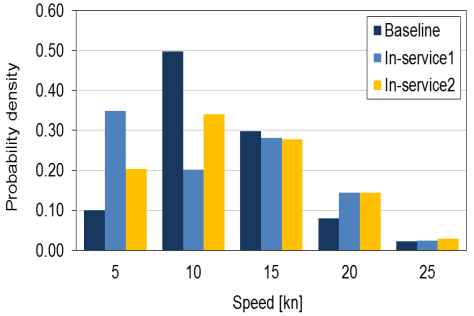
Digital Engineering: “an integrated approach that uses authoritative sources of systems’ data and models as a continuum across disciplines to support lifecycle activities from concept through disposal”

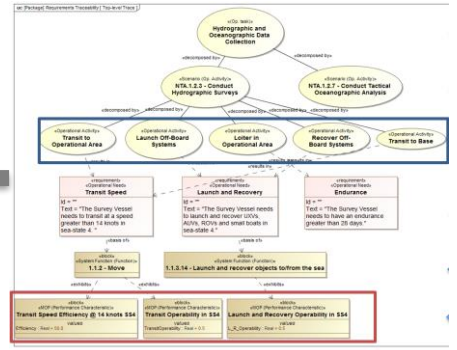
Dau. 2019. *Defense Acquisition University Glossary* [Online]. Available: https://www.dau.mil/glossary/Pages/Glossary.aspx#!both|D|27345 [Accessed 13/06/2019 2019].

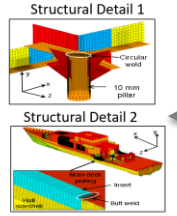


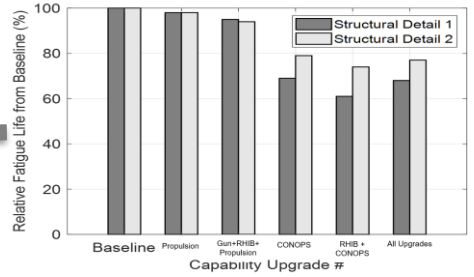












Conclusions

- Paper intended to contribute to the discussion on naval vessel batch-building programs.
  - Opportunity to include new/updated operational requirements…
- Research Question:

  "How can new operational requirements be identified, managed and integrated into the design of follow-on batches of vessels in a naval vessel batch-building program?"
- Key Insights:
  - SE + Design activities change for follow-on batches.
  - Informal Operational T&E → Continuous Operational T&E.
  - Ongoing (funded!) analytics, SE and design capability critical.
    - Parent vessel margins and robust trade-off studies.
  - Digital Engineering…
  - Further work required!

Acknowledgements

The author would like to acknowledge the impact on the framework proposed in this paper that his conversations with colleagues (past and present), have had.

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