Brownfield Systems Development: Moving from the Vee Model to the N Model for Legacy Systems

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Sysnovation, LLC
603 Indiana Avenue
Valparaiso, IN 46383 USA
www.sysnovation.com

David D. Walden, ESEP
Voice: +1-952-807-1388
Email: Dave@sysnovation.com

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Abstract

Most systems engineering standards, references, and textbooks consider systems development from a “greenfield” (i.e., clean-sheet, new development) perspective. There are several development (or life cycle) models used for greenfield developments, with the “Vee” model being a popular choice. Many development efforts are better considered from a “brownfield” perspective (i.e., improving upon or replacing legacy systems). This paper proposes an extension of the Vee model, called the N model, which adds a site survey and various reconstruction processes to help move from the as-is system to the to-be system for brownfield development efforts. Three examples are provided to demonstrate how the N model can be applied in different situations.

Current Author Contact Information:
David D. Walden, ESEP
Sysnovation, LLC
603 Indiana Avenue
Valparaiso, IN 46383 USA
Voice: +1-952-807-1388
Email: Dave@sysnovation.com
www.sysnovation.com

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Topics

- **Purpose/Introductions**
- Definitions
- Greenfield Systems Development and the "Vee"
- Brownfield Systems Development and the "N"
- Examples of N Model Usage
- Wrap-up/Summary

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Purpose/Introductions

- Most systems engineering standards, references, and textbooks consider systems development from a "**greenfield**" (i.e., clean-sheet, new development) perspective. (ISO/IEC/IEEE 15288, 2015) (INCOSE SEHv4, 2015)
- There are several development (or life cycle) models used for greenfield developments, with the **"Vee" model** being a popular choice. (Rook, 1986) (Forsberg, et al., 2005)
- Many development efforts are better considered from a "**brownfield**" perspective (i.e., improving upon or replacing legacy systems). (Baley and Belcham, 2010) (Seacord et al., 2003)
- This paper proposes an extension of the Vee model, called the **N model**, which adds a site survey and various reconstruction processes to help move from the as-is system to the to-be system for brownfield development efforts.

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Greenfield vs. Brownfield

"**Greenfield** land is undeveloped land in a city or rural area either used for agriculture, landscape design, or left to evolve naturally."

"**Brownfield** land means places where new buildings may need to be designed and erected considering the other structures and services already in place." "The land may be contaminated … and has the potential to be reused once it is cleaned up."

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Quotes and Images sources: Wikipedia and (Baley and Belcham, 2010)

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Greenfield Systems Engineering

- Usually have no or limited legacy system constraints, other than system interfaces.
- Typically have no, or limited, continuity considerations.
- Also known as "clean-sheet" systems engineering.

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Adapted from: (Seacord et al., 2003) (Hopkins and Jenkins, 2008)

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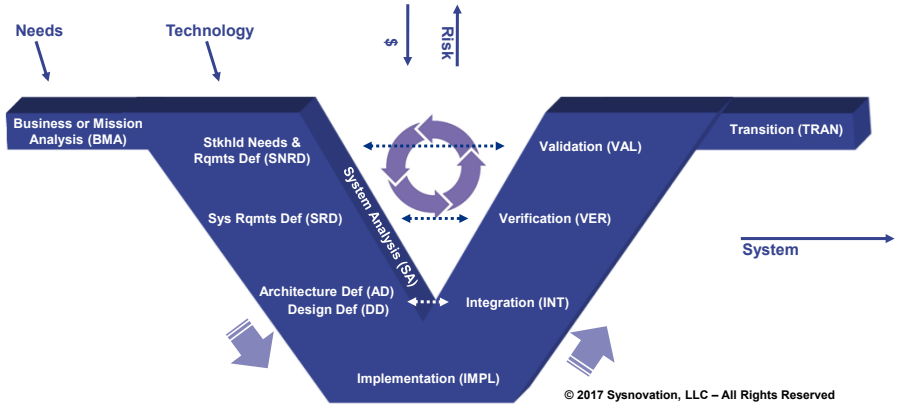
V - The "Vee" Model



Adapted from: (INCOSE SEH, 2015) (Forsberg et al., 2005) (Rook, 1986)

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Pros and Cons of the Vee Development Model

- Pros:
  - Depicts top-down definition and bottom-up realization
  - Shows the horizontal relationship between definition and realization
  - Well-defined phases
  - Well-defined handoffs between phases
  - Most suitable for projects of moderate complexity in familiar domains
- Cons:
  - Reflects a serial view of projects similar to the Waterfall model
  - Not easy to account for feedback or changes in the up-front information (need to go "off the Vee")
  - Required abstraction to multiple Vee instances for each level of the system hierarchy

Adapted from: (Walden, 2017)

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Brownfield Systems Engineering

- Usually involve significant modification, extension, or replacement of an existing system in an existing environment.
- Typically have explicit continuity requirements.
- A key aspect of brownfield development efforts is moving from the "as-is" initial legacy system to the "to-be" updated legacy system
- Also known as "legacy" or "in-service" systems engineering.

"Brownfield is much, much harder than Greenfield, whether [systems] or house remodeling."
Fred Brooks

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Adapted from: (Seacord et al., 2003) (Hopkins and Jenkins, 2008)

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Drivers for Brownfield

Reason for Change	Description
Perfective	• Changes made to improve the system • Also called enhancements • Represents approximately 48% of changes
Adaptive	• Changes made to keep pace with changing environments • Represents approximately 29% of changes
Corrective	• Changes made to repair defects in the system • Represents approximately 19% of changes
Preventive	• Changes made to improve future maintainability and proactively seek to simplify future evolution • Represents approximately 4% of changes

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Adapted from: (Seacord et al., 2003)

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Characteristics of Greenfield and Brownfield Development Efforts

Aspect	Greenfield	Brownfield
Life Cycle Stage(s) (of Initial System of Interest)	Concept, Development	Utilization, Support
Focus	New or novel features	Maintenance or adding new features while retaining select legacy functionality
Maturity (of Initial System of Interest)	Low to Moderate	High for maintenance; Mix for existing system and environment, plus new development for upgrade or replacement
Architecture and Design Review	Reviewed and modified at multiple levels	Reviewed only when significant updates
Verification & Validation	The entire system of interest typically needs to verified and validated	Only parts of the system need to be verified and validated (there may be regression testing for the unchanged parts)
Manufacturing/ Production	May be in place if using the existing line, or is developed (or tailored) as development progresses	Mostly in place
Maintenance and Logistics	Developed (or tailored) as development progresses	Mostly in place
Practices and Processes	Developed (or tailored) as work progresses	Mostly in place, though not necessarily relevant to the new team
Team Composition	Newly formed group	Mix of old and new, bringing both historical biases and fresh ideas

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Adapted from: (Walden, 2019) (Baley and Belcham, 2010)

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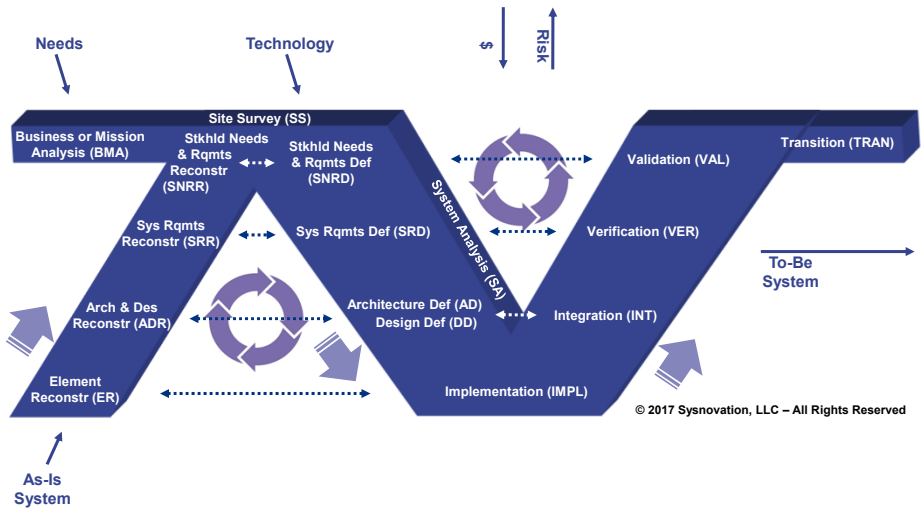
N – The "N" Model for Brownfield



Adapted from: (Walden, 2017)

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Pros and Cons of the N Development Model

- Pros:
  - Adds up-front site survey & as-is system reconstruction activities
  - Depicts bottom-up reconstruction, top-down definition, and bottom-up realization
  - Shows the horizontal relationship between reconstruction and definition and realization
  - Well-defined phases
  - Well-defined handoffs between phases
  - Most suitable for Brownfield projects of moderate-to-high complexity in familiar domains
- Cons:
  - Reflects a serial view of projects similar to the Waterfall and Vee models
  - Not easy to account for feedback or changes in the up-front information (need to go "off the N")
  - Required abstraction to multiple N instances for each level of the system hierarchy

Adapted from: (Walden, 2017)

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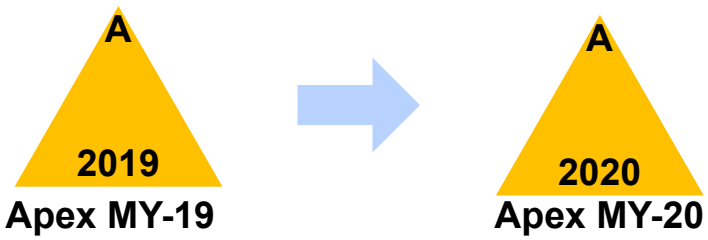
Example 1
Minor Feature Updates with Mature SE



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Example 1
Application of the N Model

- Minimalistic application of the N model for the brownfield development of Apex 2020.
- The Site Survey reveals that an accurate baseline of the Stakeholder Requirements, System Requirements, and System Architecture and Design already exist.
- Therefore, the reconstruction activities do not need to be done.
- The major activity is to determine the gap between Apex 2019 and the requirements for Apex 2020.

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Example 2
System Replacement Updates with Immature SE

Albatross

Eagle

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Photo Source: www.britannica.com

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Example 2
Application of the N Model

- Moderately robust application of the N model for the brownfield development of Eagle.
- The site survey of Albatross reveals that only a partial, inaccurate baseline exists.
- There is a solid bill of materials (BOM), so Element Reconstruction will not be necessary.
- However, it is likely that Architecture and Design Reconstruction will have to be done to approximate the system design and architecture.
- Also, both the Systems and Stakeholder Requirements will have to be reconstructed.
- After this reconstruction is done, then the gaps between the reconstructed Albatross and the new Eagle requirements can then be determined.

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Example 3
Major Updates by a Different Organization

F-123

F-123+

Photo Source: worldwarwings.com)

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Example 3
Application of the N Model

- Robust application of the N model for the brownfield development of F-123+.
- The site survey of F-123 reveals that the Air Force has only the original drawings submitted in the 1970s. There have been several aircraft changes that have taken place since then. Past Air is not willing to share any of their internal detailed drawings.
- In addition, it is well known that the warfighters often make unauthorized "changes" so each aircraft tail number may have some unique changes.
- All these factors point to Element Reconstruction being necessary.
- Architecture and Design Reconstruction will have to be done to recreate the system design and architecture.
- Both the Systems and Stakeholder Requirements will have to be reconstructed.
- After all these reconstructions are done, then the gaps between the reconstructed F-123 and the new F-123+ requirements can then be determined. However, the gaps may have to be determined on an individual tail number basis.

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Wrap-up/Summary

- This paper proposed an extension of the Vee model, called the N model, which adds a site survey and various reconstruction process areas to help move from an as-is system to a to-be system in brownfield development efforts.
- Three examples were provided to demonstrate how the N model can be applied in different situations.
- Topics for future research have also been identified (see paper).

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Comments?
Questions?

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