32nd Annual **INCOSE** international symposium

hybrid event

Detroit, MI, USA
June 25 - 30, 2022

Integration: More Than Interface Management
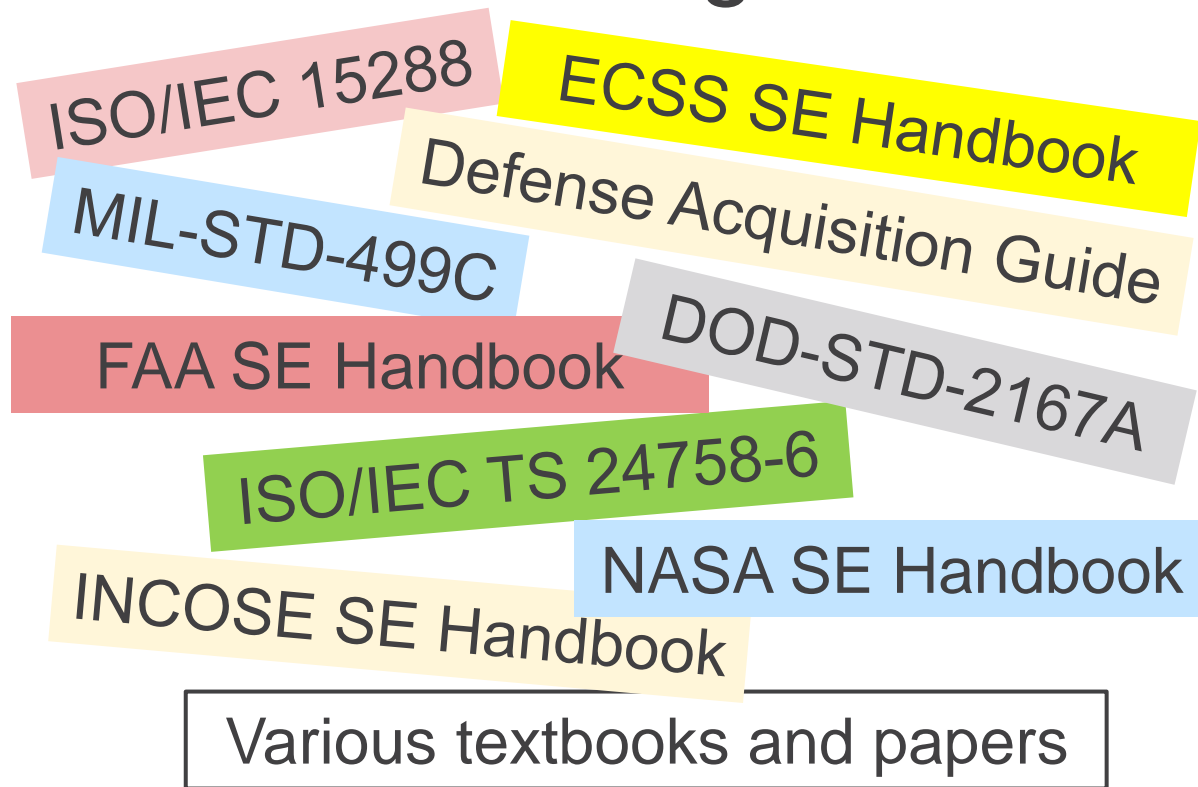
Jim Armstrong

www.incose.org/symp2022

The Issue

- ## Sources of guidance

ISO/IEC 15288

ECSS SE Handbook

Defense Acquisition Guide

MIL-STD-499C

DOD-STD-2167A

FAA SE Handbook

ISO/IEC TS 24758-6

NASA SE Handbook

INCOSE SE Handbook

Various textbooks and papers

- ## Vocabulary used

Assembly

Incorporating

Combination

Realization process

Components

Lower level to higher level

Bottom-up

Top-down

Fishbone

Big bang

Interface Management

- Interface Management
    – Requirements and Design
- Described as
    – Cross-cutting process
    – Separate process

Interfaces

- Interfaces spread over SE processes
  – Requirements, architecture/design, verification…
- Focus on immediate interaction of adjacent physical components
- Functional interactions of remote components addressed
- Reliance on interface control documents or similar approaches.

Interface Topics Vary Among Systems

USDOJ IT System ICD Template

- 1.0   **SCOPE**
  - 1.1   System Identification
    - 1.1.1   System
    - 1.1.2   System
  - 1.2   Document Overview
  - 1.3   Applicable Documents
- 2.0   **CONCEPT OF OPERATIONS**
  - 2.1   System Overviews
    - 2.11   Interface Overview
  - 2.2   Functional Allocation
  - 2.3   Data Transfer
  - 2.4   Transactions
  - 2.5   Security and Integrity
- 3.0   **DETAILED INTERFACE REQUIREMENTS**
  - 3.1   Interface 1 Requirements
    - 3.1.1   Interface Processing Time Req's
    - 3.1.2   Message (or File) Requirements
    - 3.1.3   Communication Methods
    - 3.1.4   Security Requirements
  - 3.2   Interface 2 Requirements
- 4.0   **QUALIFICATION METHODS**
- 5.0   **NOTES**
- 6.0   **APPENDICES**
- 7.0   **APPROVALS**
- 8.0   **RECORD OF CHANGES**

International Space Station Payload Hardware ICD

- 1.0 INTRODUCTION
- 2.0 DOCUMENTATION
- 3.0 PAYLOAD INTERFACE
- 3.1 STRUCTURAL/MECHANICAL
- 3.2 ELECTRICAL POWER INTERFACES
- 3.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS
- 3.4 PAYLOAD VIDEO INTERFACE REQUIREMENTS
- 3.5 THERMAL CONTROL INTERFACE REQUIREMENTS
- 3.6 VACUUM SYSTEM REQUIREMENTS
- 3.7 PRESSURIZED GASES INTERFACE REQUIREMENTS
- 3.8 PAYLOAD SUPPORT SERVICES INTERFACES REQUIREMENTS
- 3.9 ENVIRONMENTAL INTERFACES
- 4.0 APPLICABILITY MATRIX
- 5.0 EXCEPTION PROCESSING
- **APPENDIX**

Other Things To Consider

- Allocations
- Multiples
- Operations
- Support
- Environment
- New Technologies
- Organizational Architecture
- Culture
- Configuration Management

Allocations

- Basic allocations
  - Weight, power, cost, unusable fuel…
- More interesting
  - Moment or product of inertia, Thermal, Error Budgets (RMS?)
- Or even
  - Electromagnetic Interference/Radiation
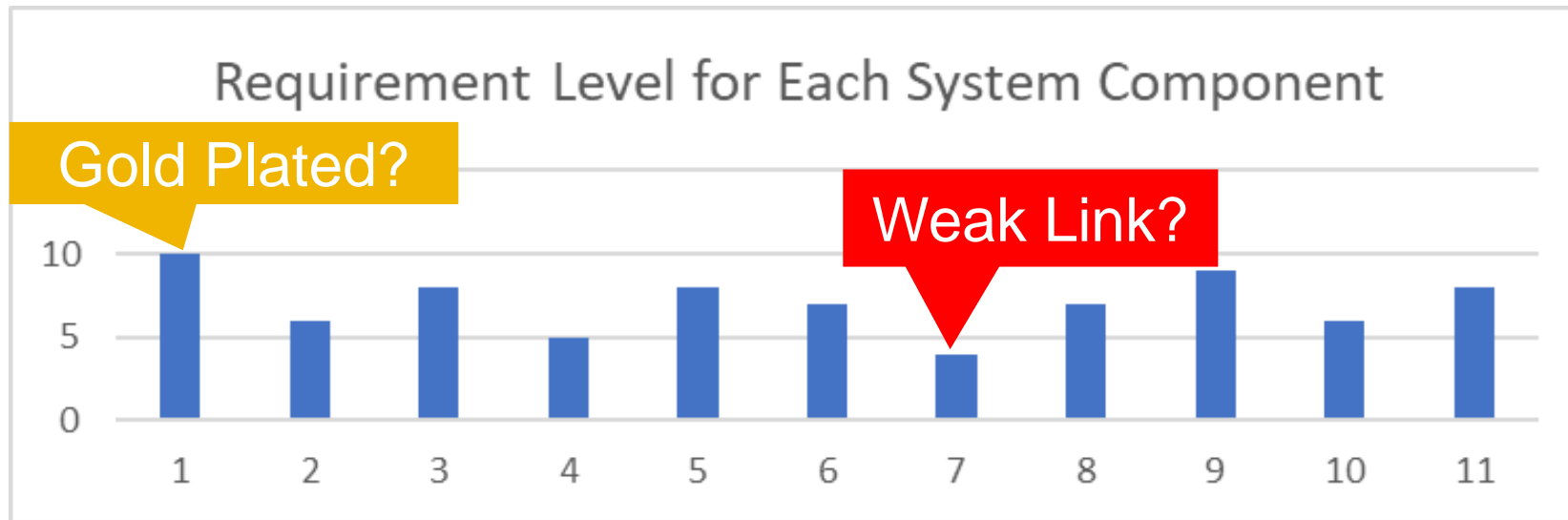
More Complex Allocations

Compound Parameters

- ## Aircraft range
  - Lift, Drag, Fuel efficiency, Dry and Wet Weight, Mission profile…

- ## Link Margins
  - Power, Sensitivity, Noise, Propagation, 4/3 Earth Model, Environment…
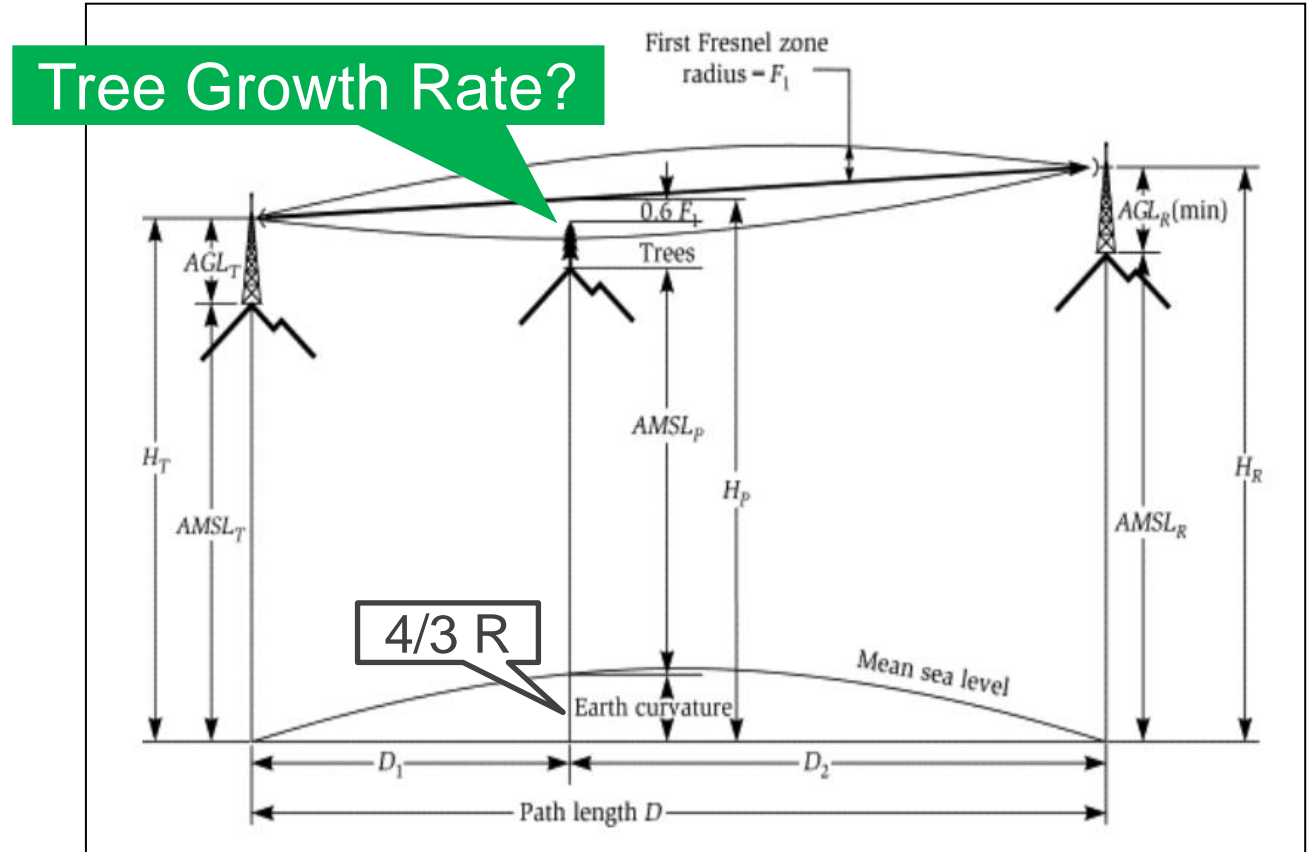
Even More Allocations

- System level requirements across subsystems

Issues with Multiples

At times, one works well –multiples don't

- Leaded gasoline to lessen engine knock

- Plastic bags

- Cell phones in high demand situations

- Radar scope screen update design

- Pre-GPS 3-drone triangulation guided bomb

Operations

- Engine to Generator flex coupling failed on fishing boat

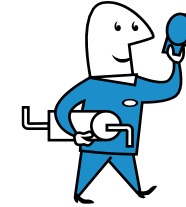- Problem: Strain during idle operations working nets – engine fluxuations
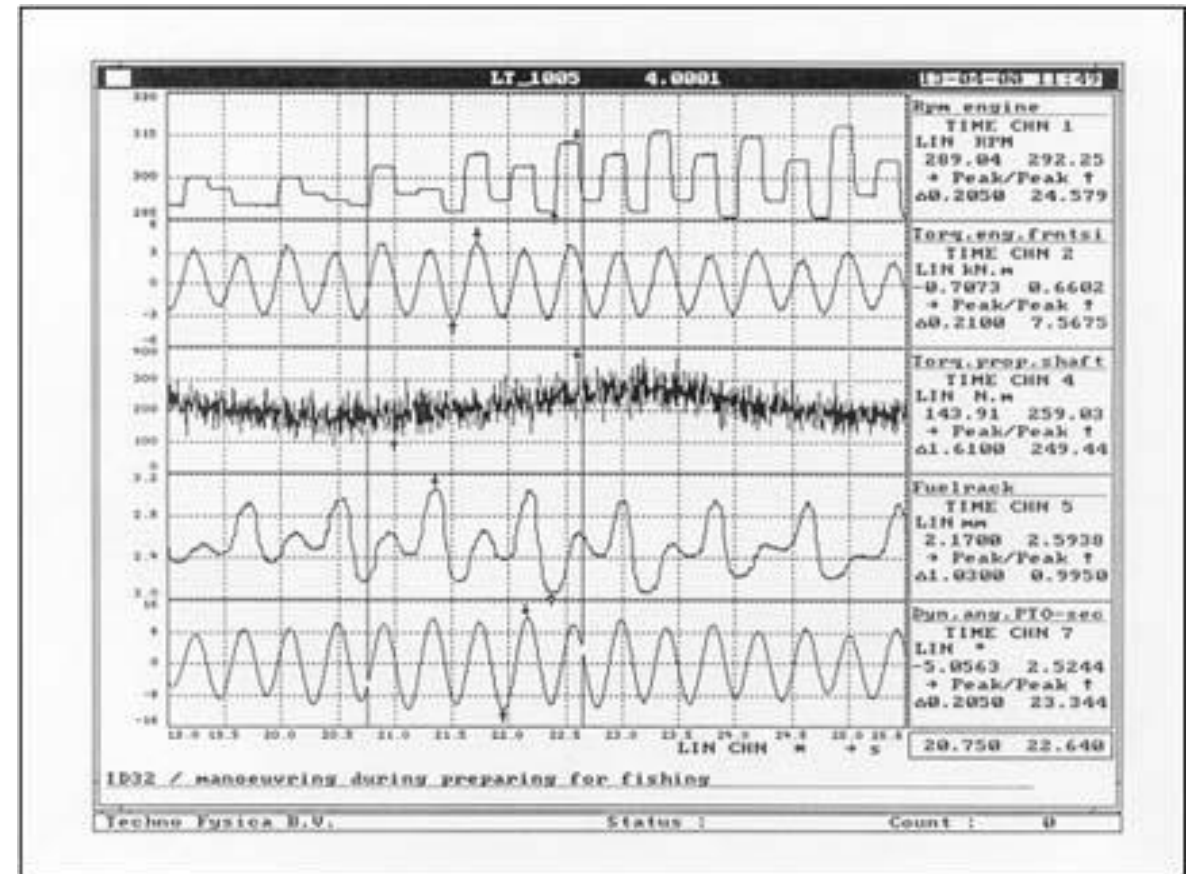
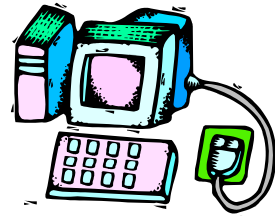# Integrated Logistics Support
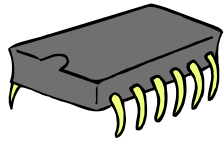
Supply Support
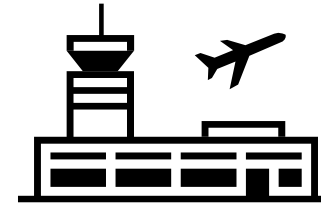
Support Equipment

Technical Data

Manpower & Personnel

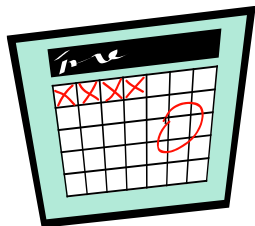**Packaging, Handling, Storage, and Transportation (PHST)**

Computer Resources Support

Facilities

Training & Training Support

Maintenance Planning

Requirements for these elements + Design Interface with the System of Interest

Indirect Support Impacts

Example: Tactical Communications Switch Built-in-Test

- Requirement:
  - 85% Identify Single Part
  - 15% not more than 3
- Policy: Unused part not returned to supply – sent to depot
- Impact: Higher return rate from field and more initial spares needed
- Solution: Improve Built-in-Test to high 90's%

Environment

Rail Examples

- France/Albuquerque
  - Classic interface issues

- UK High Speed
  - Broader view
  - Who starts where going where?
  - How do they get to and from the train?

More Environment

Transit Oriented Development

- Are surroundings conducive to using the system?

- Which paths on right are more likely to be used?

# More Environment

Loganair SAAB 2000
- Hit by lightning
- Autopilot went downward
- Pilots believed they would override autopilot
- <u>Only plane in fleet not true</u>
- Almost crashed
- Data anomaly happened to turn off autopilot

New Technologies (Local – Within System)

- Solid State ILS
  - Worked well in Europe
  - Failures in thunderstorms in USA
- NICAD Batteries in Tactical Communications Van
  - Met interface and performance requirements
  - Not allowed on cargo aircraft
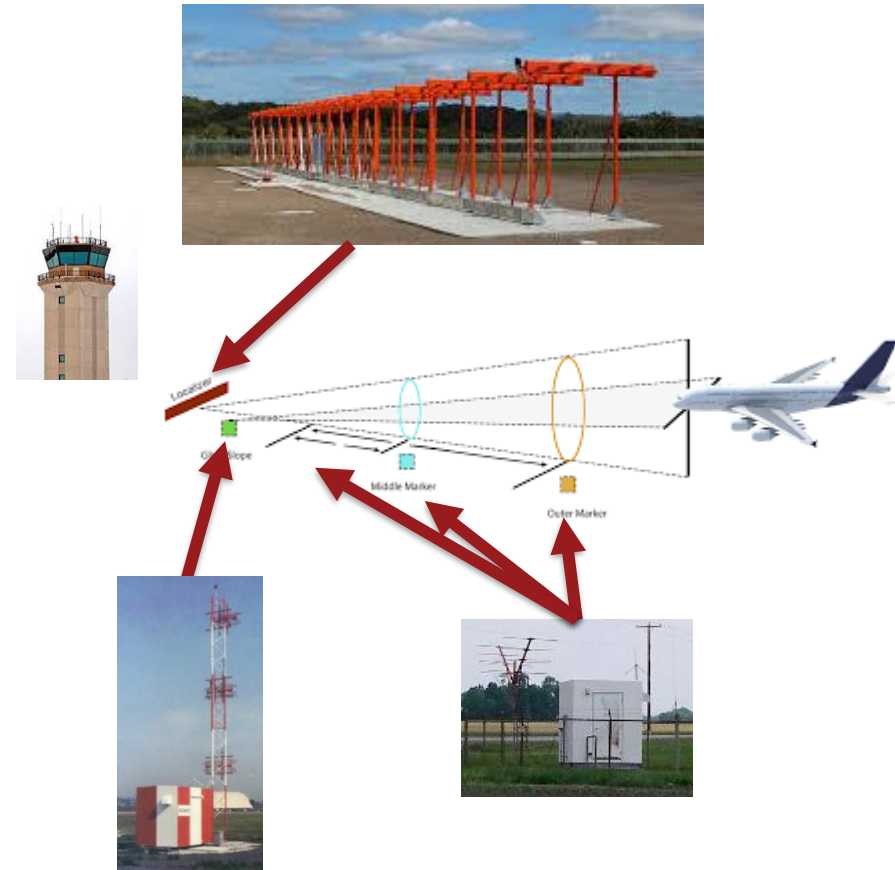
New Technology (Global – External Impacts)

- Solar Cars – INCOSE IS2021 Keynote

  – positive carbon footprint impact presented

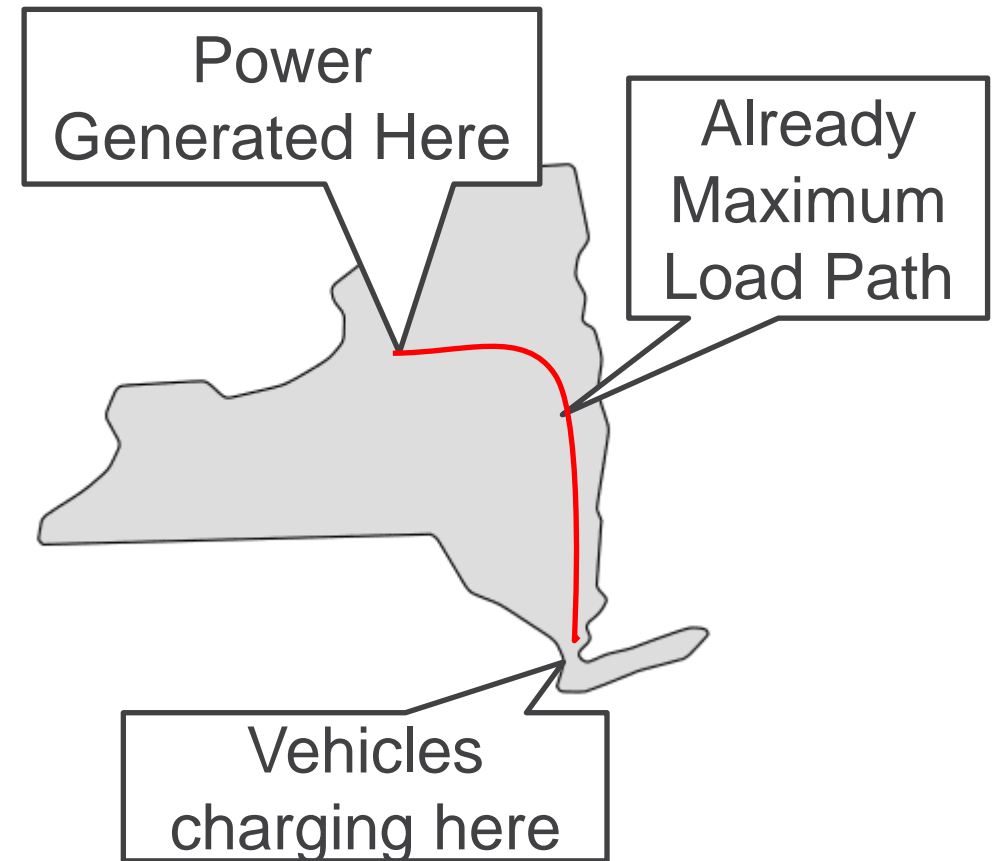 – negative impacts of battery manufacture recognized

Lightyear One

New Technologies (Global and Multiples)

- New York City expects 2M electric vehicles by 2040

- Power grids need major upgrades

- Not only place this is the case

Power Generated Here

Already Maximum Load Path

Vehicles charging here

Organizational Architecture

- "Any organization that designs a system (defined broadly) will produce a design whose structure is a copy of the organization's communication structure." (Conway, 1968)

- Mars Polar Lander
  - Spacecraft expected metrics
  - Ground sent 'English' (feet)

- Integrated Product Teams
  - Help integration of specialties on product the team builds
  - Can cause non-integrated application of specialties across products in a system – e.g., different soldering standards

Culture

- Potential issues with impacts of behaviors
  - Aircraft crew communications
  - Training attitudes
  - Local habits – Frequent floor waxing clogs cooling intakes

Configuration Management

- Apollo 13 highlighted potential impact
  - Thousands of changes are made on any sizeable program
  - Many corporate processes focus on internal changes and lack serious treatment of external interfaces
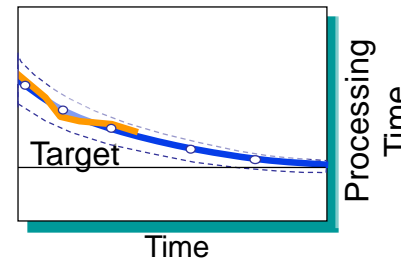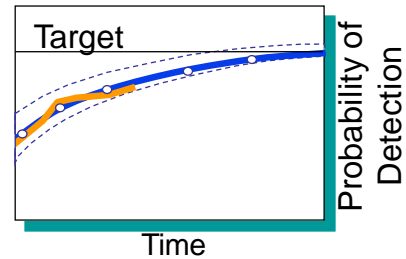
Tools to Use

- ICWGs and SEITs – monitor broader issues than just direct interfaces

- TPMs – track progress of key allocations

- System Readiness Levels – ask if the selected technologies have been used together before

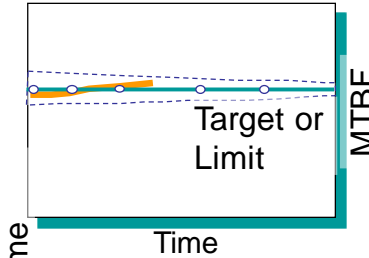- Schedule networks and critical path analysis

TPMs

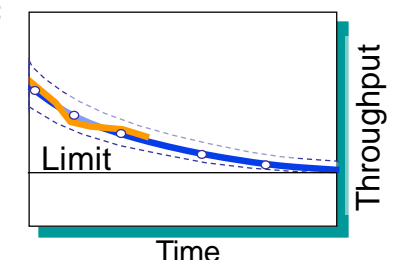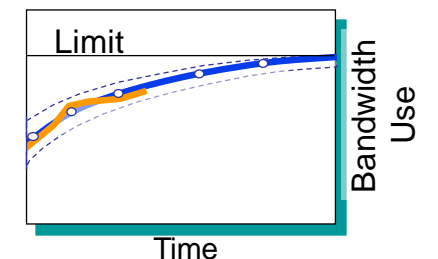- Track technical parameters
- Assess impact on integration

Manage Improvement

Target

Probability of Detection

Time

Target

Processing Time

Time

Maintain Level

Target or Limit

MTBF

Time

Manage Margin

Limit

Bandwidth Use

Time

Limit

Throughput

Time
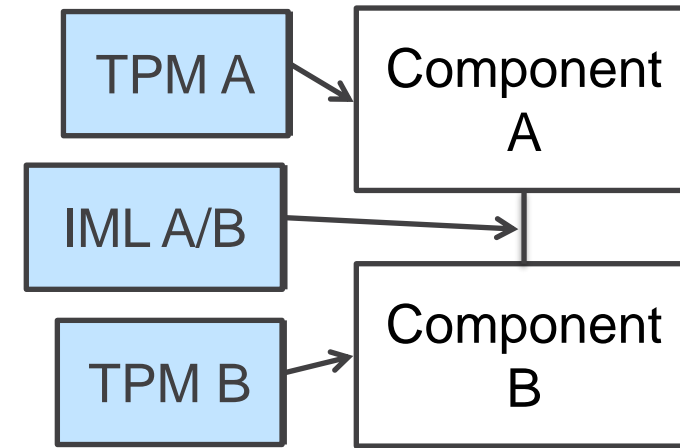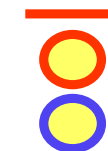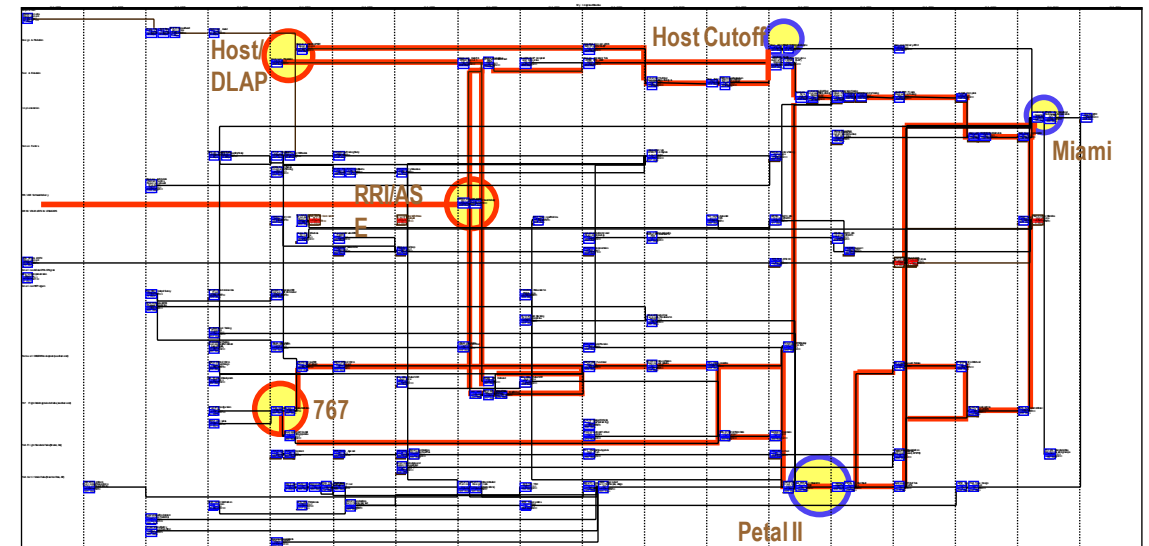
System Readiness Levels

- Adds Integration Maturity Level
  - Have these two technologies worked together before?

- Example: Electronic controls added to Puget Sound Ferry

Schedule

- Integration of multiple segments

- Tight schedule

- Issue: no time to address test issues between integration phases

Legend:
- Path at or near critical
- Key Events
- Fixed Events

Summary

SEs must be aware that interface management is necessary but not nearly sufficient

Examples of areas that have issues outside of normal interface definition and management:

- Allocations
- Support
- Multiples
- Environment
- Operations

- New Technologies
- Organizational Architecture
- Culture
- Configuration Management
- Schedule

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