IN PURSUIT OF RELIABLE SCHEDULES

Introducing NetPoint Numerati

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PMA Technologies, LLC

NetPoint+GPM CONFERENCE

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Presentation Outline

Schedules encompassing thousands of activities contain overwhelming amounts of data. Even in the case of level 2 schedules, the volume of information increases greatly as updates and revised baselines are generated.

In this Keynote, Dr. Gui introduces new schedule analytics functionality in NetPoint for modeling and recasting attributes and data within a schedule or within two compared schedules. NetPoint schedule analytics provides meaningful schedule metrics and scores schedule reliability through a novel Schedule IQ™ algorithmic application of *Core Traits of a Reliable Schedule*.

Biography

Gui Ponce de Leon, PhD, PE, PMP, LEED AP

CHIEF EXECUTIVE OFFICER
PMA CONSULTANTS, LLC

Dr. Gui is one of our nation's foremost planning and scheduling experts. His experience includes roles as investor's developer, construction manager, program manager, forensic scheduler, EPC contractor planner/scheduler, and expert witness. Dr. Gui has pioneered innovations in project management throughout his career. With GPM, he is on a quest to transform scheduling from tasks performed by specialists using a *black box* to stakeholder-centric processes that promote collaboration, enhance stakeholder interaction, and inherently result in reliable schedules.

Why Not Aspire to Great Schedules

"Construction scheduling, as we know it, has been practiced for over 50 years. This being the case, stakeholders responsible for delivering a project should be entitled to a *great*, not just a good, schedule. A great schedule is authored, understood, and followed by key stakeholders–as opposed to by just one savvy scheduler. A great schedule is a credible predictor of credible performance, both at the onset and as the project progresses. Lastly, a great schedule is free of technical deficiencies."

Foreword to *Core Traits of a Reliable Schedule*

Reliability is the *Sine Qua Non* of Great Schedules

"The authors posit that a schedule that is comprehensive, credible, well constructed, and controlled (considered the four corners of a reliable schedule) captures the notion of a great schedule."

Foreword to *Core Traits of a Reliable Schedule*

Topics Selected for Discussion

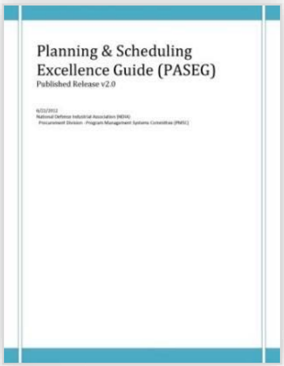
- A — Reliable Schedule Standards
- B — Metrics Analysis Supports Standards
- C — NetPoint v5.2 Schedule Analytics
- D — Schedule IQ™

A

RELIABLE SCHEDULE STANDARDS

Reliable Schedule Standards

2011 & 2012



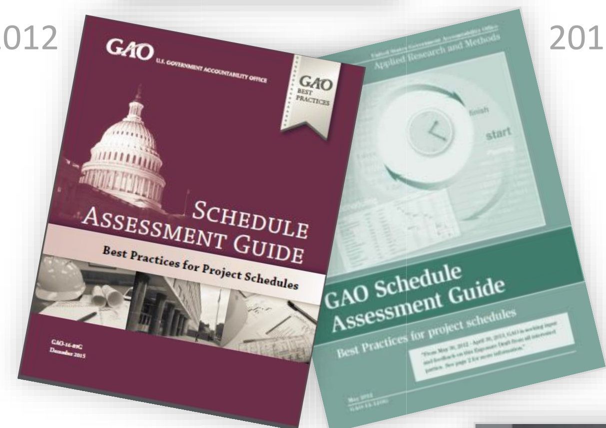
National Defense Industrial Association (NDIA)

Planning & Scheduling Excellence Guide (PASEG)

Introduces generally accepted scheduling principles

2012

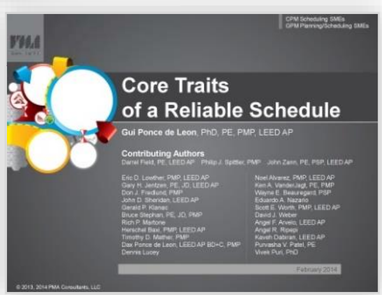
2015



GAO *Schedule Assessment Guide*

Discusses 'Ten Best Practices' associated with high-quality and reliable project schedules

2014



Core Traits of a Reliable Schedule aka The 20-Trait Protocol

Codifies the essential elements of reliable schedules into 20 core traits

PASEG Generally Accepted Scheduling Principles (GASP)

GASP			GASP Essential Element: The Schedule
Valid	1	**Complete**	*. . . captures the entire discrete, authorized project effort from start through completion*
Valid	2	**Traceable**	*. . . logic is horizontally & vertically integrated with cross-references to key documents & tools*
Valid	3	**Transparent**	*. . . provides visibility to assure it is complete, traceable, has documented assumptions & provides full disclosure. . .*
Valid	4	**Statused**	*. . . has accurate progress through the status date*
Valid	5	**Predictive**	*. . . provides meaningful critical paths & accurate forecasts for remaining work through program completion*
Effective	6	**Useable**	*. . . is an indispensable tool for timely & effective management decisions & actions*
Effective	7	**Resourced**	*. . . aligns with actual & projected resource availability*
Effective	8	**Controlled**	*. . . is built, baselined, & maintained using a stable, repeatable, & documented process*

GAO Guide Best Practices for Project Schedules

The GAO guide identifies 4 characteristics of reliable schedules and catalogs 10 best practices for project schedules accordingly

	10 Best Practices for Project Schedules
Comprehensive	1. The schedule captures all activities
	3. Resources are assigned to all activities
	4. The schedule realistically reflects the durations of all activities
Well Constructed	2. Schedule activities are logically connected
	6. The schedule critical path is confirmed as valid
	7. The schedule identifies reasonable total float
Credible	5. The schedule is traceable horizontally & vertically
	8. Risk analysis is used to determine a reasonable contingency
Controlled	9. Updating the schedule is based on actual progress & logic
	10. A baseline schedule is set promptly & is maintained

Reliable Construction Schedules per the *20-Trait Protocol*

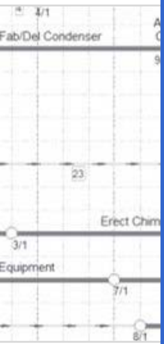
The Schedule Is Comprehensive		The Schedule Is Credible		The Schedule Is Well Constructed		The Schedule Is Controlled	
A1	Aligned	B1	**Predictive**	C1	Hierarchical	D1	**Statused**
A2	**Complete**	B2	**Risked**	C2	Phased	D2	Weathered
A3	Conforming	B3	Weather Fit	C3	**Logical**	D3	**Re-baselined**
A4	**Formulaic**	B4	Resource Flowing	C4	**Connected**	D4	Forensic
A5	**Resourced**	B5	**Flexible**	C5	Calendar-Fit	D5	Trended

*Traits in **green** have elements in common with a GAO best practice for project schedules*

B

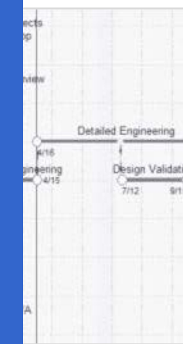
METRICS ANALYSIS SUPPORTS STANDARDS

Metrics Analysis Supports Standards



What Are Schedule Metrics?

Metrics are measurements of information about a schedule with respect to important features



Examples:

- Number of stakeholders named as schedule signators
- Percent of activities without a predecessor
- Percent of activities on the critical path
- Critical path total float as a ratio to project length
- Mean and median total float
- # of milestones + # of benchmarks as a ratio to # of activities

Schedule Metrics Can Be Categorized Into Three Sets

1

Data Metrics

Relevant schedule counts and schedule attributes that characterize the schedule:

# of negative-total-float activities
# of milestones
# of calendars
# of resources
# of redundant links

2

Reliability Metrics

Key schedule parameters relative to a normative range and schedule performance (execution) metrics

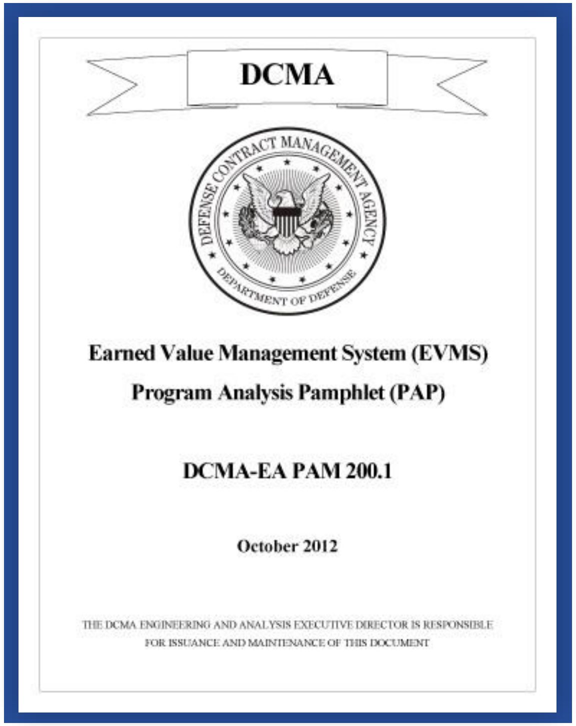
Critical path index
Milestone density
Completion index
Float performance index
Schedule index

3

Comparative Metrics

Quantify and help identify variances for selected filters between two schedule issues for a project

In the Beginning, There Was the 14-Point Assessment


DCMA

DEFENSE CONTRACT MANAGEMENT AGENCY

DEPARTMENT OF DEFENSE

Earned Value Management System (EVMS)

Program Analysis Pamphlet (PAP)

DCMA-EA PAM 200.1

October 2012

THE DCMA ENGINEERING AND ANALYSIS EXECUTIVE DIRECTOR IS RESPONSIBLE FOR ISSUANCE AND MAINTENANCE OF THIS DOCUMENT

2005

The Defense Contract Management Agency aka DCMA released its 14-Point Assessment as a framework for asking educated questions about the health of a schedule and about metrics analysis

2009

Schedule metrics analysis was fast becoming part of best scheduling practices; it wasn't long before myriad software apps had embraced the DCMA 14-Point schedule metrics

The 14-Point Assessment in a Nutshell

#	14-Point Assessment Metrics
1	At most, 5% of remaining activities may be with open ends
2	There should be NO leads/negative lags
3	At most, 5% of FS logic ties should have lags
4	At least 90% of logic ties should be FS logic
5	At most, 5% of activities have imposed hard constraints
6	At most, 5% of remaining activities have total float ≥ 44 days*
7	There are NO activities with negative total float
8	At most, 5% of remaining activities have duration ≥ 44 days*

* Metric is not schedule-level sensitive

The 14-Point Assessment in a Nutshell *(cont'd)*

#	14-Point Assessment Metrics
9	No remaining/actualized activities left/right of data date
10	Activities with duration > 0 should be resource loaded
11	At most, 5% of activities missed their baseline finish dates
12	A delay on a critical activity equally extends the schedule
13	Critical path length index (CPLI) = (critical path length + critical path total float) / critical path length ≥ 0.95**
14	Baseline execution index (BEI) = # of activities completed / (# of activities completed + # of activities missing their baseline finish dates) ≥ .95

** Incoherent vis-à-vis metric #7

Metrics: A Common Denominator in the Pursuit of Reliability

Schedule metrics, originally intended as a report card on the health of a schedule, are evolving as measures to:

1. Gauge potential schedule reliability issues
2. Develop solutions
3. Assess their effectiveness

- **2012 *PASEG***–adds 11 reliability metrics to the 14-Point Assessment (a 25-point assessment), and recommends using a suite of complementary metrics
- **2015 *GAO Guide***–provides 20 standard data metrics and 60 reliability metrics
- **2014 *20-Trait Protocol***–provides guidance on 42 indicators of schedule reliability, including 15 schedule metrics

Selected *PASEG* Schedule Execution Metrics

Critical path length index (CPLI)	Favorable if > 1.00, unfavorable otherwise
Schedule performance index (SPI)	Favorable if > 1.00, unfavorable otherwise
Baseline execution index (BEI)	Favorable if > 1.00, unfavorable otherwise
Current execution index (CEI)	At least 80% of activities scheduled to finish in the prior update actually finished
Total float consumption index (TFCI) [applied to project duration to predict critical path total float (CPTF) at completion]	(Critical path length ***up to data date*** + critical path total float) / critical path length up to data date For example, if after 100 days of progress, a 250-day project is 10 days behind schedule (CPTF = -10), the project will complete (250 / 100) x -10, or -25 days behind schedule

SPI = budgeted cost of work performed / budgeted cost of work scheduled

Deltek Acumen Fuse Metrics to Ensure Schedule Quality

9 Metrics	Tripwire (Normative Range)	14-Point Assessment Metric Number
Missing Logic	At most, 5%	1
Logic Density™	2-4 logic ties per activity*	Not Included
Critical	Not disclosed in the literature	Not Included
Hard Constraints	Not disclosed in the literature	5
Negative Float	Not disclosed in the literature	7
Insufficient Detail	Durations ≤ 10% of project duration*	4
# of Lags	At most, 5% of FS logic have lags	3
# of Leads	There are NO leads	2
Merge Hotspot	Activities with > 2 predecessors*	Not Included

* Metric is not schedule-level sensitive

Deltek Acumen Fuse Schedule Quality Index™

Average Fuse Schedule Index for 13 months for thousands of projects as reported by Deltek

Observations on the State of Schedule Metrics

1

No attempt to measure overall schedule reliability

2

Metrics proposed overlook schedule level

3

Weather is the elephant in the room

4

Overlook planning basis metrics altogether

5

Overlook conformance to contractually imposed dates

6

Absence of metrics left of the data date (CPM syndrome)

C

NETPOINT V5.2
SCHEDULE ANALYTICS

NetPoint v5.2 Schedule Analytics

Measure, score, validate, and ***enable*** schedule reliability through an interactive, flexible application of the *20-Trait Protocol* using the comprehensive, credible, well-constructed, and controlled framework

- Data metrics, i.e., varying activity counts, logic counts, and other relevant schedule counts
- Up to 45 metrics are analyzed and combined into *Schedule IQ™*, a reliability score for baselines and updates
- Weather enabling protocol that uses weather calendars to calculate "weathered start dates" and "weathered finish dates"
- Comparative analysis pinpoints changes between a current baseline or an update against a prior baseline, update, or target

A 30-Point Assessment

The Schedule Is:	NetPoint Schedule Metrics	NetPoint Reliability Indicators	Captures 14-Point Assessment Metric Number
Comprehensive	Over 200	10	8 & 10
Credible		5	6, 7 & 13
Well Constructed		10	1, 2, 3, 4 & 5
Controlled		5	9, 11, 12 & 14

Example Reliable Schedule Gauge Indicators

5 example metrics measuring the extent that a **level 3** schedule is Comprehensive (10 gauge indicators in total)

Comprehensive Indicator Description & Tripwire
At least 3 stakeholders are signators to the schedule
At least 95% of activities are assigned to a WBS element
At least 95% of activities are assigned a code
At least 80% of physical work activity durations are at the right granularity
At least 95% of activities are resource loaded

Example Physical Work Activity Duration Granularity

Normative activity duration ranges (*major projects*, per the *20-Trait Protocol* and PMI's *CPM Scheduling for Construction)*

	20-Trait Protocol	DCMA	Deltek Fuse	PMI CPM Scheduling
Level 1	2 - 12 months	≤ 44 days	≤ 10% of project duration	3-12 months
Level 2	5% - 15% of project duration, generally 6 weeks - 6 months			2-6 months
Level 3	1% - 3% of project duration, generally 2 - 6 weeks			2-6 weeks
Level 4	≤ 1% of project duration, generally ≤ 2 weeks			2-4 weeks

Example Reliable Schedule Gauge Indicators

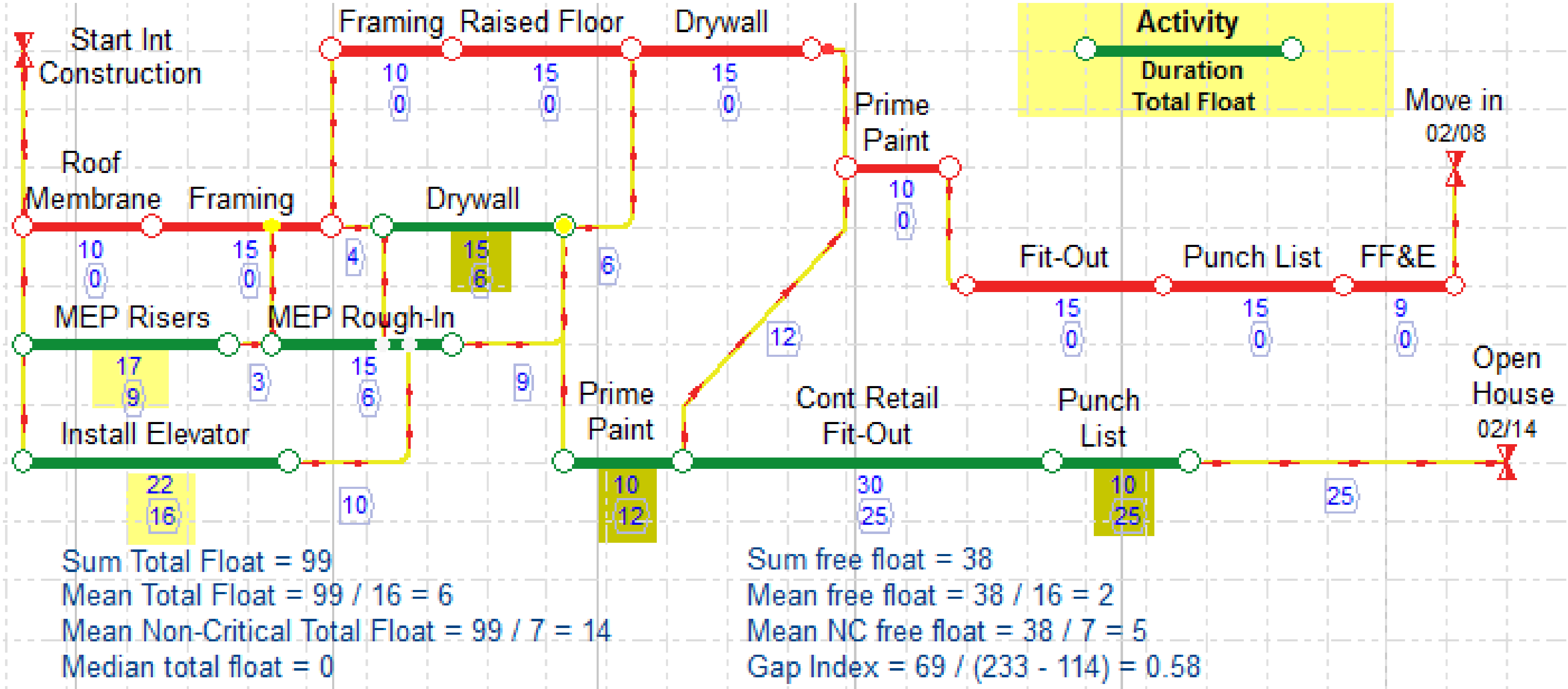
5 example metrics measuring the extent that a **level 3** schedule is credible (5 gauge indicators in total)

Credible Indicator Description & Tripwire
Critical path index (CPI) = (critical path total float (adjusted for weather) / remaining project length) is between 5% and 10%*
15% to 30% of activities are on the critical path
Likelihood of completing by the required finish date ≥ 70%
Weather index = (weather dates per year / # of reasonable weather days per year) ≥ 95%
Float performance index ≥ 80%

* CPI can be calculated for every contractual milestone and contractual benchmark

45 Metrics for Measuring Float As a Resource

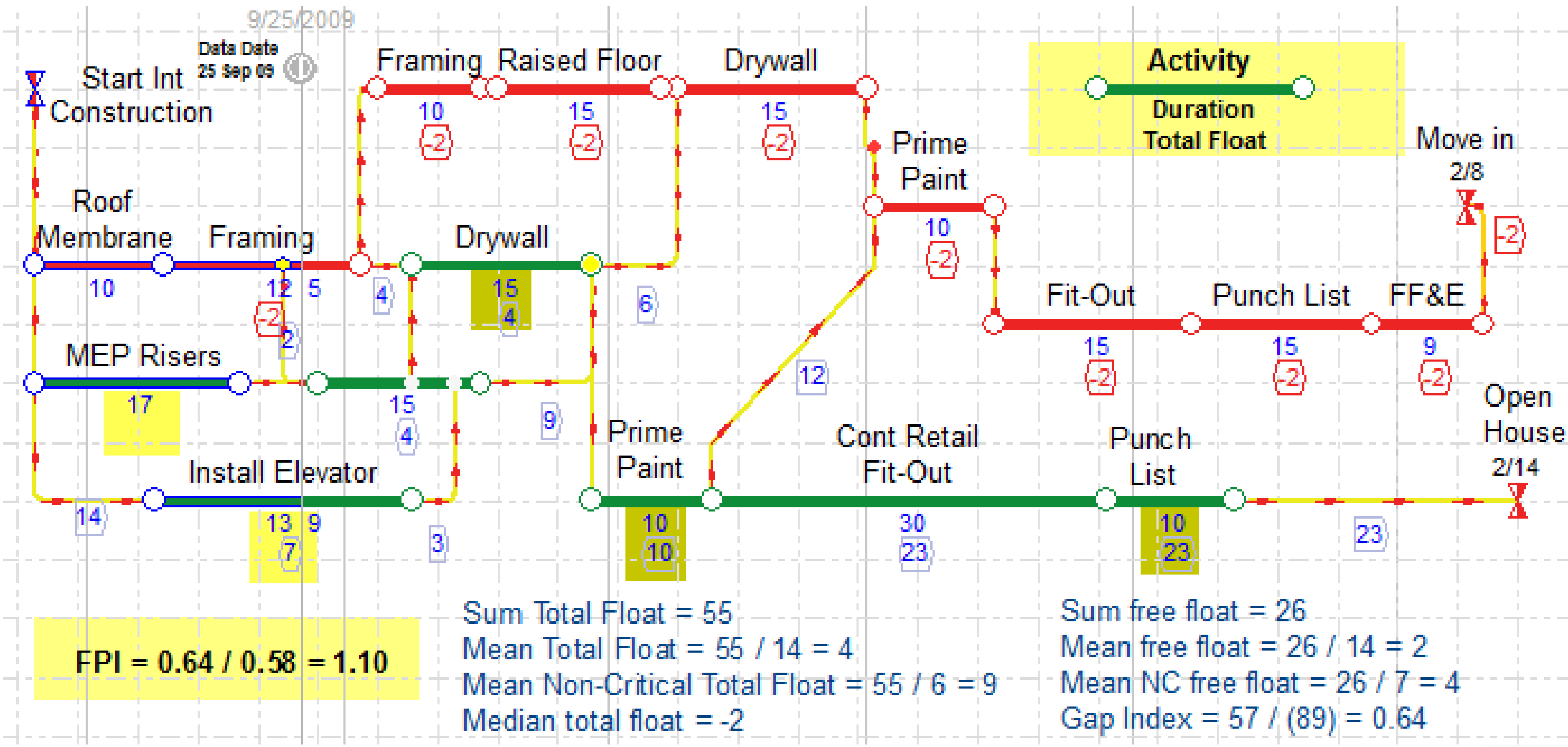
- Mean total float, total float percentiles, and mean free float
- As gaps do not repeat total floats, gap index = sum gaps / sum durations (non-critical activities) is a useful off-critical path metric



Float Performance Index (FPI)

FPI measures the rate of float depletion off the critical path

FPI relies on gap indices vs. on total floats or free floats



Example Reliable Schedule Gauge Indicators *(cont'd)*

5 example metrics measuring the extent that a **level 3** schedule is well constructed (10 gauge indicators in total)

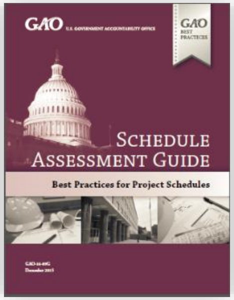
Well-Constructed Indicator Description & Tripwire
Milestone/benchmark (to activity) density is 2% to 5%
At most, 2% of activities are assigned a constraint date
At least 80% of logic ties are FS logic
At most, 5% of links are redundant
Activity-to-activity logic index is 1.5 to 2.5 (excludes redundant links)

Redundant Logic Threshold–A Well-Constructed Metric

<u>Redundant logic</u> represents unnecessary logic ties between activities

Redundant Link:

Activity-successor link that cannot ***unilaterally drive*** *the successor under any combination of durations and lags, because the successor is always necessarily driven by another successor to the activity*

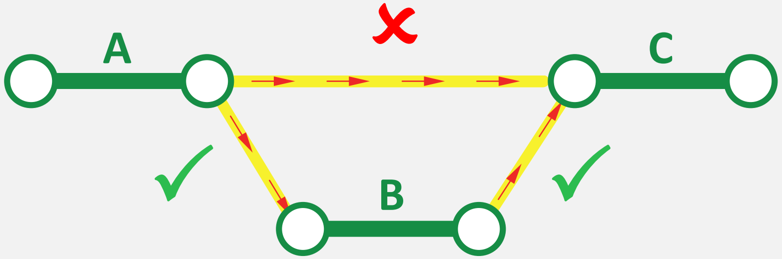


Quote from the GAO Guide (2015 Edition, p. 31)

"The network should be clear of redundant logic"

Redundant Logic Example

Redundant links cause fictive parallel relationships or path convergence and needlessly obfuscate the display of the schedule



The classic and indeed most obvious case of redundant logic comprises Activity A preceding Activity B on FS logic, Activity B preceding Activity C on FS logic, making–if included–an FS link between Activities A and C unnecessary and thus redundant

The Redundancy Conundrum

Algorithms to detect and eliminate redundant links are not trivial in a PDM network with 4 relationship types

Out of 64 possible logic patterns in a PDM network with 4 relationship types*

NetPoint®

- **13** are redundant
- **51** are valid

Deltek | ACUMEN

- Finds redundancy in **only 3** of the true **13** redundant logic patterns
- Finds redundancy in **14** valid logic patterns

* If SF logic is excluded, out of 9 possible logic patterns, 3 are redundant

D

SCHEDULE IQ™

Schedule IQ™

Algorithm that provides an overall reliability score for project schedules based on:

1

Planning basis (e.g., contract dates conformance, extent that activities are WBS coded, weather basis, etc.)

2

Network characteristics (open ends, logic index, % of links that are FS, etc.)

Algorithmic application of the 20-Trait Protocol as postulated in *Automate This: How Algorithms Came to Rule Our World* by Christopher Steiner

Schedule IQ™ Inner Workings–*Un-progressed* Baselines

Schedule IQ™ operates as a series of 39 independent *reliability indicator* tests, each test yielding a score that contributes to the total score (100)

Un-progressed Baseline	# of Independent Tests	Contribution to IQ Score
Comprehensive	12	34%
Credible	11	25%
Well Constructed	15	38%
Controlled	1	3%

Schedule IQ™ Inner Workings–*Progressed* Baselines

The number of independent *reliability indicator* tests increases to 45 for progressed baselines; the contribution to IQ score changes accordingly

Progressed Baseline	# of Independent Tests	Contribution to IQ Score
Comprehensive	12	31%
Credible	11	23%
Well Constructed	15	34%
Controlled	7	12%

Interpretation of Schedule IQ™ Scores

IQ Range	
≥ 91	Highly Reliable Schedule
81-90	Reliable Schedule
61-80	Somewhat Reliable Schedule
51-60	Marginally Reliable Schedule
≤ 50	Unreliable Schedule

Conditional 20-Trait Protocol Traits

The NetPoint Metrics Manager interface allows 3 core traits to be *"turned off"*

1

Weather-related core traits, B3 The Schedule is *Weather Fit* and D2 The Schedule is *Weathered*

2

Risk assessment-related core trait, B2 The Schedule is *Risked*

3

Core Trait B4 The Schedule is *Resource Flowing*

Un-progressed Baseline Upper Bounds in Schedule IQ™

The Schedule IQ scores shown remove resource-flow logic (20-Trait Protocol Core Trait B4) from consideration

Max IQ	
91	If the schedule is not risk assessed and critical path index is less than 5%
90	If activities are not resource loaded
89	If critical path index is less than -5%
89	If neither a narrative documenting assumptions nor acknowledged signators are provided with the schedule
89	If less than 85% of the activities are assigned to a WBS element
88	If weather is not integrated into the schedule

E

SUMMARY

Take-Aways

1

Metrics analysis is crucial for the typical level 3 *master* schedule

2

NetPoint metrics functionality advances schedule analytics from the well constructed and credible to the *reliable* realm

3

There is much to be learned about the behavior of critical path, total float, & gap metrics relative to percent complete

4

No judgment is made in Schedule IQ™ as to means & methods portrayed in the schedule

Take-Aways *(cont'd)*

5

The IQ score of a contractually required schedule submittal may be useful as a protocol to determine whether the submittal is reviewable or, say where IQ is below 60, should be returned for revision and resubmittal

6

Schedule analytics and Schedule IQ™ can be applied to any group of activities by a filter or time window to ascertain whether the score is/is not homogeneous

7

Schedule analytics needs to evolve to measure period density, activity count, activity count growth, earned schedule, and other yet untested metrics

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APPENDIX A–Selected NetPoint Metrics Definitions

Float index: for a schedule, gap index right of the data date as a ratio to gap index for a base-case schedule.

Gap: extent the predecessor may be delayed without delaying the successor or the successor may gain schedule without overriding logic.

Gap index: right of the data date, sum of gaps (excluding activity-milestone gaps and redundant link gaps) as a ratio to sum of remaining durations for non-critical activities

Logic index, activity-to-activity: number of valid links (i.e., other than redundant links) as a ratio to the number of activities.

Out-of-sequence progress: actual dates for two connected activities breach the relationship type (resulting in negative actualized gap).

Period density: for any period, number of activities scheduled in that period; the highest period density is the 100th percentile period density.

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APPENDIX B—NetPoint v5.2 Float-Related Metrics

Activities	Total Float	Link Gap Metrics	Other Float-Related Metrics
With negative total float	Critical path index	With zero gap	Float performance index
Critical	Critical path total float	With positive gap	Gap index
Near-critical	Mean	With negative gap	Activities with total float ≤ 5th percentile
With positive drift	Mean non-critical	With gap ≥ 20 periods	Activities with total float ≤ 10th percentile
With total float = drift	Median	With extreme gap	Activities with total float ≤ 50th percentile
With extreme total float	5th percentile	With actualized gap	Mean free float
With positive free float	10th percentile	With actualized negative gap	Mean non-critical free float
Forensic critical	80th percentile (Extreme total float)	FF links with gap = 0	Gap sum embedded in the critical path
Forensic near-critical	Total float index	SS links with gap = 0	Gap sum embedded in the as-built critical path

Thank You!

Dr. Gui Ponce de Leon

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