State of Good Repair

Want Your Money? What you Need to Know about Metrics for SGR with regard to FRA Funding

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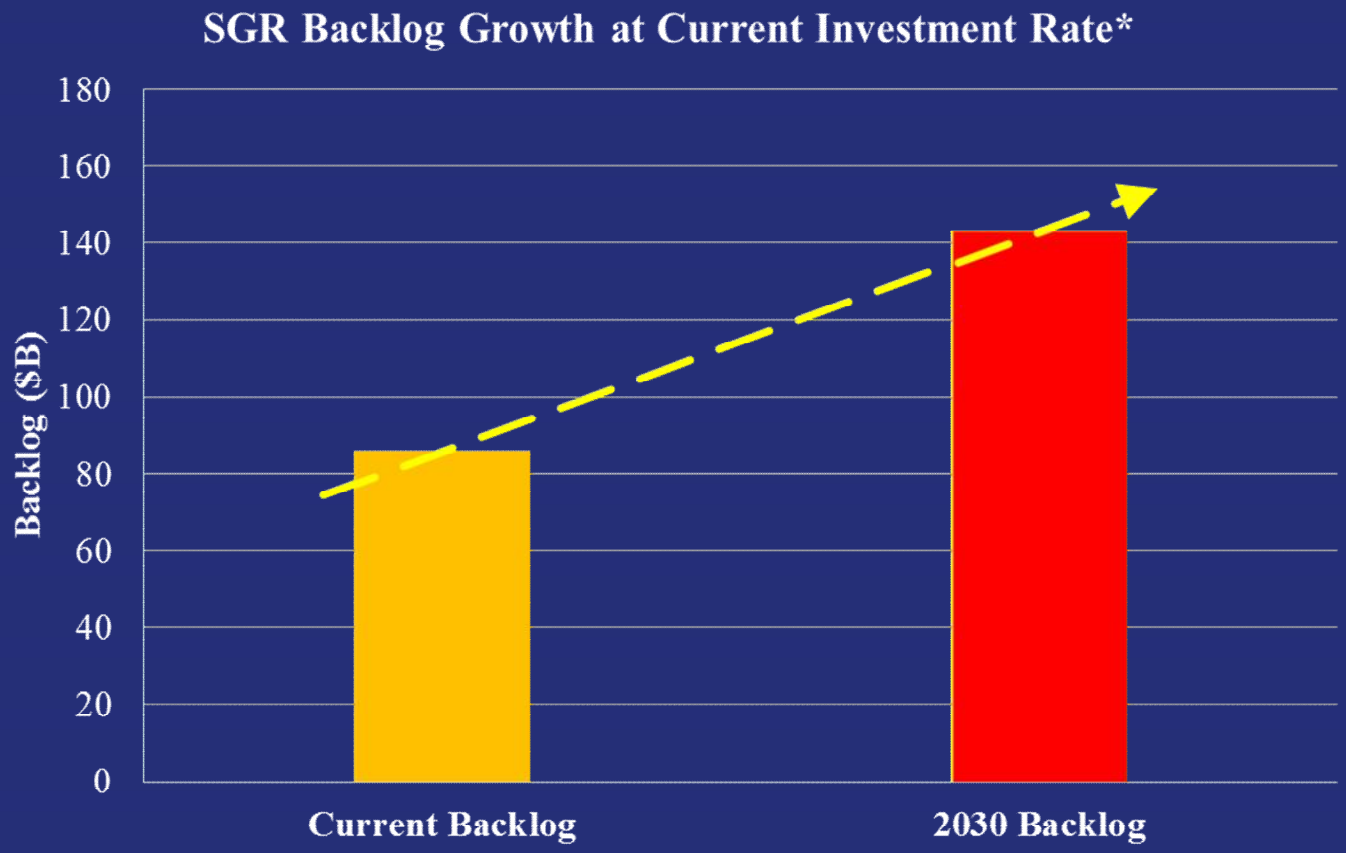
Why We are Talking about SGR

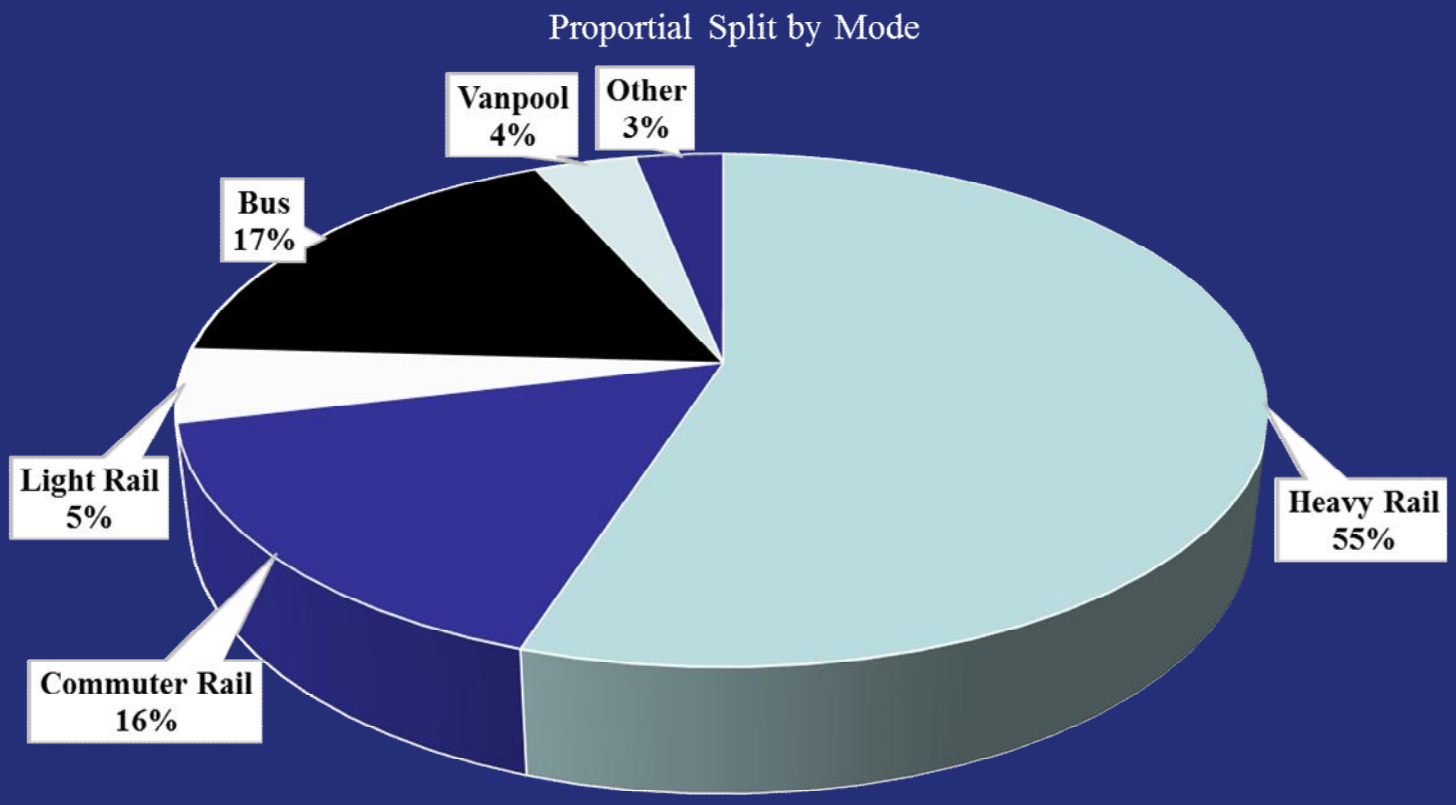


** Based on FTA statistics in 2014.*

Funding Needed

- Current funding projects an added $8.2B / year shortfall to eliminate backlog by year 2030
- $18.5B / year needed
- Every year funding is less, increases time to eliminate backlog
- Funding at current levels results in annual backlog growth.
- **One third of transit assets are in marginal or poor state of repair AND track and structures classified as the asset type with the largest total value of marginal to poor assets.**

Modal Split in SGR Needs



** Based on FTA statistics in 2010.*

National Transit Asset Management System

- Provides grants to finance capital projects to maintain public transportation systems in a state of good repair.
  - $2.1B FY2013
  - $2.2B FY2014
- Define State of Good Repair including objectives and ways to measure / assess asset conditions
- Establish SGR performance measures and targets
- Develop Transit Asset Management Plan and an Accountable Executive
- Report NTD data on asset inventories and assessed condition of assets.

State of Good Repair

- "*The condition in which a capital asset is able to operate at a full level of performance.*"
- Broadly defined sliding scale or metric range (0-100, e.g.)
- No penalty for missing goals or rewards for making them, at least for now.

Applicability - Tiered Approach
Building a Transit Asset Management Plan

- Tier – I (Operates rail or 100 revenue vehicles)
  - Inventory of capital assets
  - Assessment of asset condition
  - Tools to assess condition and predict actions
  - Prioritization based on investment outlook
  - Policies for development of Transit Asset Management and State of Good Repair
  - Annual activities planned for SGR
  - Resources needed to maintain assets
  - Evaluation plan

Asset Categorization

Top tier	Fleet	Facilities	Rail Guideway	Systems	Stations
Second tier	revenue coaches	Property (rail repair facility)	line	signaling	**A particular station**
Third tier	All coaches within a production group	building (service building)	tracks	audible	**escalator**
Fourth tier	individual coach	roofs	Rail / wheel	relay	**escalator motor**
Fifth tier, etc.	**Vehicle components (e.g., engine Cummins ISB)**	**adhesive system**	**Linear (station 02 to 03)**		

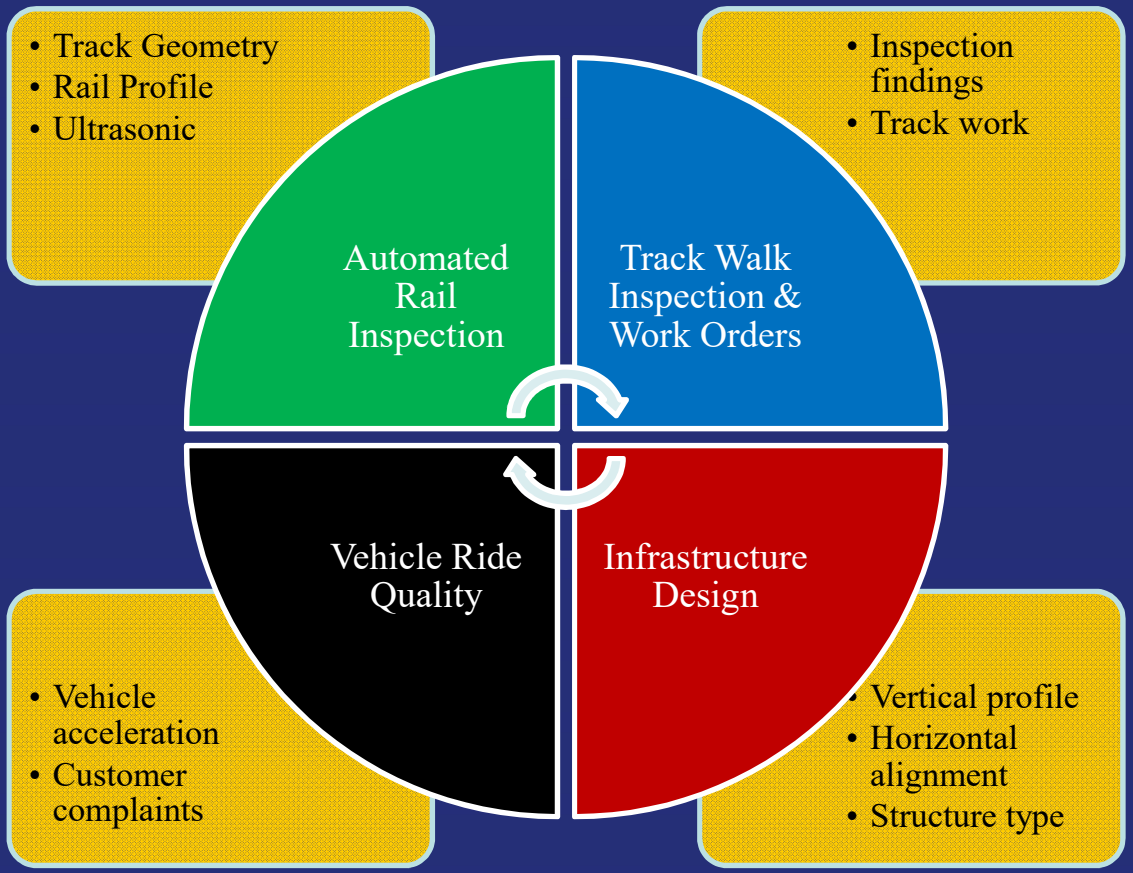
Track segment defined by milepost, varying length, track feature, related wayside infrastructure, tonnage, vehicle use, etc.

SGR Approaches for Asset Assessment

Performance Measures

- Maintenance cost per vehicle mile
- Percent of useful life
- Mean distance between failure
- On-time performance and capacity
- Customer service
- Noise and vibration / ride quality
- Asset condition and priority code
- Quantitative condition rating system
- Continuous Quality Improvement

Example: Wealth of Track Data



Integrated Data is Key

- Integration of data is needed to help answer key questions from disparate data systems and to make decisions on needed actions. For example:
  - Replacement and work history
  - Rail head wear rate
  - Gage variation
  - Conicity
  - What work can be done while addressing other issues to improve efficiency and reduce costs?
- Many agencies developing or installing data integration technologies

Data Analysis Capabilities - Example

- Run-on-run automated rail inspection comparisons
  - Match data sets using feature identification algorithm to locate by position
  - Develop data filtering approach to smooth data to an appropriate level of fidelity, such as moving average (boxcar filter) of adjustable temporal scale
- Compute arithmetical difference between runs and examine rate of deterioration using an exponential decay $e^{-\lambda t}$
  - Correlate changes in rail and likely effect on wheel profile, ride quality and wear

Assessing SGR beyond Simple Age or Distance Metrics

- FTA proposes use of age to assess SGR
- Consider risk-based approach applied to safety, maintenance costs, passenger service, etc.
- Use of failure rates and MTTF

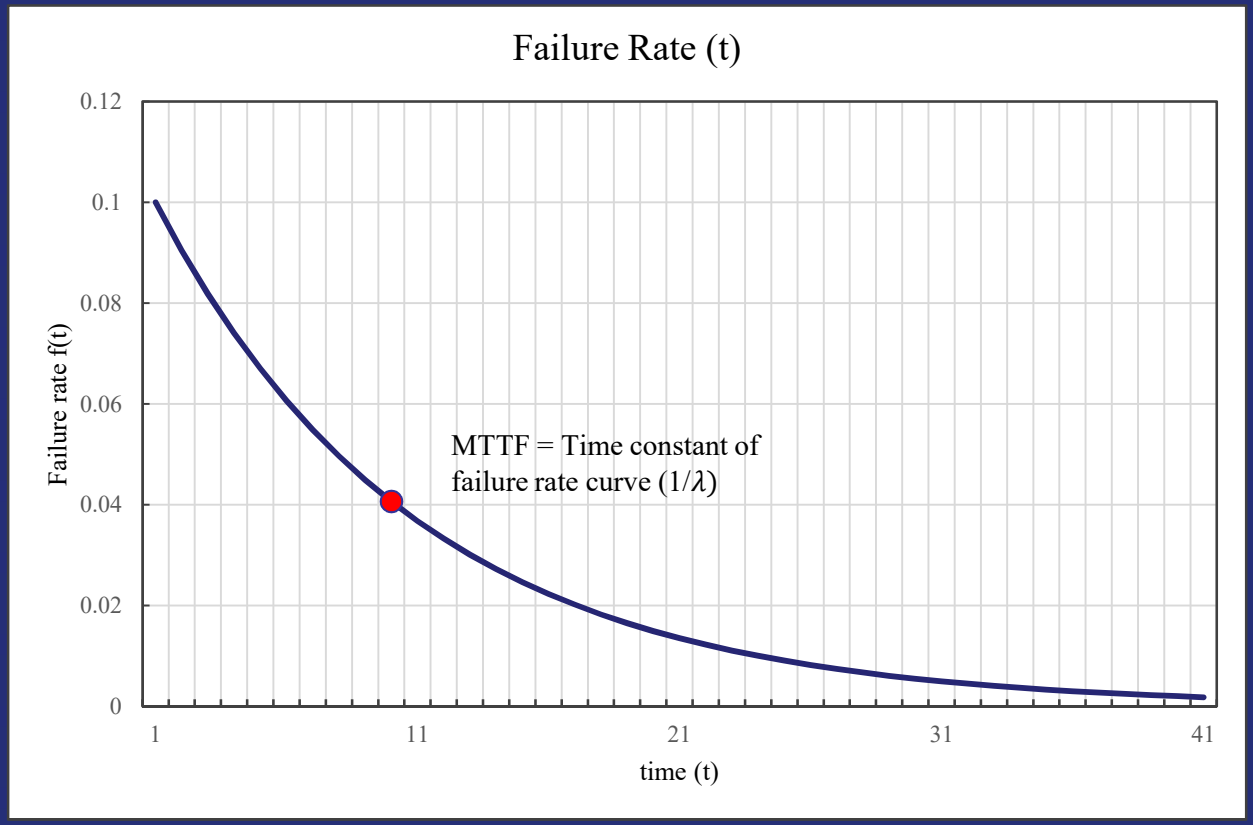
SGR Metrics

- Keeping trains running
  - Probability that x number of cars fail on the same day. Think of door problems, propulsion problems.
  - Probability that one of your track segments experiences a broken rail, or kinked rail.
  - Probability of requiring wheel maintenance to prevent hollow wheel and or unsafe equivalent conicity.

Failure Rate

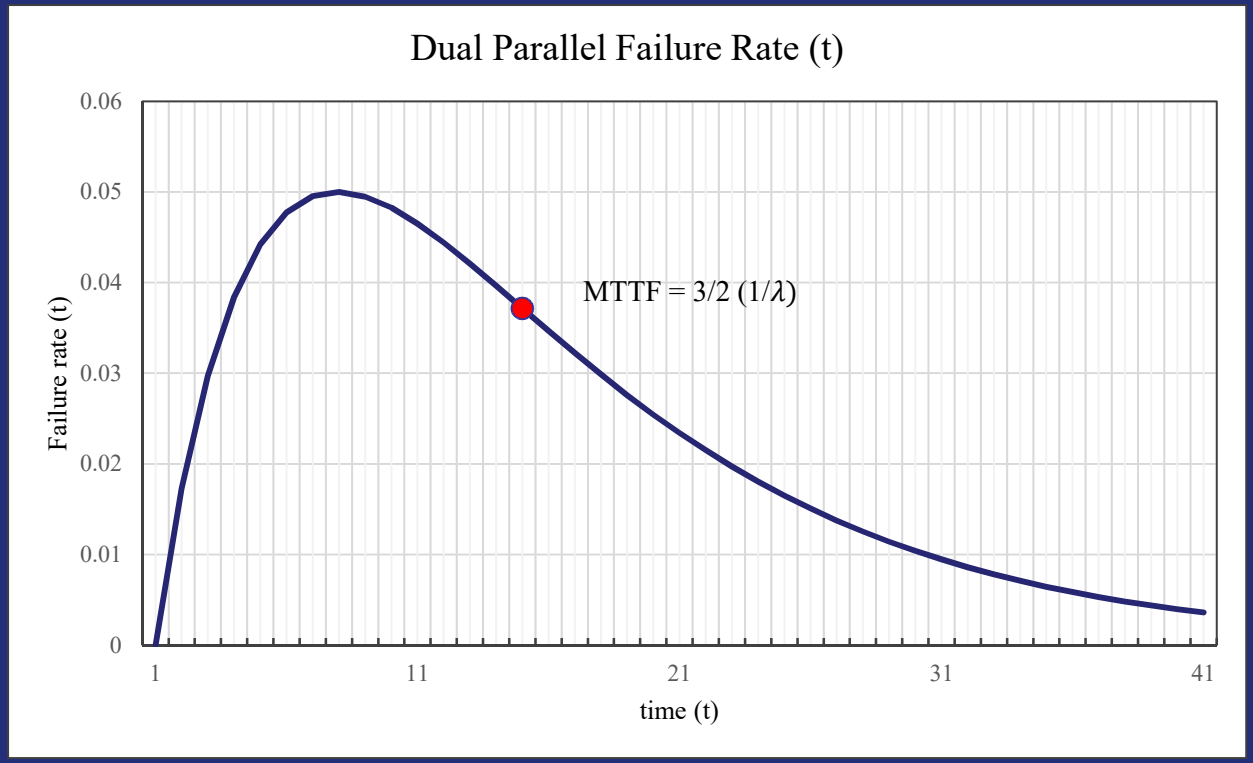
- $f(t) = \lambda e^{-\lambda t}$ (simple constant failure rate)
- MTTF $\approx \frac{1}{\lambda}$; time constant

Failure Rate and MTTF
Simple Failure



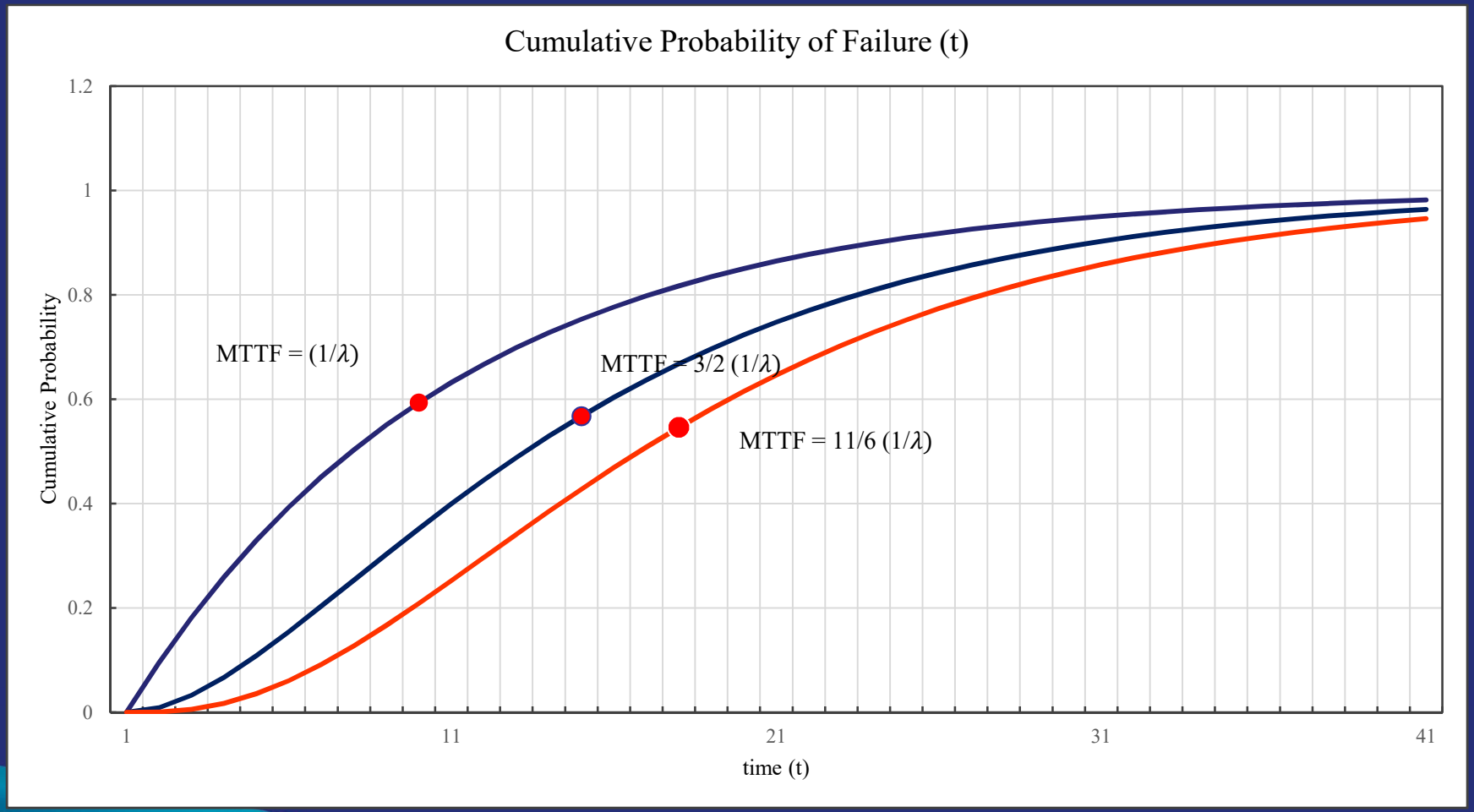
If you are basing your maintenance on time or distance, you are assuming some level of failure rate risk.

Failure Rate and MTTF
Two Parallel Failures



Higher number of parallel components produces lower MTTF proportional to a simple harmonic series. (3 = 11/6, 4= 25/12, 5 =21/10, etc.

Cumulative Probability of Failure



Underpinnings of Time and Distance-based Maintenance Plans

- Failure rates (measures of reliability) can be useful tools to analyze series and parallel failure conditions.
- Sophisticated analysis tools are available to manage risk assessments.
- Challenge in defining the level of granularity applied to assets.
- What is an asset?

Conclusions

- SGR is a big issue and will be a focus of our attention for the foreseeable future.
- U.S. FTA providing significant funding for improving SGR but to get this money, transit agencies (all light rail agencies) will need to develop a Transit Asset Management plan. (Tier-I).
- FTA SGR definition is broad and does not reward or penalize for making or missing targets – at this time.
- Age- and time-based metrics may be insufficient to assess SGR.
- Data collection, data interrogation and database management will be key in managing any type of SGR.
- Methods available for interrogating inspection data for rail and wheel as well as monitoring vehicle performance, etc.

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