

The *Life & Times* of PTC

NTSB's PTC Conference

March 2, 2005

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Ron Lindsey

Positive Train Control

a means to prevent accidents
due to train crew errors

OBJECTIVE

Provide a common threshold of understanding of Positive Train Control

What It Is

What it isn't

The opportunities for deployment

The considerations of deployment

AGENDA

Housekeeping

The Life of PTC

The Times of PTC

Thoughts & Recommendations

Primary Definitions

Movement Authority: the permission to occupy a portion of track as to TIME / DISTANCE / SPEED.

WHY ?

Vital Process: a process that generates movement authorities (fail safe perspective).

Safety Critical Process: a process that directly supports vital processes.

VITAL'S VANITY

- Demanding regulation
- Demanding system design
- Demanding maintenance
- Demanding hypocrisy (explained later)

Traffic Control

the fashion in which movement authorities are generated and delivered. The *vitality* of railroad operations.

Traffic Management

the fashion in which traffic control is managed to meet the operating requirements (e.g., density, traffic mixture, efficiencies, etc.)

Train Control

the handling of the train in accordance with the movement authorities provided.

TC vs. TM vs. TC

	Authorities	Purpose	Player	Benefits
Traffic Control	Generates	Prevent dispatcher errors	Vital Logic	Safety

TC vs. TM vs. TC

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Traffic Control	Generates	Prevent dispatcher errors	Vital Logic	Safety
Traffic Mgmt.	Manages	Meet Operating Requirements	Dispatching Operation	Business

TC vs. TM vs. TC

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Train Control	Uses	Prevent crew errors	Crew	Safety

TC vs. TM vs. TC

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Primary Traffic Control Types: North America

Signaled Territory: a method of traffic control in which movement authorities are automatically generated and presented to the train crews via wayside or on-board signals.
(a RR's automatic traffic lights – beyond the control of the dispatcher)

Non Signaled Territory (a.k.a. Dark): a method of traffic control in which movement authorities are generated by the dispatcher via manual or computerized processes and delivered to the train crew.
(50% of U.S. trackage is dark, albeit a smaller % of traffic)

The *Sanity* of Dark Territory

	SIGNALED	DARK
Train Location known	By Block	NO
Authority Generation	Vital Infrastructure	Train Sheet / Computer Matrix
Transmission of Authority	Signals	Voice Radio
Switch Position	Known	Unknown
Broken Rail Protection	YES	NO
SAFE OPERATION ?	YES	YES

Drives European Suppliers Crazy: closer headways, passenger service, vital/vital/vital

What's Vital in Dark Territory ?

Signal folks declare that nothing is vital in dark territory. They're thinking equipment, and not functionality.

The train sheets and computerized conflict checkers provide the vitality: **totally simplistic compared to signaled vitality**

and yet, the ultimate traffic control system is dark territory gone postal . . .

Moving Block

. . . a sophisticated, dynamic conflict checking system, a.k.a. *Vital Office*

It provides the continuous, automatic advancement of movement authorities from the dispatching office based upon the input of the train's position and braking characteristics relative to possible points of conflict.

(not yet deployed in North American freight railroads)

The Teddy Bears

- “We run a **scheduled railroad**”
- Must have **Zero tolerance** for potentially unsafe operations
- Signaling systems are primarily deployed for **safety** purposes
- Everything is **vital** ... except perhaps dark territory
- PTC will provide for more effective **traffic management**
- A RR’s **Train Control Department** deals with train control
- Traditional dispatching systems (a.k.a. **CAD**) are designed to manage the railroad’s operation



The Teddy Bears: continued

- Railroads require **moving block**.
- Railroads need **real time data** to manage their operations.
- The RRs' **VHF** (voice radio) network is saturated – more spectrum is required.
- Railroads, singularly and collectively, have **technology strategies**.
- Just get me through the **next few years**, then it will be someone else's problem.



The Life of PTC

Why PTC

What PTC Is

What PTC Isn't

TRAIN ACCIDENTS: Sources & Mitigation

Equipment or infrastructure fails	Proper Maintenance
Train improperly handled	Engineer Training
Movement authorities are improperly generated and/or provided to the train crew	Vital Infrastructure & Logic
Movement authorities are exceeded as to speed / distance / time	

Defining PTC

Railroad Safety Advisory Committee (RSAC)

**A consensus approach to formulating regulations:
FRA, Labor, RR's, & Suppliers**

1997: RSAC-PTC

**Defined the core objectives of PTC and
performed a safety benefits business
case analysis for PTC**

PTC Definition

A system that prevents train crews from exceeding their authorities by providing *enforcement* ... so as to

1. Prevent train-to-train collisions

a.k.a. positive train separation (PTS)

2. Keep trains from over-speeding

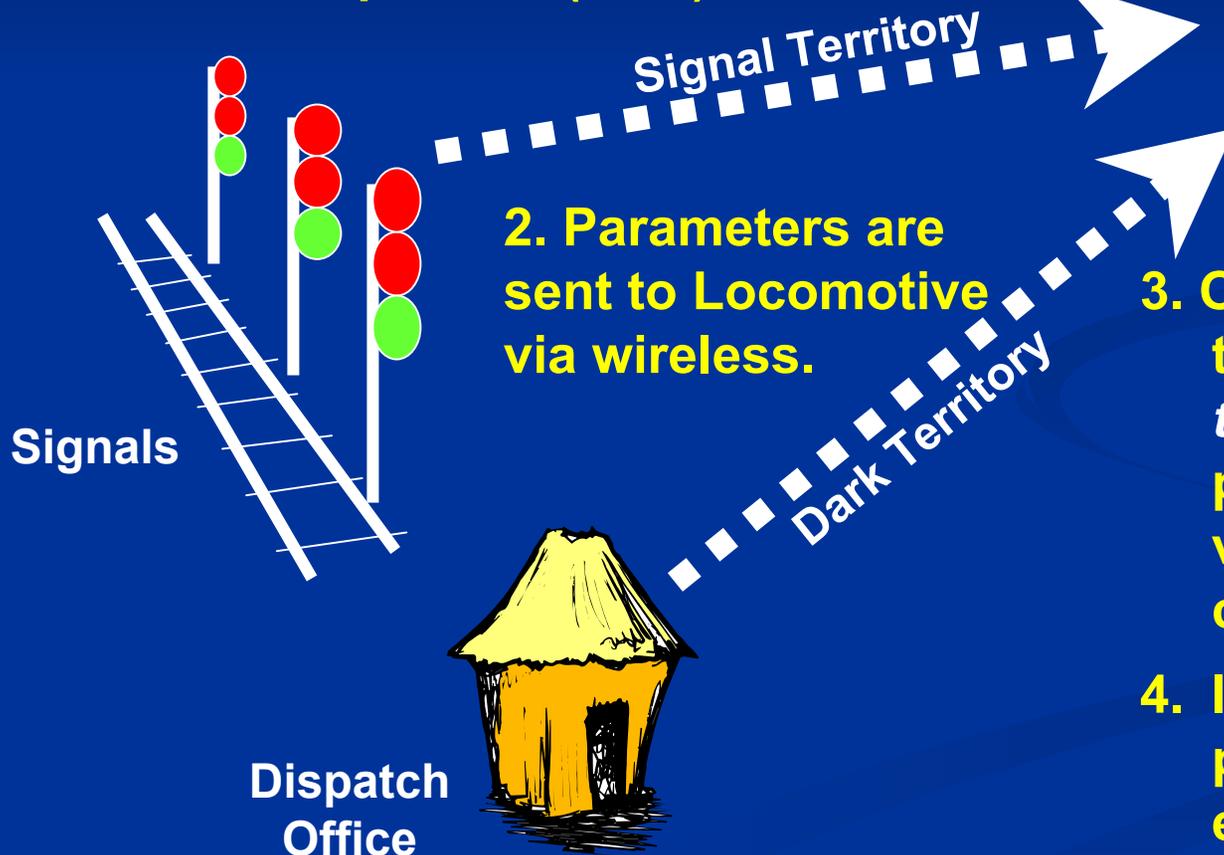
3. Protect work zones

The
Core
Objectives

However, no quantification of objectives, e.g., how much protection.

How PTC Works

1. Authorities are generated by traffic control equipment at the wayside (signaled) or via the dispatcher (dark).



2. Parameters are sent to Locomotive via wireless.

3. On-board PTC monitors train's compliance to *targets* to detect potential authority violations and alert crew
4. If alerts not handled properly, then enforcement is made to avoid likely violation²².

Enforcement Platforms

- **PTC:** Authority generation & enforcement makes no changes to vital processes
a.k.a. Overlap


Referred to as
Vital PTC in
this conference

Major
Source of
Confusion
- **PTC + Vital:** Authority generation & enforcement changes the vital processes
e.g., Precision Train Control™ (PTC™)
- **ALERT:** no authority knowledge
a.k.a. Proximity Warning System

Functionality by Platform

Core Objectives



Train-to-train collisions within authority

Speed restrictions

Work gang within authority

Proximity warning

Generate authority

ALERT	PTC a.k.a. Overlay	PTC + VITAL

NO

SOME

YES

Functionality by Platform

Core Objectives



- Train-to-train collisions within authority
- Speed restrictions
- Work gang within authority
- Proximity warning
- Generate authority

	ALERT	PTC a.k.a. Overlay	PTC + VITAL
Train-to-train collisions within authority	NO	NO	NO
Speed restrictions	SOME	NO	NO
Work gang within authority	NO	NO	NO
Proximity warning	YES	NO	NO
Generate authority	NO	NO	NO

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SOME

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Functionality by Platform

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Proximity warning	YES	NO	NO
Generate authority	NO	NO	VITAL

NO

SOME

YES

Safety Benefit Analysis

- Accident Review Team (ART) of RSAC-PTC reviewed 25,000 accidents
- Determined whether each one was a PTC Preventable Accident (PPA) based upon 4 different levels of safety enhancement platforms.
- The costs of PPA's were then accumulated by type of platform and compared to the cost to deploy each type of enforcement nation-wide.

CONCLUSION: None of the Platforms were justified on safety benefits.

NO IT U LOVE

PTC is the result of reversed evolution ... and that's good

- From Visionary to Responsible
- From Complex to Pragmatic
- From Vital to Non-Vital
- From Cost Prohibitive to Financially Possible
(a business / technology strategy permitting as discussed later)

PTC Design Issues

- Enforcement Accuracy: too soon vs. too late
- If PTC not available, then current operating rules and vitality remain
- Incorporate standards to the extent possible
(discussion on *Interoperability & Interchangeability* later)
- Minimize on-board cost given 20,000 multiplier
(every \$10,000 can be \$20 million for the industry)
- Management Oversight to prevent crews from *running the alerts*
- No Increase in Risk: where risk is defined as *severity multiplied by the likelihood of the train being coincident in time and space with an unsafe condition*

RISK ASSESSMENT

Axiomatic Safety Critical Assessment Process (ASCAP)

A clever and appropriate simulation model that *runs trains* over a particular territory to generate fail-unsafe occurrences. It determines *relative*, not absolute, risk of various platforms.

HOWEVER, ASCAP has failed to meet the expectations of key players: railroads, labor, suppliers and FRA. The scope increased constantly, and it directly attacked the well-entrenched, if not sacred, risk assessment processes of traditional suppliers.

What PTC doesn't include

- **The generation of movement authorities**
Traffic control systems do that
- **The handling of dispatcher activities**
Dispatching's Traffic Management systems (?) do that
- **The tracking of trains**
In-bound communication systems provide that
- **Grade crossing monitoring and enforcement**
Considered inappropriate for freight operations
- **The monitoring of on-board / wayside equipment**
Health monitoring systems provide that

Other Descriptions

FRA

“PTC systems issue movement authorities to train and maintenance-of-way crews, track the location of the trains and maintenance-of-way vehicles, have the ability to automatically enforce movement authorities, and continually update operating data systems with information on the location of trains, locomotives, cars, and crews.”

[FRA's Website](#)

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[FRA's Website](#)

NTSB, 1996

“...(PTC) has advantages beyond safety that should be considered: Increase in rail line efficiency and utilization, savings in fuel use, reduced wear and tear on equipment through train pacing.”

NTSB's Testimony, 3/27/96, to Subcommittee on Railroads

NTSB: NOW

“Prevent train collisions and over-speed accidents by requiring automatic control systems to override mistakes by human operators.”

NTSB's Website

Missed the *work zone* objective
Only listed passenger-related efforts

ZetaTech's 4/13/04 presentation of

**"Quantification of the Business Benefits of Positive Train Control"
a report commissioned by Congress via FRA**

PTC: What does it do?

1. management of track occupancies through centralized route and block interlocking logic
2. issuance of movement authorities via the data link to equipped trains and work vehicles
3. tracking of equipped train location and track occupancies via data link
4. speed enforcement for equipped trains
5. pacing for fuel economy for equipped trains
6. monitoring and control of wayside systems
7. reporting of equipped train diagnostics and operating parameters
8. general exchange of instructions and messages

Only 1 of the 8 “do’s” is correct

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PTC: What does it do?

1. management of train
centralized
2. is

Totally Missed 2 Core Objectives

1. Keep trains from hitting trains
2. Protect workers in work zones
from train crew errors

systems
diagnostics and
exchange of instructions and messages

Why the Confusion?

- Increasing influence
- 
- Traffic control systems for passenger service often employ a form of automatic train control.
 - Freight's signaling systems and the associated workers are often referred to with *Train Control* phraseology, and not that of *Traffic Control*.
 - Earlier PTC-related systems (now defunct) that provided both traffic and train control were referred to generically as *Advanced Train Control Systems*.
 - UP's now defunct *Precision Train Control*™ (PTC™) included both traffic and train control and set precedence for acronym.

But, the most likely reason is . . .

A well-intentioned, but overly- simplistic appreciation of Wireless Data

Running a RR is about **managing assets**

The more **timely** the **status data** are, the better the assets can be managed

The majority of assets are remote or **mobile** ... and therefore inaccessible by wire

Hence, **wireless** communications is required to obtain the data

“Quantification of the Business Benefits of ~~Positive Train Control~~”

WIRELESS DATA

PTC: What does it do?

1. management of track occupancies through centralized route and block interlocking
2. issuance of movement authorities to equipped trains and work trains
3. tracking of equipment location and track occupancy
4. fuel economy for equipped trains
5. monitoring and control of wayside systems
7. reporting of equipped train diagnostics and operating parameters
8. general exchange of instructions and messages

a constant referral to REAL TIME data

In fact ...

Most, if not all, of the BUSINESS benefits so far associated with PTC are due to the availability of wireless data

... and not due to the functionality of PTC

But then they say ...

If PTC uses wireless and sends in position reports, then that same data and path can be used for traffic and asset management benefits .

VOILA! a free ride for business benefits ... that should therefore be included in PTC pursuits

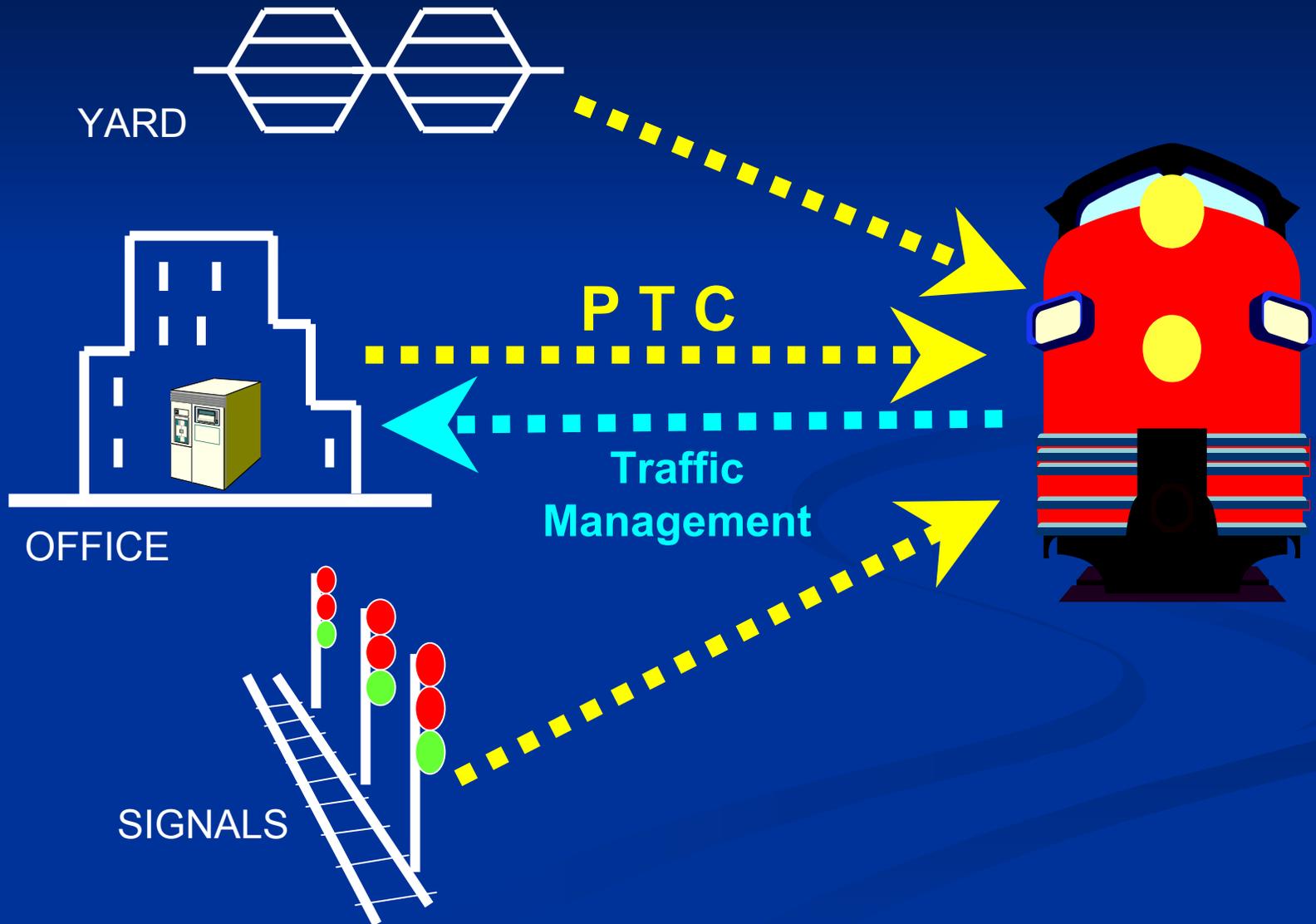
Whoooooaaa!!!!!!

1. PTC only requires movement authority parameters (a.k.a. **targets**) being provided on-board (outbound messages to locomotive). **PTC has no requirement to send data back to office ... or elsewhere.**

whereas ...

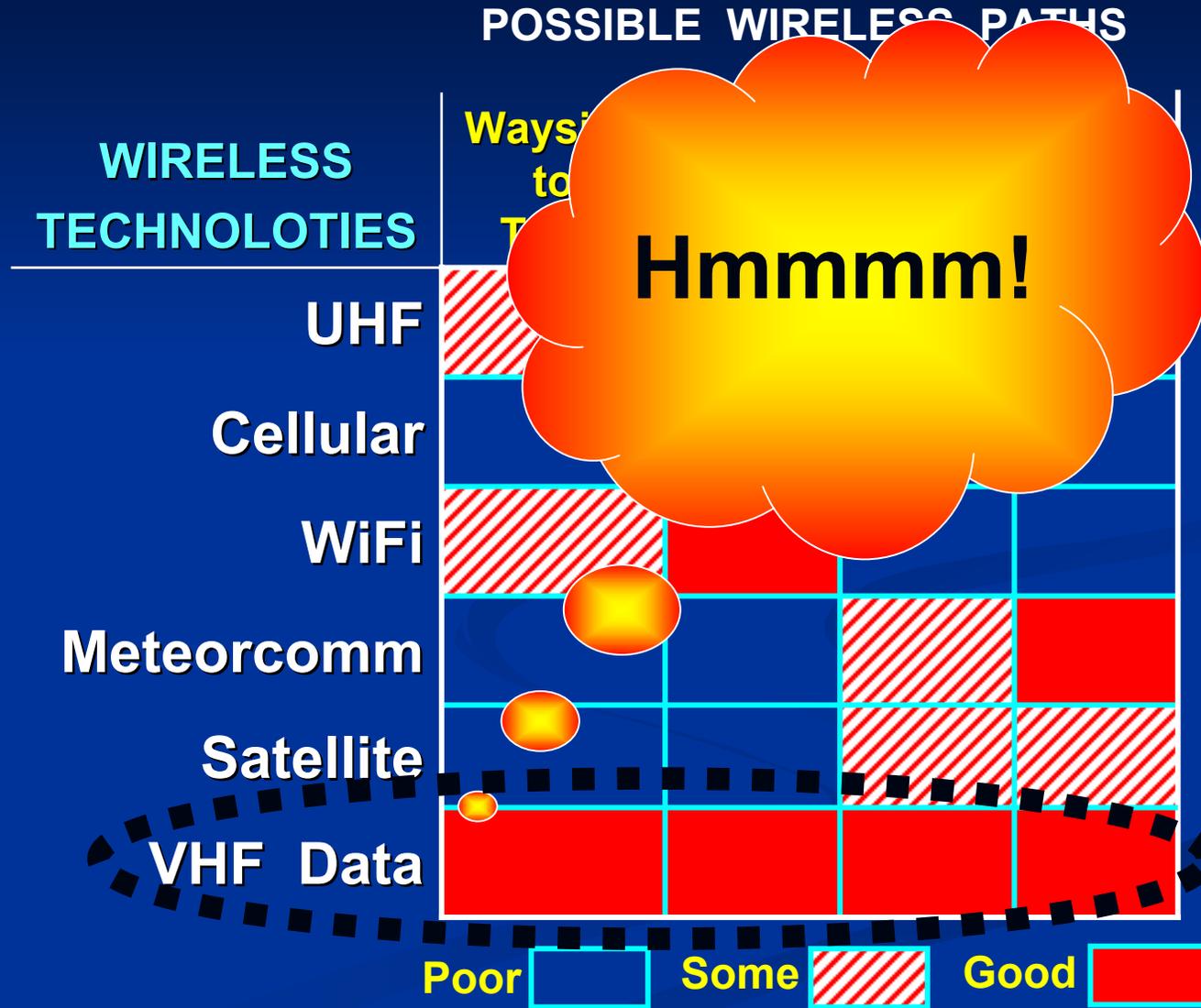
2. Traffic and asset management functionality only requires data to be sent to the office on a timely basis.

PTC vs. Traffic Management



Whoooooaaaaa!!!!!!: continued

3. Wireless technologies differ substantially from each other, unlike wired technologies. Hence, a technology good for PTC may not be appropriate for asset management ... or visa versa



Primary Radio Requirements

Yard Voice

large # channels in small area

Main Line Voice

few # channels in large area

Yard/Main Line Data

Current VHF Allocation

Railroad's VHF Spectrum for Voice Traffic



Major Metropolises



Most Mainline



Wasted Spectrum

No VHF Spectrum for Data Across the Industry

KEY

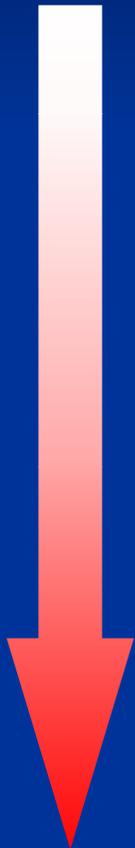
Yard
Voice

Road
Voice

DATA

DE-FRAGGING VHF

Consolidate Users into a Uniform Allocation of *Spectrum Blocks*



Yard Voice

Main Line Voice

Yard/Main Line Data

Defragged VHF

BENEFITS

- Maintain maximum use of current analog equipment
- Minimal expenditure for digital technologies, e.g., APCO 25
- Minimal expenditure for RR-wide data network
- Pursue synergies for industry-shared infrastructure

REQUIRES INDUSTRY DIRECTIVE

Whoooooaaa!!!!!!: continued

- 4. Traffic management requires a modicum of position and time and not always via wireless

Hmmmm!

Survey says ...

	NON SCHEDULED	SCHEDULED
DARK	15 minutes	5 minutes
SIGNALLED	5 minutes	OS reports

All railroads claim to have schedules

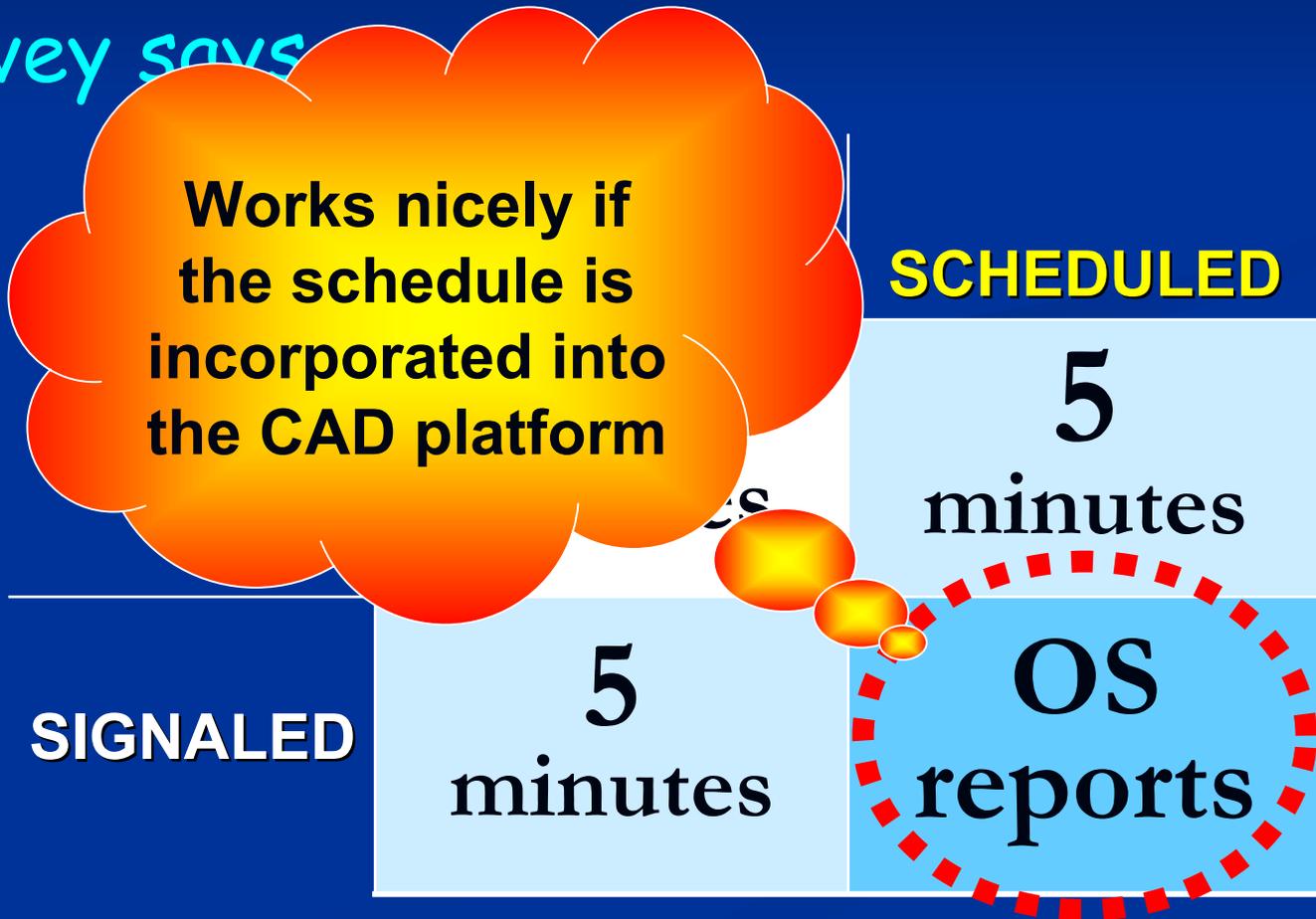
But, less than 50% of such operations are truly adhered to.

TRULY SCHEDULED is when some *significant level of analysis* has been made to allocate and balance key operating assets with a resulting schedule mandated and *actually adhered to*.

Whoooooaaaaa!!!!!!: continued

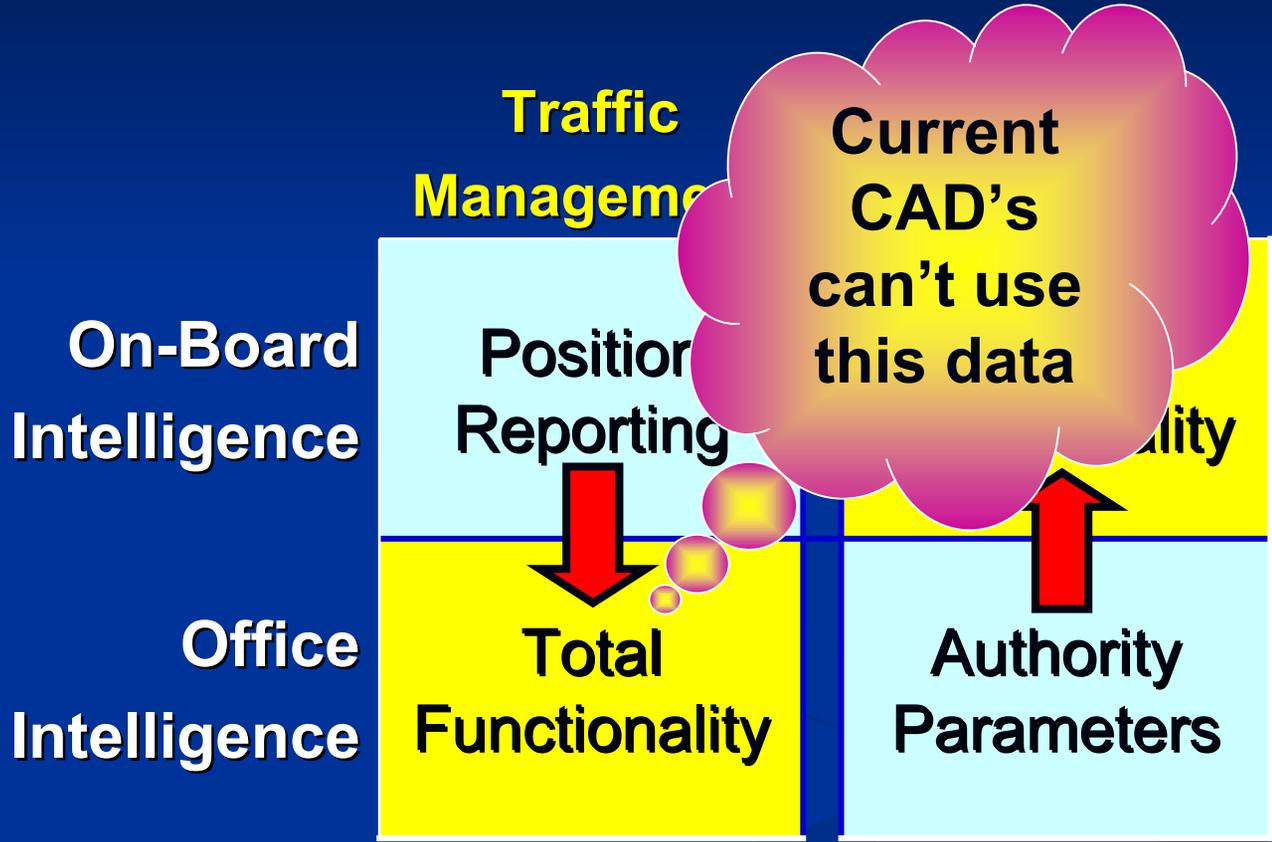
- 4. Traffic management requires only a modicum of position and speed data ... and not always via wireless.

Survey says



Whoooooaaaaa!!!!!!: continued

5. Even if the data was available, the back office systems to use them don't exist ... and such systems would not be the same as that required by PTC



current Traffic Management

- **Reactive, crisis-based**
- **Train Position known to a limited extent**
- **Train speed not known**
- **Crude dispatcher display schematic:**
 - designed to handle infrastructure – not manage trains effectively
- **Meet / Pass are simple priority-based**
 - dispatchers left to develop their own “picture”

PTC vs. TM Implementation Costs

	<u>P T C</u>	<u>Traffic Mgmt.</u>
On-board Module	✓	
Back Office System		✓
Infrastructure Equipment	✓	
Wireless Communications	✓	✓

Wireless is only part of the cost to implement
PTC or Traffic Management Improvements

But, can it be shared ?

Whoooooaaaaa!!!!!!: continued

- 6.** If wireless could be shared, then who should pay for it.

PTC provides platform for business

... or ...

Business provides platform for PTC

... or ...

They each do their own thing

... or ...

a strategic platform that encompasses both

... hold that thought

The Times of PTC

Opportunities

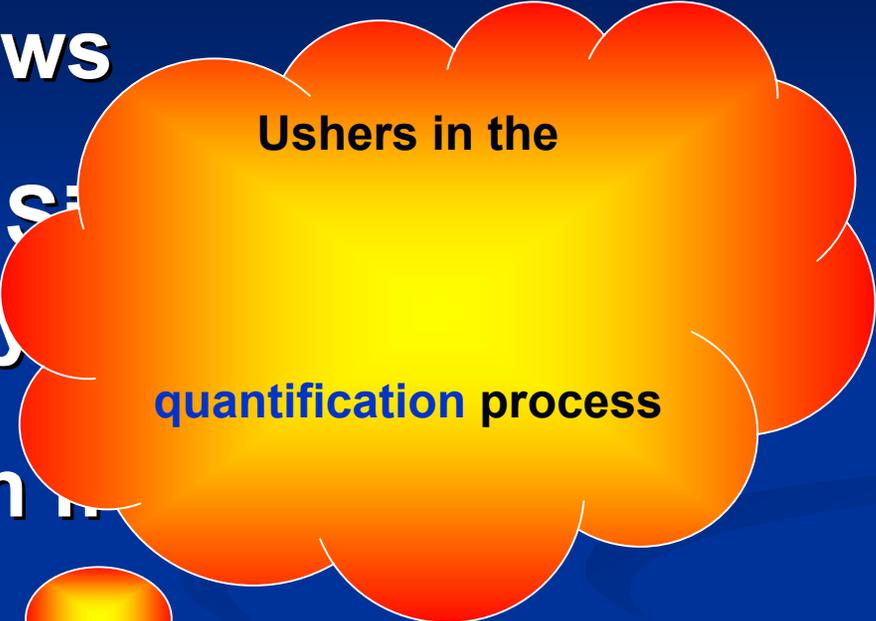
Considerations

PTC- based Opportunities

- One Person Crews

- Transition from Staffed
Dark Territory

- Throwing switch in



Ushers in the
quantification process

- Achievable without PTC functionality.
- However, PTC can be a source or risk reduction to compensate for a perceived or real increase in risk.

Government-infused Opportunities

■ FRA Regulation

RSAC Safety Benefits Case came up short

■ Domestic security

Tracking, monitoring, and detecting may provide for the infrastructure, e.g., switch position / container

■ Congressional Mandate

What would it take ?

or, the Regulator that isn't here

FCC's VHF Refarming

- The sleeping giant rulemaking that reconfigures the channel / frequency allocation; a 4-fold increase
- Railroad's and other industries have been avoiding the inevitable – the switch to a digital platform
- Timeframe is closing in - 2013
- Will require \$1Billion investment by the industry
- Railroads, neither individually nor collectively, are known to have given serious consideration to this
- **Changes the business plan from ROI to mandatory**

Roadblock ... or ... Opportunity?

THE Opportunity Exists

With Restructured VHF & 2013 alone,
without consideration of leading technologies and other
current infrastructure (UHF / commercial services)

RR's can achieve the ultimate, industry-
wide, comprehensive wireless
infrastructure that will address the critical
operating requirements, i.e.,

The CAN BE Railroad

The *CAN BE* Railroad

- A new approach to Traffic Management
- Asset Tracking
- Infrastructure Monitoring
- Incorporating individual applications that cannot support their own technology infrastructure.

As such, I believe the ROI of delivering the CAN BE railroad will well exceed the cost of making the inevitable transition in VHF now ... instead of waiting until 2013

HOWEVER, one problem



Six IT Decisions Your IT People Shouldn't Make

By Jeanne W. Ross and Peter Weill, Harvard Business Review, November 2002

Traffic Management

Using the train control system in a fashion to meet the railroad's operating objectives, e.g.,

Reactive vs. Proactive

Reactive Traffic Management

- **crisis-based**
- **Train Position known to a limited extent**
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COVERAGE

TIMELINESS

	TRAIN	LINE	DIS PATCHER	SUB- DIVISION	DIVISON	SERVICE LANE	SYSTEM
weekly							capacity planner
2 days				scheduled trains		service planner	
1 day				unscheduled trains		planner	
shift			Line-up				
4 hours	Auto-router						
1 hour	Auto-router						
15 minutes							
real time							

EXECUTION & REPLANNING

FORECASTING & PLANNING

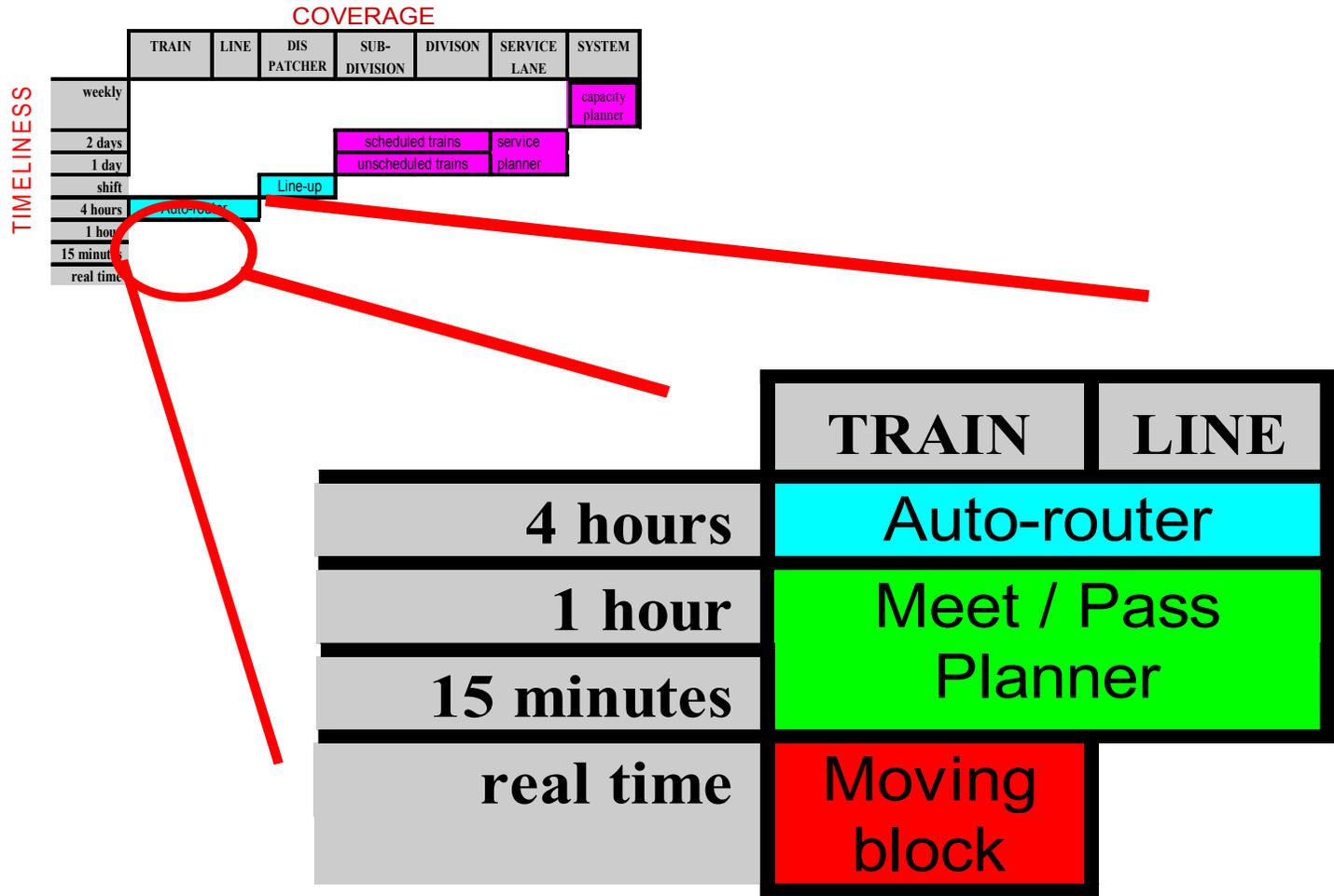
COVERAGE

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shift			Line-up				
4 hours	Auto-router						
1 hour	Auto-router						
15 minutes	Auto-router						
real time	Auto-router						

RE-PLANNING handles
the disruptions that
compromise schedules
... but, the tools and data
don't exist

The Wireless Data Domain



Proactive Traffic Management

generating and delivering
movement authorities in a fashion
to meet the railroads operating
directives ... and also projecting
the future state of the railroad so
as to identify disruptions and
mitigate their effect

Traffic Management Alternatives

REACTIVE

- Current mode
- Disruptions handled as they occur
- Dispatcher's skills determines variables handled
- M/P planners, if any, are priority based (auto-routers)
- Position data only available, by block in signaled territory, nothing in dark territory
- Crude presentation of data

PROACTIVE

- Future mode
- Disruptions are projected and mitigated if not avoided
- Dispatcher has proper re-planning tools
- M/P planners have multiple objective functions
- Accuracy of speed and position data determine effectiveness
- TBD presentation to deal with future state of RR

Related Business Drivers

- Homeland Security monitoring requirements, e.g., switches
- The synergy of communication based applications that cannot afford an individual ROI analysis, e.g., locomotive diagnostics / locomotive tracking / work order –mainline/industrial switching / consist security violations / infrastructure monitoring / coordination with public agencies
- Reduction in commercial communications services
- Integration of substantial UHF infrastructure via new technologies, e.g., software defined radio (SDR)

CONSIDERATIONS

Interoperability

Interchangeability

Risk Assessment

INTEROPERABILITY

Often Stated:

being able to cross railroad boundaries without degradation in functionality

Idealistic, not pragmatic, doesn't consider all financials

Interoperability's Dimensions

ARENAS

Mobile
Wayside
Office

FUNCTIONS

Safety
Train Movement
Business

TECHNOLOGIES

Positioning
Communications
Intelligence



frontline PTC Mobile Interoperability

ARENAS

Mobile

Wayside
Office

FUNCTIONS

Safety

Train Movement
Business

TECHNOLOGIES

**Positioning
Communications
Intelligence**

The Financials the Mobile PTC Platform

FUNCTION: Providing for each railroad's individual functional requirements associated with the PTC platform – may include integrated business (non-safety) functions

OPERATIONS: The effect on a railroad's operations to provide for interoperability

CAPITAL BURDEN: The capital investment to provide for interoperability

Alternative PTC Mobile Platforms

INTERCHANGE

Each RR has its own box
And changes out at
interchange point

Function

Operations

Capital



□ Poor

▨ Some

■ Perfect

Alternative PTC Mobile Platforms

INTERCHANGE

ON-THE-FLY

Each locomotive has multiple units that are switched at interchange points

Function

Operations

Capital

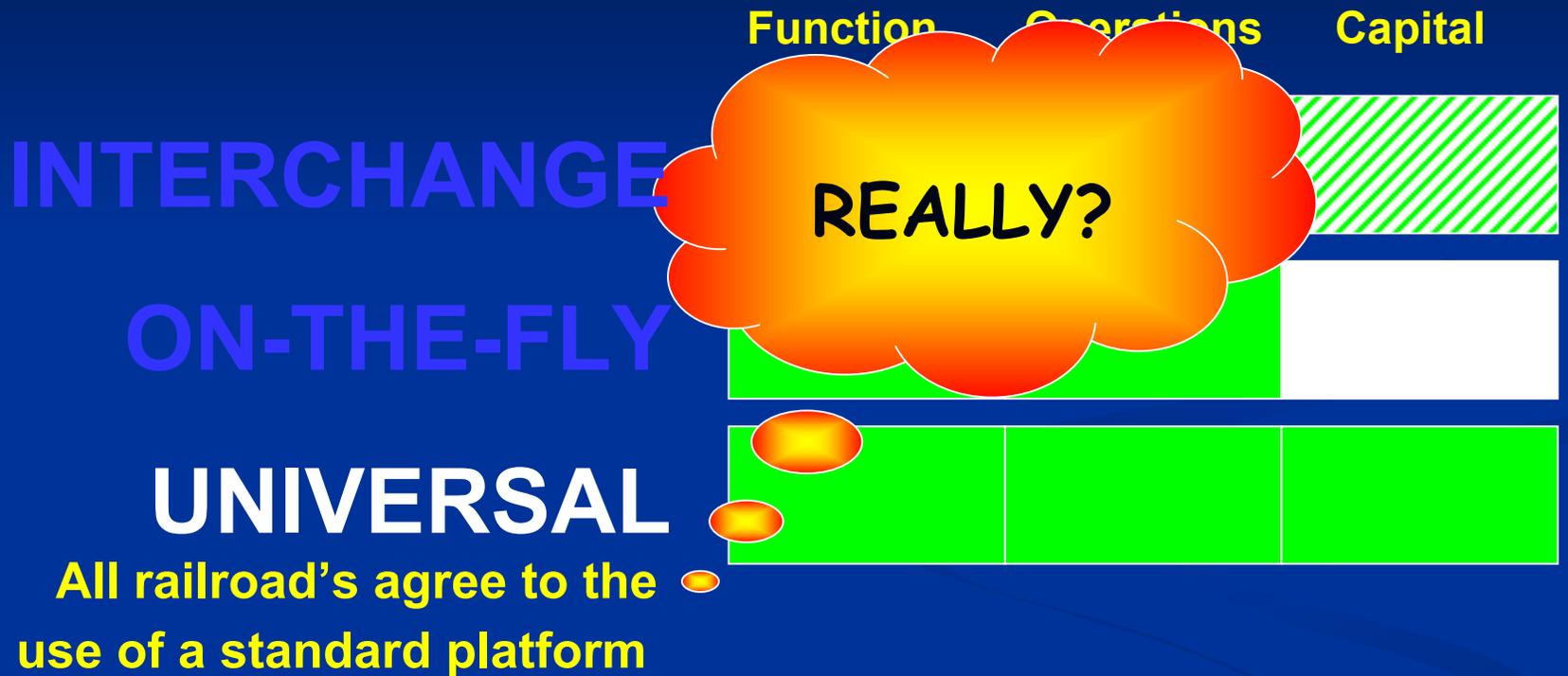


□ Poor

▨ Some

■ Perfect

Alternative PTC Mobile Platforms



□ Poor ▨ Some ■ Perfect

PTC Mobile Platform Standard

East Coast PTC Project

Developed Objected Oriented (O/O) perspective of the on-board requirements and off-board communications, i.e., **isolating dollops of functionality and defining a standard message set between objects.**



Common Fixed / Multiple Variable (CF/MV)

**Since it is unlikely that all railroads will agree
(and comply) with a standard,
then flexibility is required.**

**Maximize the common
elements and provide for the
non-common**

PTC Platform Objects Construct

Core Fixed



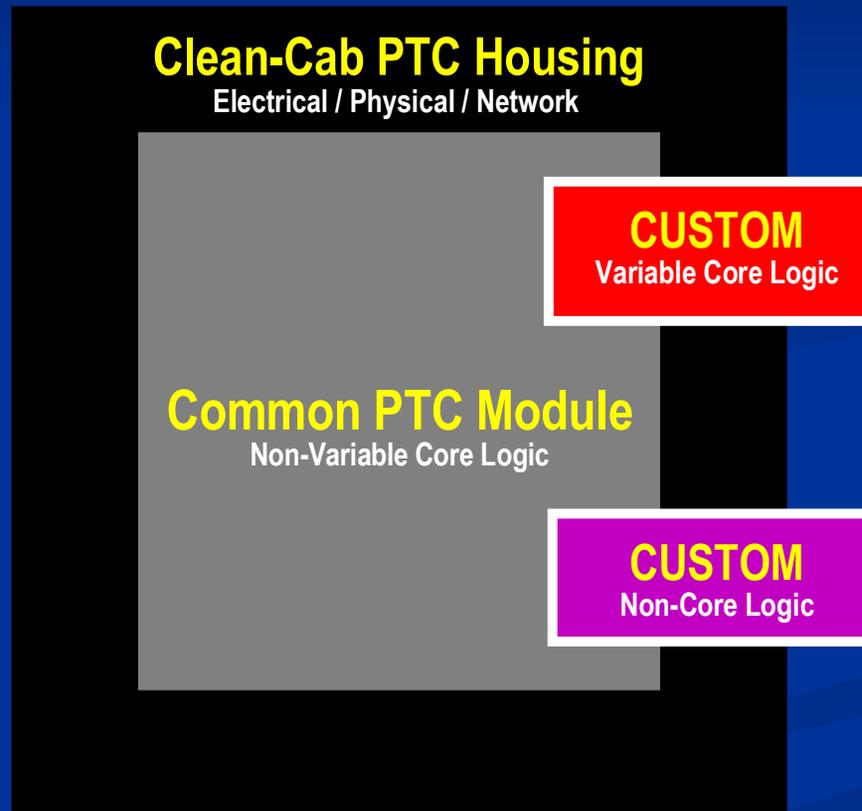
Core Variable



Non Core



Common Fixed / Multiple Variable (CF/MV)



Alternative PTC Mobile Platforms

INTERCHANGE

ON-THE-FLY

UNIFIED

/MV

Function

Operations



Interoperability is more a financial and political issue than it is a technical one



Poor



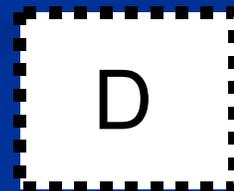
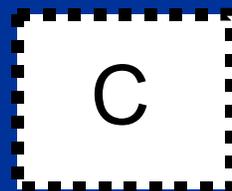
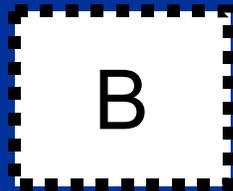
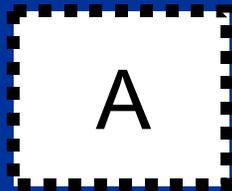
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Perfect

INTERCHANGEABILITY

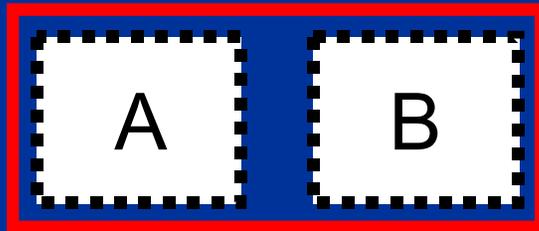
avoiding the economical erosion of Interoperability



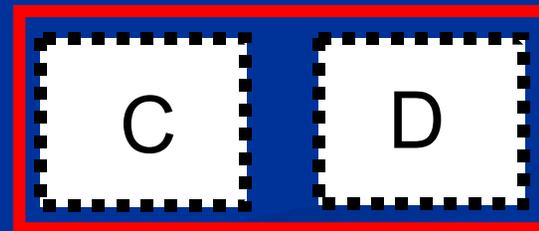
INTERCHANGEABILITY

TWO SUPPLIER APPROACHES

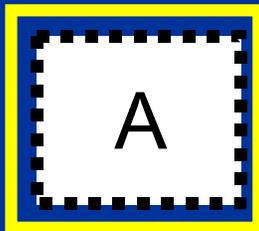
XX1



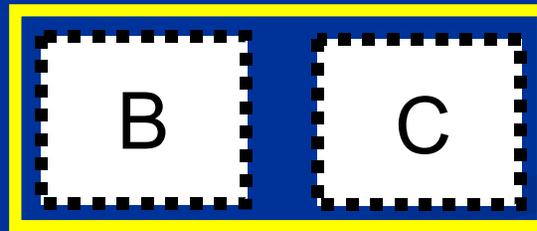
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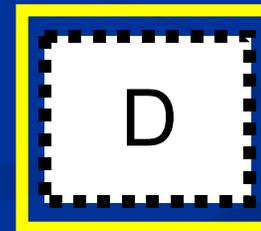
YY1



YY2



YY3



Revisiting Risk Assessment

If crews errors are a leading source for accidents, then systems that mitigate those errors will result in less risk. ... assuming they don't add new sources of risks

Therefore, how complex does Risk Assessment have to be?

ASCAP ignored traditional approaches. However, an O/O approach was introduced in *Full Spectrum*, Vol.28 that is aligned with classic risk analysis processes. It is based on an industry-wide study.

Thoughts & Recommendations

Teddy Bear Bashing

“We run a scheduled railroad”

Less than 50% of Class 1 operations are truly operated to schedule – a schedule that has pre-planned the deployment of all key operating resources.

Zero tolerance for potentially unsafe operations

Risk is an intrinsic characteristic of operations. Zero risk is both financially and functionally unachievable.

Signaling systems are primarily deployed for safety purposes

Signaling systems provide safety, but they are installed for traffic management purposes. They could be removed, safety case permitting, and the railroad could still operate safely.

Everything is vital ... except dark territory

The generation of movement authorities is vital, and that includes manual and computerized train sheets for dark territory operations.



PTC will provide for more effective train movement

PTC does not generate movement authorities, hence it has nothing to do with traffic management directly. In fact, PTC can degrade traffic movement with inappropriate enforcements.

A RR's Train Control department deals with train control

Train Control Departments deal with *traffic* control (excluding cab signaling). Train crews handle train control.



Traditional Dispatching systems (CAD) are designed to manage the railroad's operation

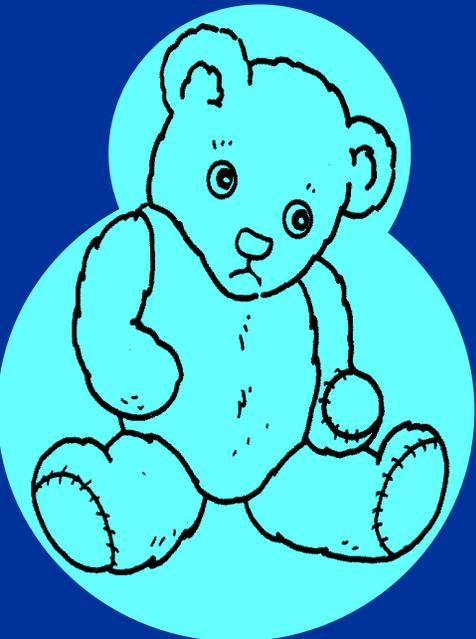
Dispatching systems are designed to operate infrastructure, not to effectively manage the movement of trains. The dispatcher isn't provided the proper data, nor the proper presentation of that data, to effectively manage trains.

Railroads require moving block

Eastern RR's clearly don't, and its not clear the Western RR's could use it that effectively if both the yards and the main line are properly evaluated together.

We need real time data to manage our operations

We need *in-time* data which is critical both financially and technically when dealing with wireless. The current back office systems are not designed to deal with either.



The RR's VHF (voice radio) network is saturated
– more spectrum is required.

The VHF spectrum is only saturated in major metropolitan areas, not along the mainline where it could be used very effectively, that is if we would properly restructure its allocation.

Railroads, singularly and collectively, have technology strategies

Neither the AAR nor any railroad or supplier have a comprehensive technology strategy that is aligned with what a railroad operation “can be” with the use of advanced technologies.

Just get me through the next few years, then it will be someone else’s problem

Railroad and supplier management is not looking functionally or financially beyond the next several years. We continue to rely on technologies and processes from the first half of the last century.



RECOMMENDATIONS: Industry

- Railroads, collectively, need to align their strategic business plan with their strategic technology plan to develop a **Can Be** perspective
- Develop a business case that brings 2013 to the present
- Evaluate & Pursue Defrag VHF
- Develop a technology perspective for positioning and communication technologies, including EGIS
- Fund *real* research on key technology issues: e.g., EGIS, Software Defined Radio, Communication Management Unit.
- **Employ sufficient paid resources – don't depend upon the volunteer efforts in task forces.**

RECOMMENDATIONS: Railroads

- Individual railroads need to align their strategic business plan with a currently non-existing strategic technology plan to develop a **Can Be** perspective ... and the associated business / safety case.
- Each railroad needs a **Technologist** that integrates the technology kiosks with re-thinking the operations processes. An individual that can capitalize on the value of technology, instead of only its cost.
- Employ airline executives that understand schedules ... and the commitment it takes ... and the benefits they provide.

RECOMMENDATIONS: Suppliers

- Integrate communications with current products to provide solutions for current and future communication environments
- Work on interchangeability standards
- Reach out and bring in advancing technologies

RECOMMENDATIONS: Labor

- Labor needs to be incorporated into key “rethinking the technologies” issues, e.g., one-person crews, MofW, Performance Standards, ... but
- They need to be willing to do so with the recognition that job skills and their allocation may change accordingly

RECOMMENDATIONS: Government

- Recognize that it's not all about high-speed passenger: freight is a major, major challenge as to security and the country's economic growth . . . but also a real opportunity
- Lighten up on the vitality thing. Not everything is vital ... or treated as such.
- The Feds have the opportunity to tie together their regulatory issues into a "total" package: domestic security, refarming, safety.
- Fund *real* research on key technology issues: e.g., EGIS, Software Defined Radio, Communication Management Unit.

In Closing

PTC is not justified on Safety Benefits alone

but

PTC can be used to compensate for the perceived
or real risk of other programs

and / or

PTC can be part of the **CAN BE** railroad
perspective that provides a wireless data
platform that is readily justified as a shared core
infrastructure component.

Additional Information

FREE

Positive Train Control in North America's Freight Railroads

Restructuring VHF

RSAC – a somewhat personal perspective:
Full Spectrum, Vol. 17

\$

Full Spectrum

The Six IT Decisions IT Executives Shouldn't Make: Harvard Business Review: November, 2002

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