AAPM 57th Annual Meeting

Fault Tree Analysis

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Disclosure

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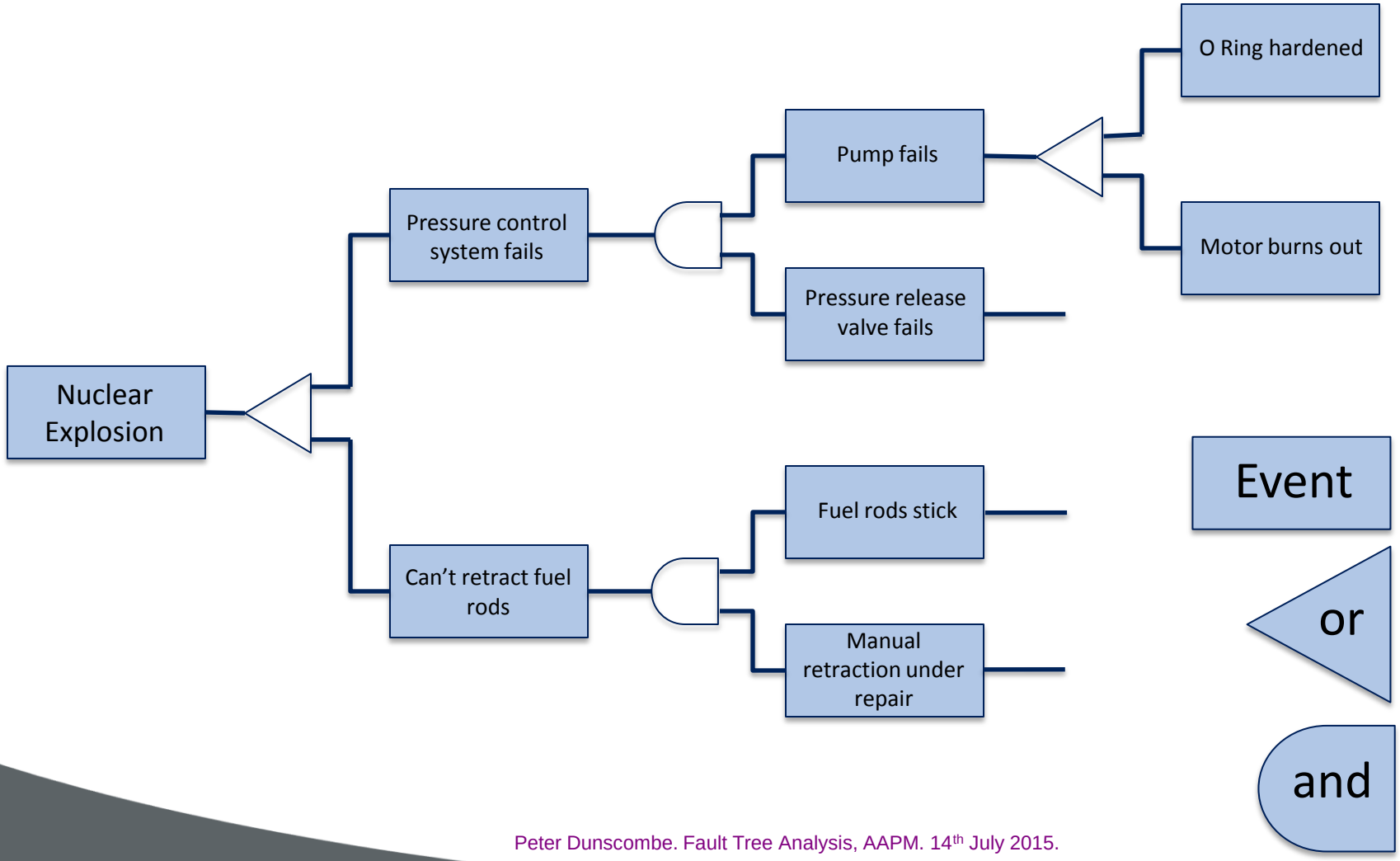
Occasional Consultant to IAEA and Varian.

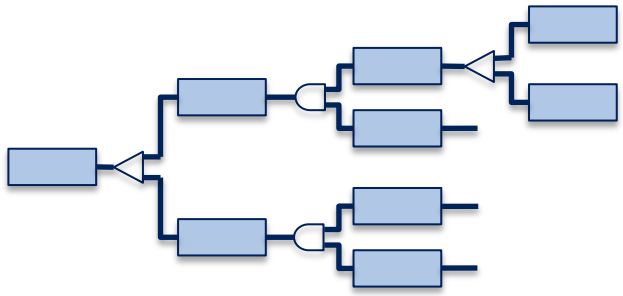
Fault Tree Analysis



Purpose of a Fault Tree Analysis

To make the (radiotherapy) system safer through using postulated failure modes, tracing the failure pathways back and, on the basis of the FTA,

- Identifying possible systemic program weaknesses.
- Placing barriers and checks (QA and QC)



Peter Dunscombe. Fault Tree Analysis, AAPM. 14th July 2015.

Fault Tree Analysis

Fault Tree Analyses are extensively used in high risk, high reliability industries such as the chemical, nuclear and aviation industries.

The AAPM's Task Group 100

Process Mapping helps us to understand the details of the patient's clinical pathway.

Failure Modes and Effects Analysis helps us to prioritize failure modes for further analysis.

Fault Tree Analysis helps us to identify:

- possible systemic program weaknesses
- where to put barriers and checks.

Objectives

- To appreciate the relationship between **Fault Tree Analysis** and **Failure Modes and Effects Analysis.**
- To explore the similarities and differences between **Fault Tree Analysis** and **Root Cause Analysis.**
- To consider TG 100's contribution to **Fault Tree Analysis.**
- To confirm the predictive power of **Fault Tree Analysis.**

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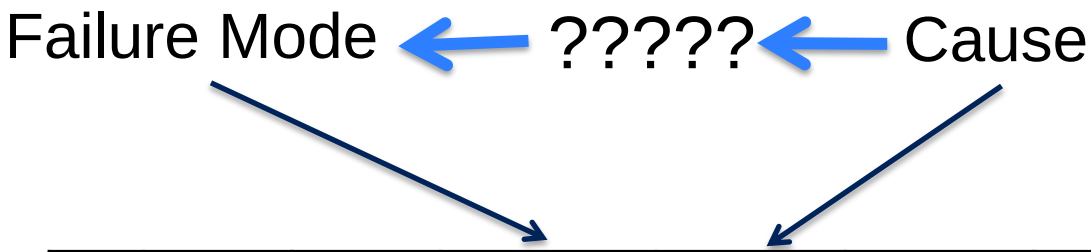
Failure Modes and Effects Analysis



Step #	Major Processes	Step	Potential Failure Modes	Potential Causes of Failure	Potential Effects of Failure	O	S	D	RPN	Examples of Causes and Failures
178	11 - Day 1 Treatment	Treatment delivered	LINAC hardware failures/wrong dose per MU; MLC leaf motions inaccurate, flatness/symmetry, energy, etc	Poor hardware design Poor hardware maintenance. Inadequate physics QA process	Wrong dose Wrong dose distribution Wrong location Wrong volume	5.4	**8.2**	7.2	354	Wrong to very wrong dose affecting all patients treated on machine (or with affected beams) until problem is found and corrected.

FTA in the context of FMEA

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FTA in the context of FMEA

Failure Mode

Cause

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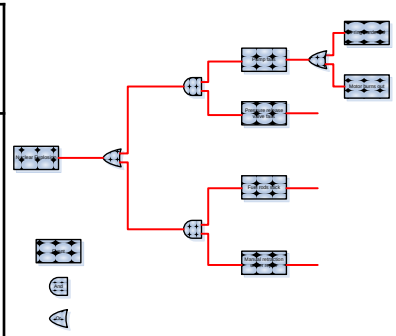

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A Fault Tree Analysis:

0%	A. Should be used during staff performance evaluations.
98%	B. Links Causes to Failure Modes in an FMEA.
2%	C. Should be done before an FMEA.
0%	D. Uses only “OR” gates.
0%	E. Must have at least 10 branches.

SAMs Question

A Fault Tree Analysis:

A. Should be used during staff performance evaluations.
B. Links Causes to Failure Modes in an FMEA.
C. Should be done before an FMEA.
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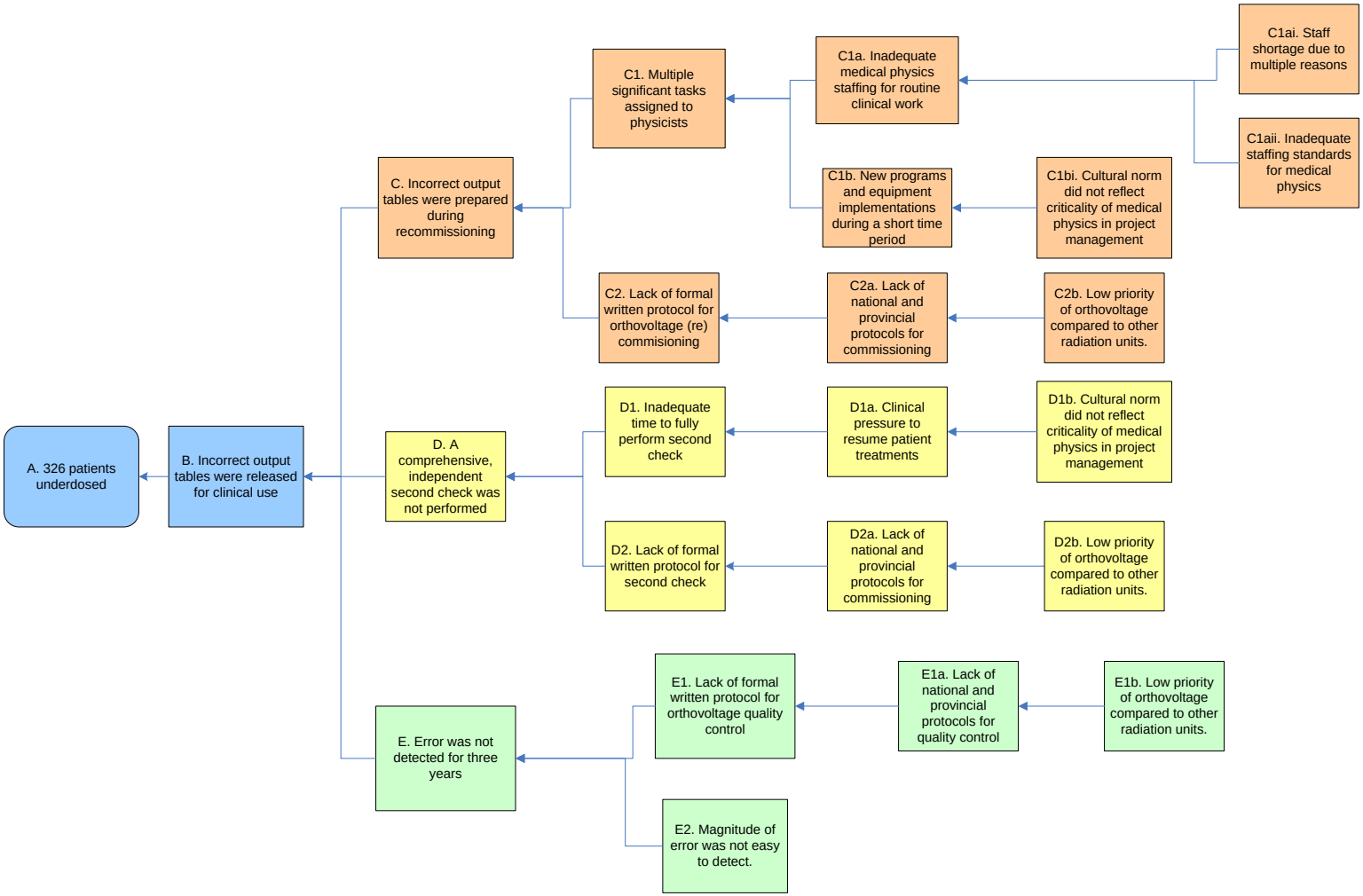
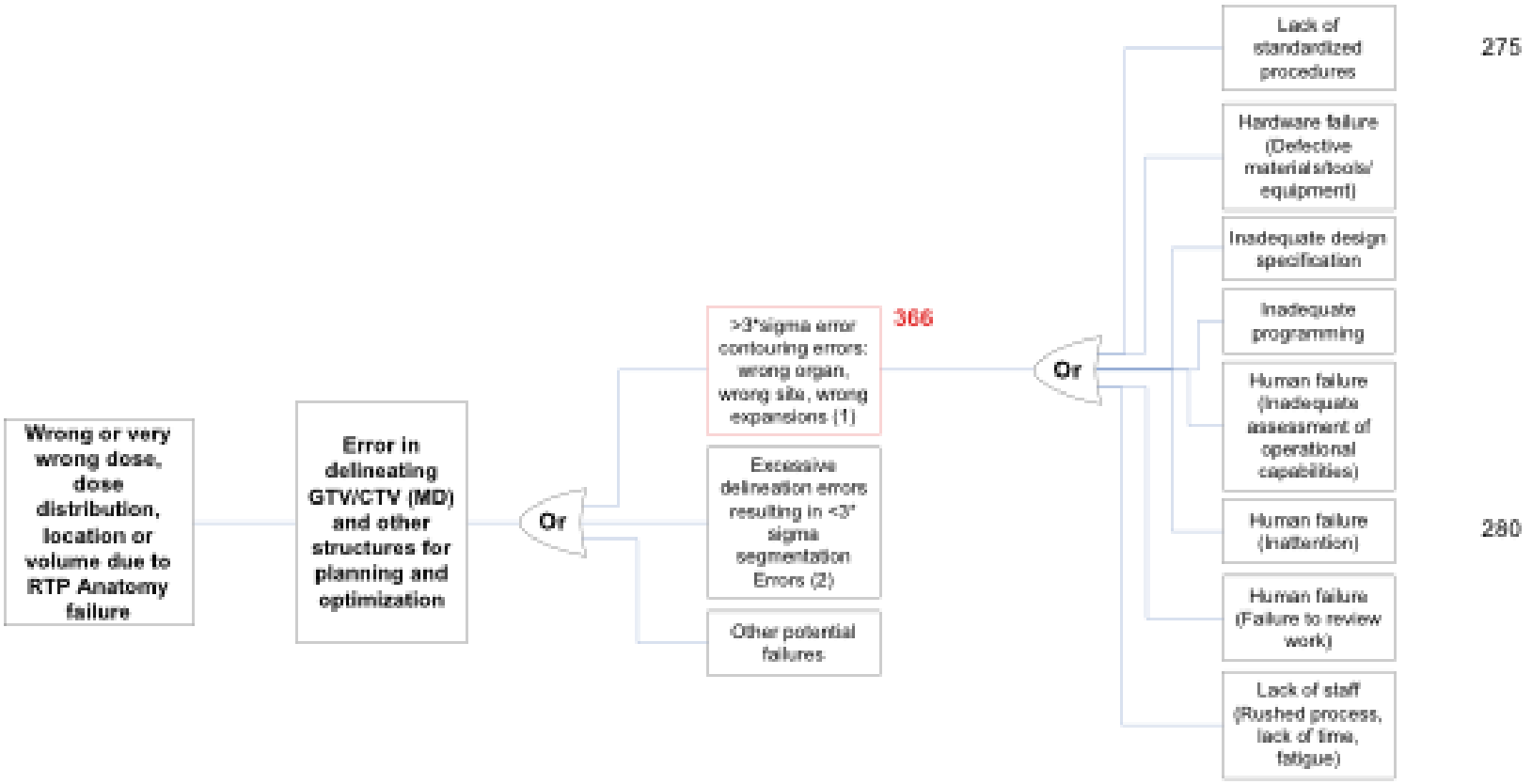
Root Cause Analysis (RCA)



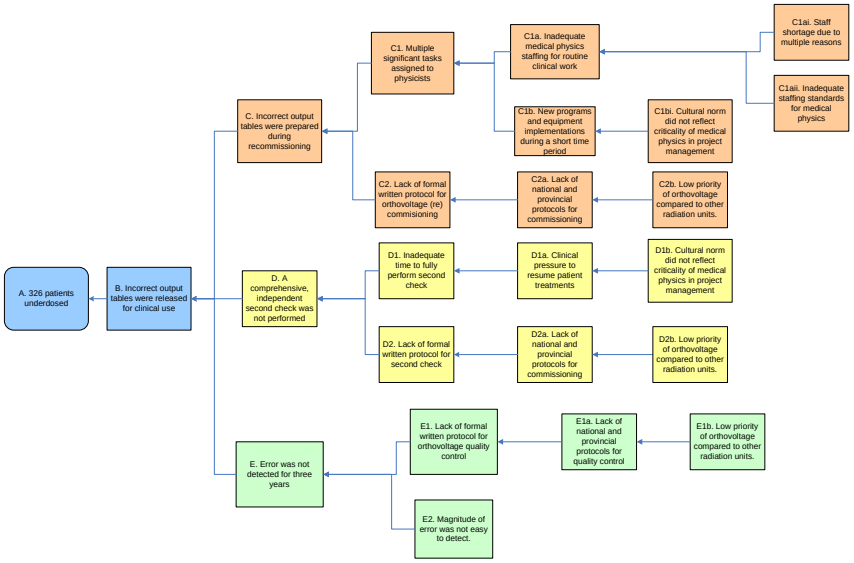
Peter Dunscombe. Fault Tree Analysis, AAPM. 14th July 2015.

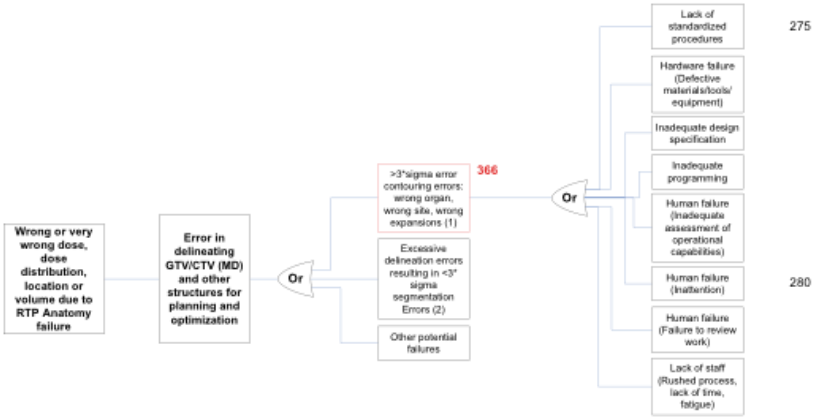
Fault Tree Analysis (FTA)



FTA in the context of RCA

Look similar?





FTA in the context of RCA

A Fault Tree Analysis can be regarded as a hypothetical Root Cause Analysis.

- An actual or potential failure starts an RCA
- Postulated failures are used to start an FTA.
- However, in both, the failure pathway is traced back to causes/contributory factors.
- An RCA uses only (implied) “AND” gates.

A Fault Tree Analysis:

2%	A. Should never be performed by a team.
20%	B. Should be performed prior to an RCA.
3%	C. Replaces a full Process Map.
74%	D. Can be Regarded as a hypothetical RCA.
2%	E. Must have at least 5 branches.

SAMs Question

A Fault Tree Analysis:

A. Should never be performed by a team.
B. Should be performed prior to a Root Cause Analysis.
C. Replaces a full Process Map.
D. Can be regarded as a hypothetical Root Cause Analysis.
E. Must have at least 5 branches.

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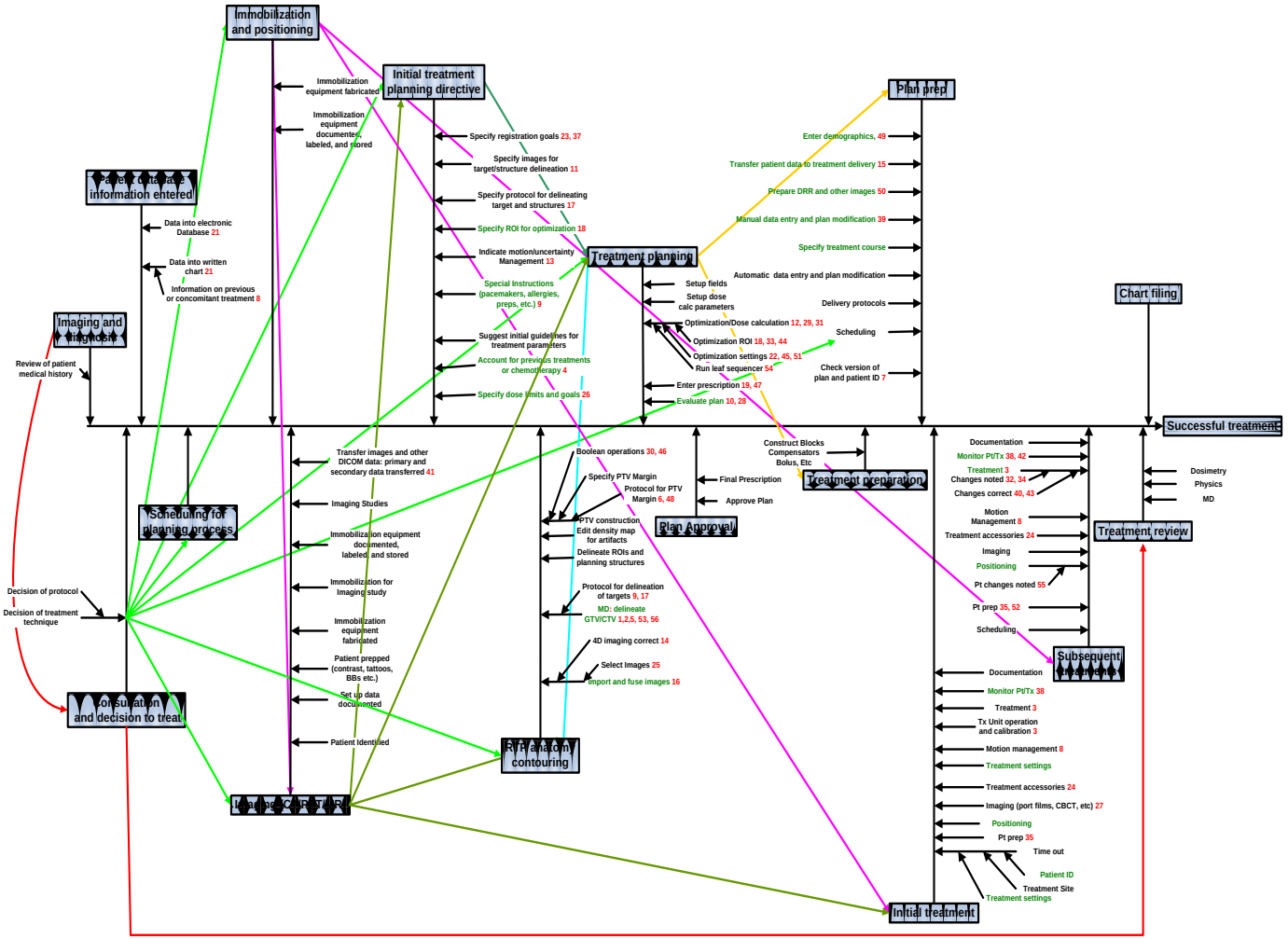
TG 100′ s Process Tree



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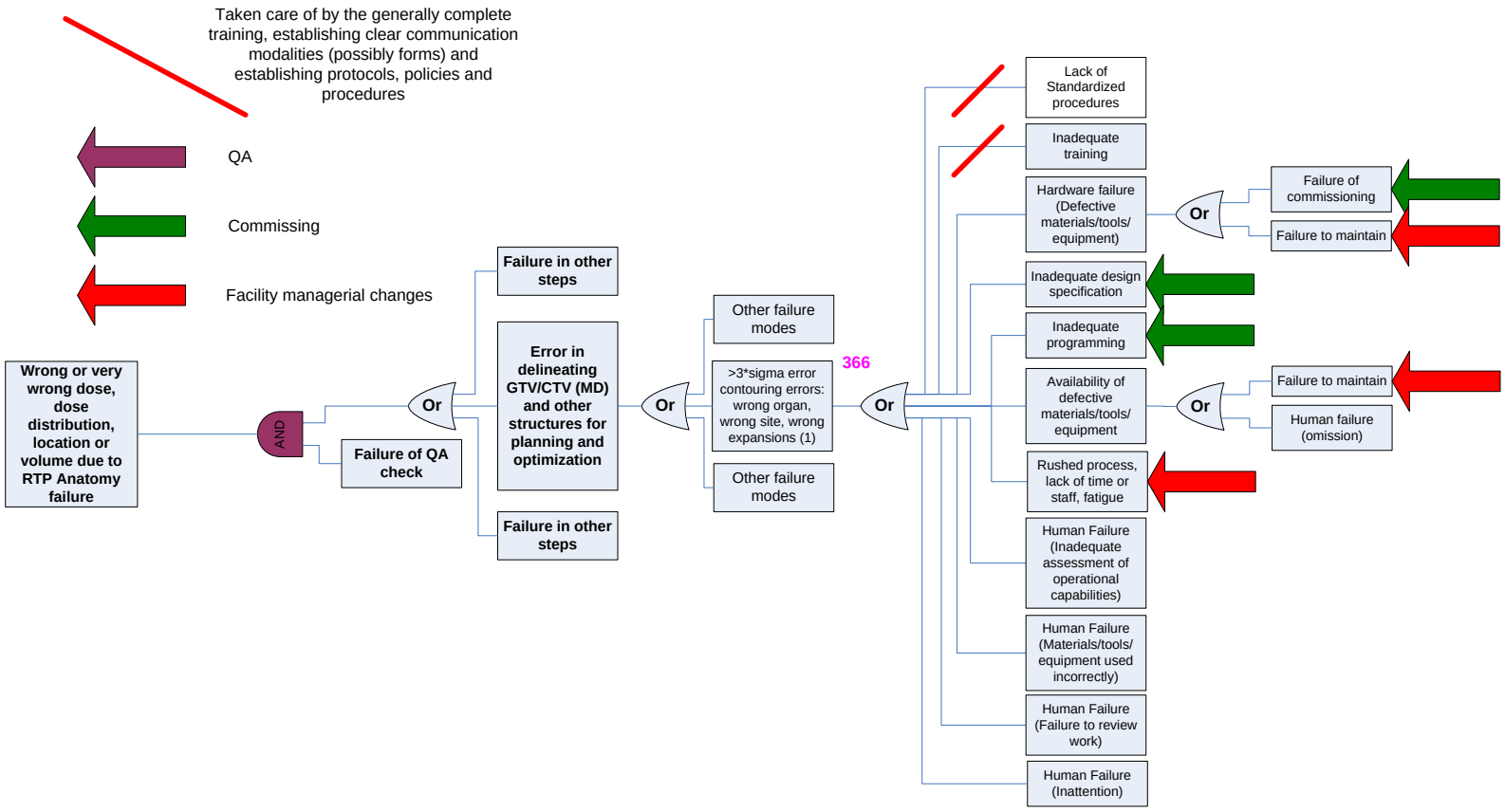
TG 100′ s Fault Tree



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TG 100’s Root Causes

Progenitor Cause Description	Number of times encountered
Inadequate resources	***65***
Hardware/software Failure	***65***
Algorithm limitations	1
Availability of defective tools	11
Data transfer problems (various categories)	6
Hardware or software failure	27
Inadequate programming	15
Inappropriate tools, etc	1
Incomplete or failed transfer	1
Poor optimizer	1
Poorly designed evaluation tool	2
Lack of Communication	***52***
Design Failure	***19***
Commissioning Failure	**17**
Data Problems	***8***
Bad data or data handling	1
Incorrect delivery systems definition in the TPS	2
Lack of limitations in the TPS	2
Poor knowledge of patient and table positions	2
Wrong machine configuration	1
Information Problems	***8***

AAPM's Key Core Requirements

"To prevent failures in radiation therapy in general (and IMRT in particular), a QM program should have elements that TG 100 terms key core requirements for quality. These core requirements are:

- Standardized procedures
- Adequate staff, physical and IT resources
- Adequate training of staff
- Maintenance of hardware and software resources
- Clear lines of communication among staff"

NPSF's Hierarchy of Actions

Stronger actions

- Architectural/physical plant changes.
- New device, with usability testing before purchase.
- Engineering control or interlock (forcing functions).
- Simplify process and remove unnecessary steps.
- Standardize equipment/process/ "care-map."
- Tangible involvement and action by leadership in support of patient safety.

Intermediate actions

- Increase staffing/decrease workload.
- Software enhancements/mods.
- Eliminate/reduce distractions (sterile medical environment).
- Checklist/cognitive aid.
- Eliminate look-alikes/sound-alikes.
- Read back.
- Enhanced documentation/communication.
- Redundancy.

Weaker actions

- Double-checks.
- Warnings/labels.
- New procedure/memo/policy.
- Training/additional study/analysis.

From US National Centre for Patient Safety

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TG 100′s Key Core Requirements and NPSF′s Hierarchy of Actions

- standardized procedures **(*stronger action*)**
- Adequate staff, physical and IT resources **(intermediate action)**
- Adequate training of staff **(weaker action)**
- Maintenance of hardware and software resources **(??)**
- Clear lines of communication among staff **(intermediate action)**

Key Core Requirements identified through TG 100's FTA include:

3%	A. Lack of substance abuse by staff.
6%	B. A shorter working day.
0%	C. Modern treatment equipment.
3%	D. IMRT capability.
88%	E. Standardized procedures.

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SAMs Question

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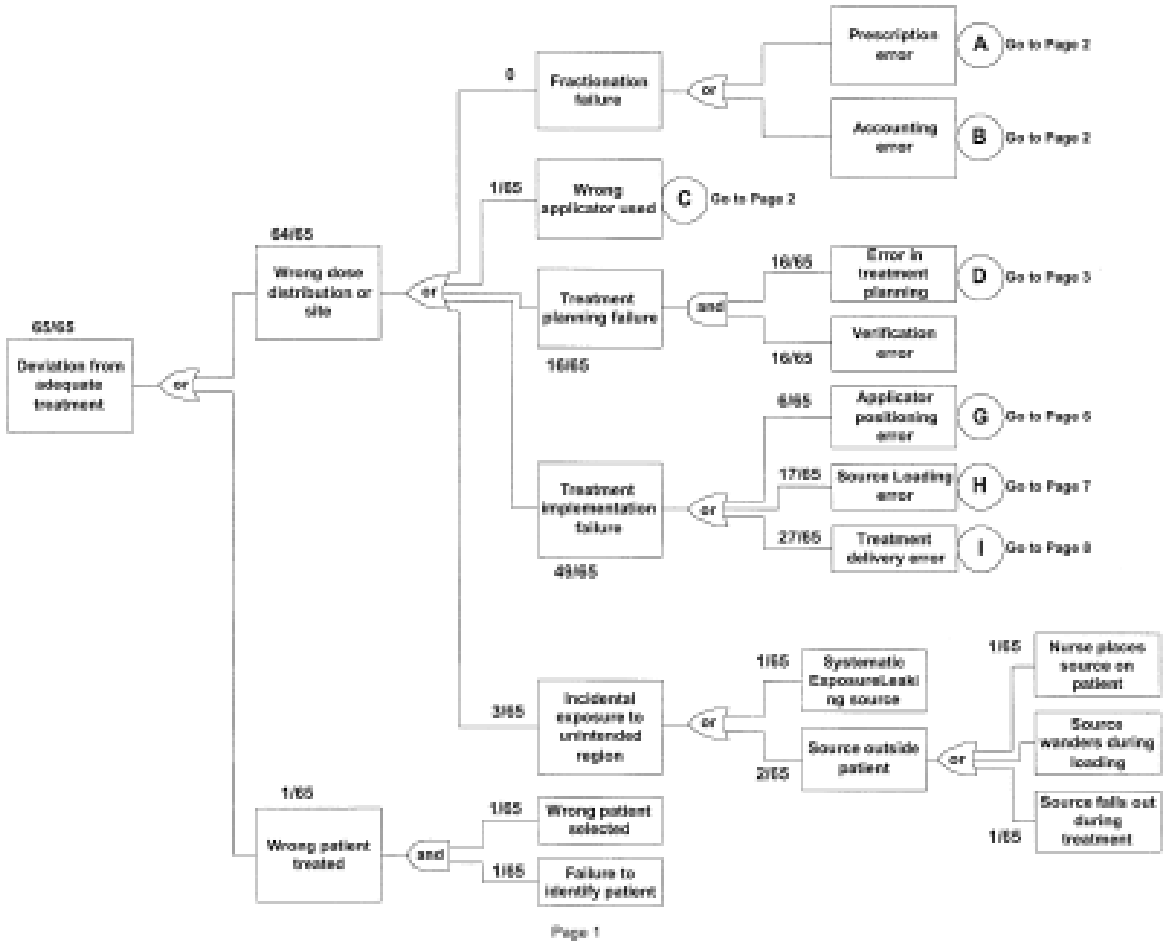
Thomadsen's Fault Tree Analysis



Thomadsen et al. IJROBP 2003 (57) 1496

Interesting quote from Thomadsen's paper

"In industries such as nuclear power, where probabilistic risk assessment originated, most failures occur only when several systems fail concurrently, and the combination of probabilities becomes important. Most medical events, although they have several root causes and concurrent unusual situations, fail along a single branch of the fault tree"

Thomadsen et al. IJROBP 2003 (57) 1496

Swiss cheese, anyone?

"Most medical events, although they have several root causes and concurrent unusual situations, fail along a single branch of the fault tree"

Prescient observation by Thomadsen

2003

"Errors often follow violations in protocols, particularly failures to perform verification procedures, and indicators that things are not correct are often present yet ignored during events."

Thomadsen et al. IJROBP 2003 (57) 1496

2006

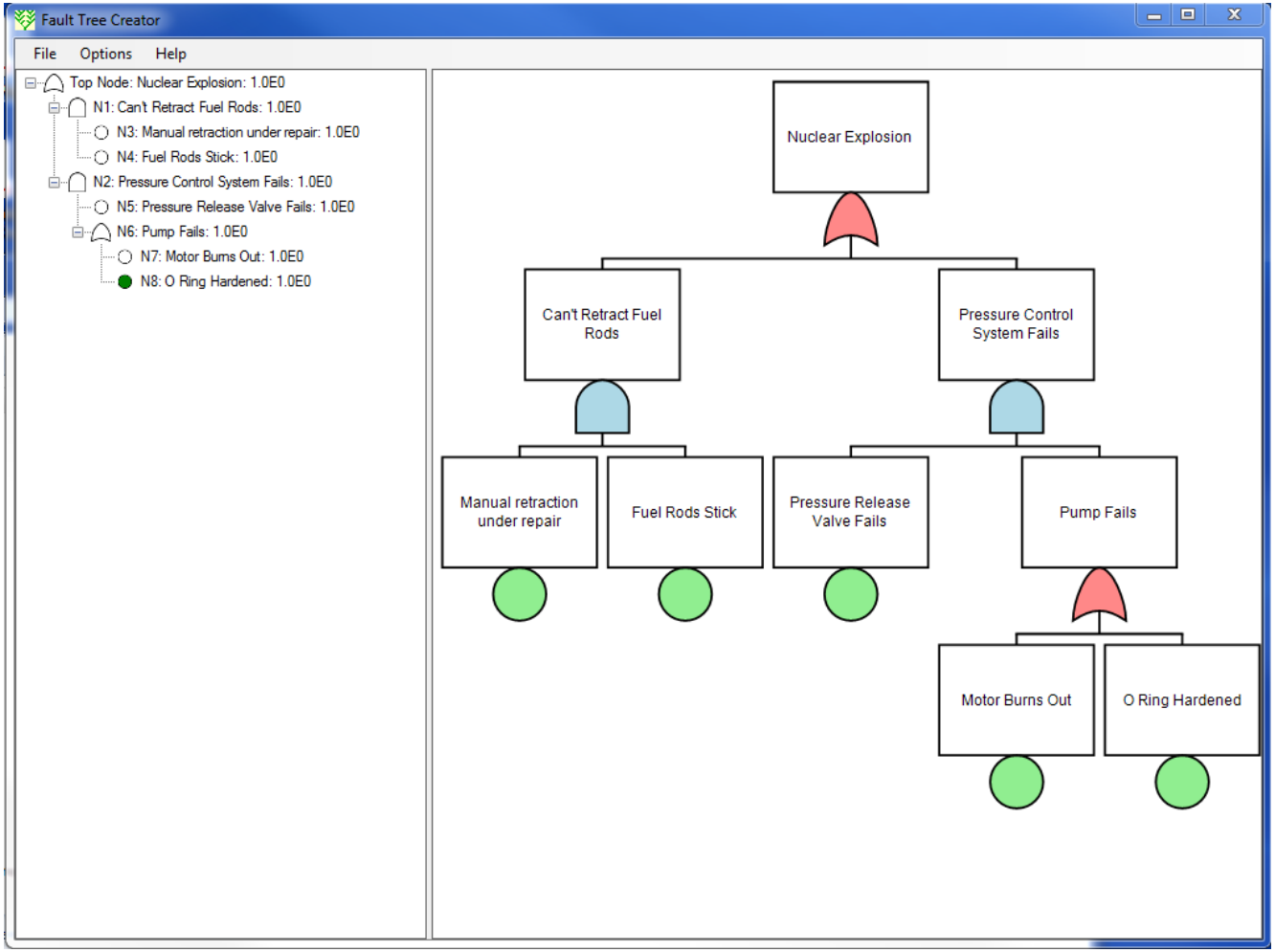
Radiation Offers New Cures, and Ways to Do Harm

By WALT BOGDANICH

Summary

- The relationship between **Fault Tree Analysis** and **Failure Modes and Effects Analysis.**
- The similarities and differences between **Fault Tree Analysis** and **Root Cause Analysis.**
- TG 100's contribution to **Fault Tree Analysis.**
- The predictive power of **Fault Tree Analysis.**

(Free) Fault Tree Software – Alf Siochi



http://alf.siochi.info/software