

# The Logical Thinking Process

*A Systems Approach  
To  
Complex Problem Solving*

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## Who AM I?

- Goal Systems International (Senior Partner)
- Author of several books



**Bill Dettmer**



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## What we're going to talk about...

*...over the next hour*

- A quick review of systems thinking and constraint management principles (:05 minutes)
- Questions and Answers about the June WebEx session (:10 min)
- Introduction to the Logical Thinking Process (:40 min)
  - How it fits in with systems thinking/constraint management
  - The five logical tools
- Q & A (:05 minutes)
- A couple of simple exercises (:25 minutes)
  - Evaporating Cloud (conflict resolution)
  - Negative Branch ("law of unintended consequences")
- "Last chance" Q & A (:05 minutes)

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## What is the *Systems Approach*?

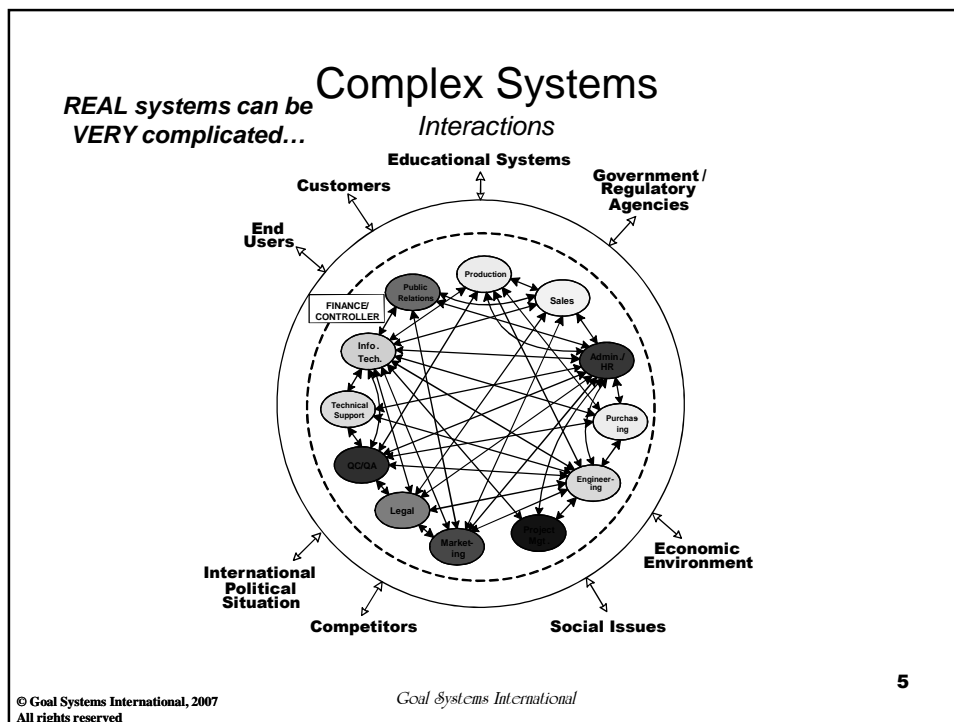
*Based on THREE concepts...*

- Holistic thinking (*No part of the system is "an island"*)
- The whole is *not* the sum of its parts
  - Interactions—interdependencies—among components are as important, or more important, than the performance of the components themselves
  - The whole system can't be managed effectively by *suboptimizing*
- Avoiding Suboptimization
  - Not all components are "created equal"
  - Some may accept inefficiencies so that more critical components can succeed

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## The Concept of System Constraints

The photograph shows a heavy metal chain with several dark, metallic links. One link in the middle of the chain is replaced by a thin, white, translucent ribbon. The ribbon is stretched across the gap where the link would be, highlighting it as the point of weakness or constraint in the chain.

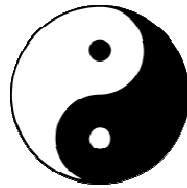
- Systems are analogous to CHAINS
- Every chain has ONE **weakest link**
  - A part that limits what the whole chain can do

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## Weakest Link...An Opportunity

If the weakest link (constraint) limits the system's potential the most...



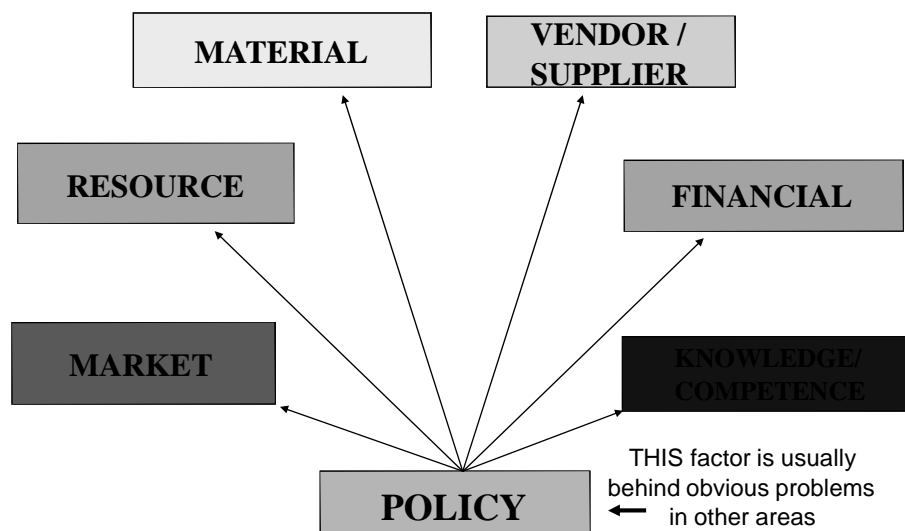
...then if it can be improved, it should also provide  
*the best opportunity to MAXIMIZE*  
system performance

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## Types of Constraints



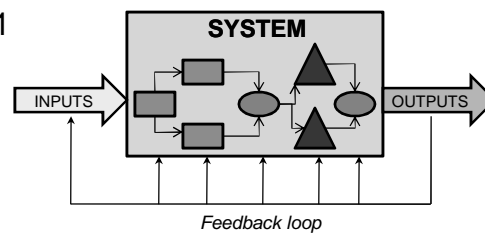
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## The Five Focusing Steps *for System Improvement*

1. **Identify** the constraint
2. **Exploit** the constraint
3. **Subordinate** everything else
4. **Elevate** the constraint
5. **Go back** to step 1



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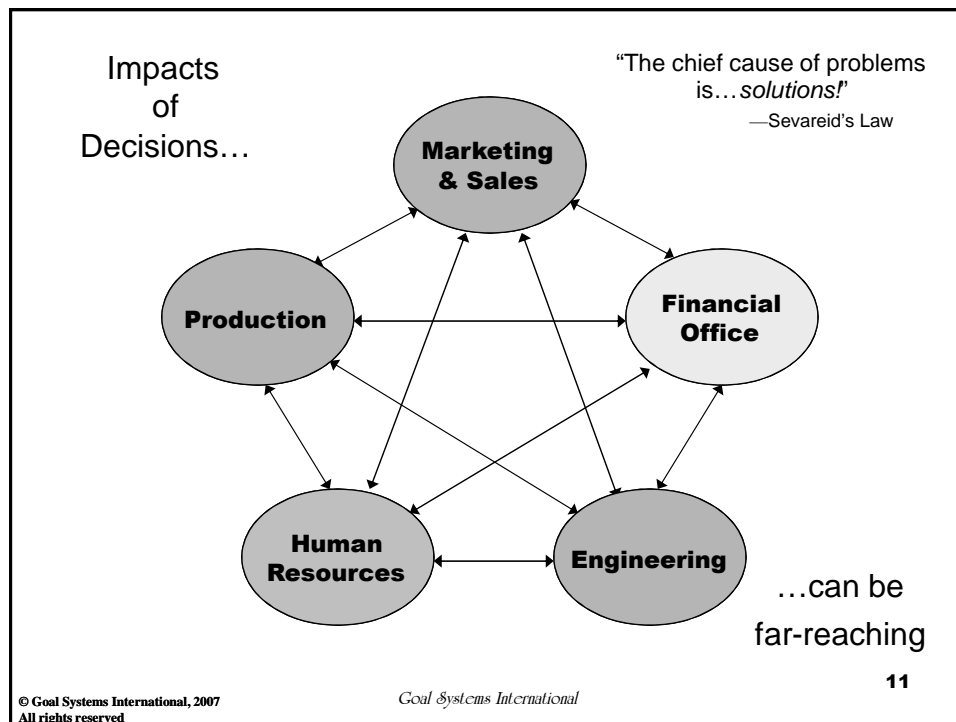
## Questions...

*...on what I've covered so far,  
or on anything that mentioned  
in our June session?*

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### Wurtzburg Corporation

*A notional example*

- Sales slightly declining for two years
- Expenses up, profits down for three straight years
- Long backlogs in production
- Difficulties in retaining qualified production operators
- Few customers
  - All long term
  - 18+ months to develop new ones
- Two biggest customers (55% of revenue) leaving in six months

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## What's Wurtzburg's Problem?

- Could these diverse problems be connected?
- If so, which one is the critical root cause of all the others?
- How would we go about finding out?



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## Policy Constraints

- Underlie almost all other kinds
- A conscious decision on how business will or will not be done
- Maybe discretionary or imposed
  - We decide
  - The law requires...
- An unconscious acceptance of historical practices
  - "This is the way we've always done it..." or
  - "We don't do things that way."
  - Thinking "inside the box"

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## Wurtzburg Corporation

- “We are a metal-stamping company.”
  - Reason given for not investing in laser-cutting technology
- “We can only satisfy customers (to our standards) within 100 miles.”
  - Reason given for not extending target marketing area

*These are Wurtzburg’s self-imposed policies...*

*They were SYSTEM CONSTRAINTS.*

*They were not immediately obvious,  
and the company did not understand their full impact.*

## How do we...

- Identify and manage system constraints that are:
  - Not physical (not visible)?
  - Not easily measurable?
  - Apply to more than just manufacturing systems?
  - Pervade the organization (complex interdependency)?
- Analyze complex system interactions?



## The Logical Thinking Process

- A set of FIVE logic trees
- A set of EIGHT rules that govern logical connections
- Provides the answers to the *only three questions* managers ever need to know...
  - *WHAT* to change?
  - What to change *TO*?
  - *HOW* to make the change happen?

## The Rules of Logic

*(Categories of Legitimate Reservation)*

1. CLARITY
2. ENTITY EXISTENCE
3. CAUSALITY EXISTENCE
4. CAUSE INSUFFICIENCY
5. ADDITIONAL CAUSE
6. CAUSE-EFFECT REVERSAL
7. PREDICTED EFFECT EXISTENCE
8. TAUTOLOGY (circular logic)

## The Logic Trees

- Intermediate Objectives (IO) Map
  - What *SHOULD* we be trying to accomplish?
- Current Reality Tree (CRT)
  - What's happening that we don't like?
  - What are the *critical root causes*?
- Evaporating Cloud (EC)
  - What conflict inhibits problem solution?
  - What do we do about it?
- Future Reality Tree (FRT)
  - How do we know the solution will work?
- Prerequisite Trees (PRT)
  - How do we *implement* solutions?

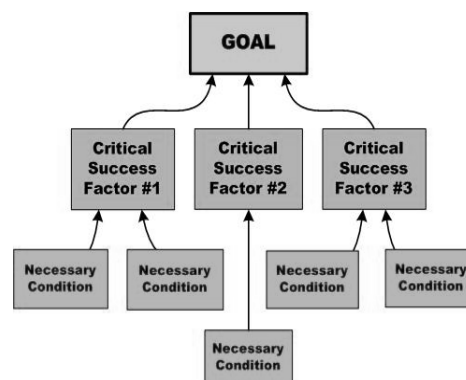
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## Intermediate (IO) Objectives Map

- Establishes:
  - Overall system goal
  - Critical Success Factors (CSF)
  - Necessary Conditions (NC)
- Determines the standard of performance required of the system



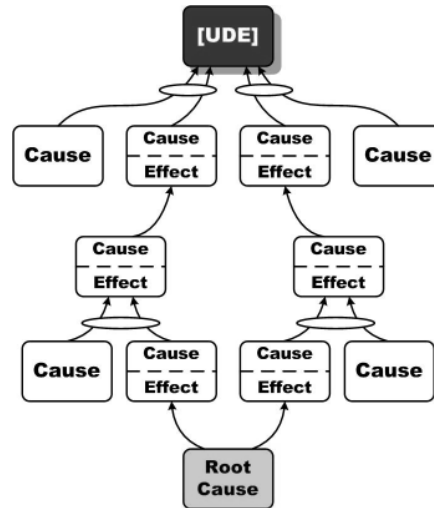
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## Current Reality Tree (CRT)

- Identifies measurable deviations from the IO Map
- Traces an unbroken chain of cause-effect back to critical root causes
  - Usually includes the system constraint
- Identifies the fewest factors guaranteed to deliver maximum benefit to the system



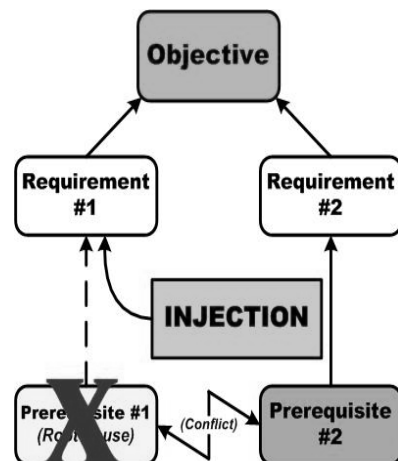
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## Evaporating Cloud (EC)

- Change usually elicits “pushback” from someone
  - Somebody wants to leave the status quo alone
- Affords the possibility of a “win” for both sides
- Helps develop a third alternative to satisfy the requirements of both sides
  - “Injection”



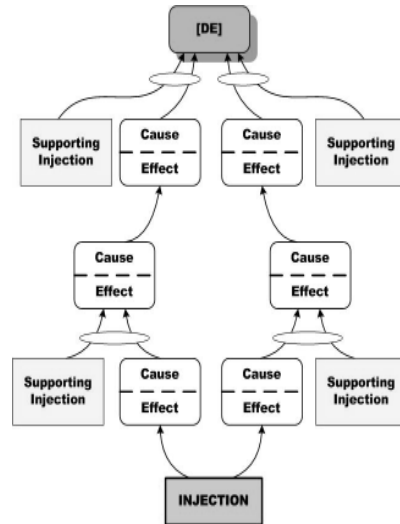
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## Future Reality Tree (FRT)

- Ideas are NOT solutions
  - Will they work?
  - Will they cause more problems than they solve?
- FRT logically projects outcomes of proposed ideas before resources are committed



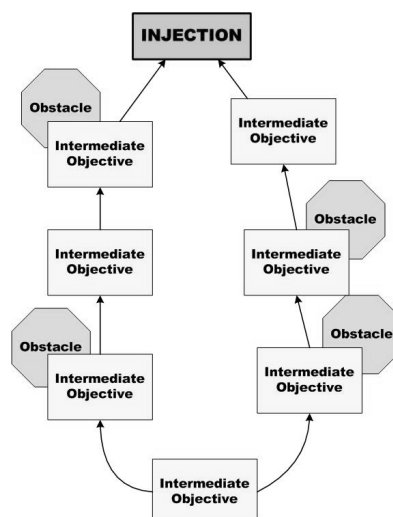
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## Prerequisite Tree (PRT)

- How to make change happen successfully?
  - What are the non-negotiable component tasks?
  - What obstacles must be overcome (and how)?
- PRT creates a sequenced implementation activity network



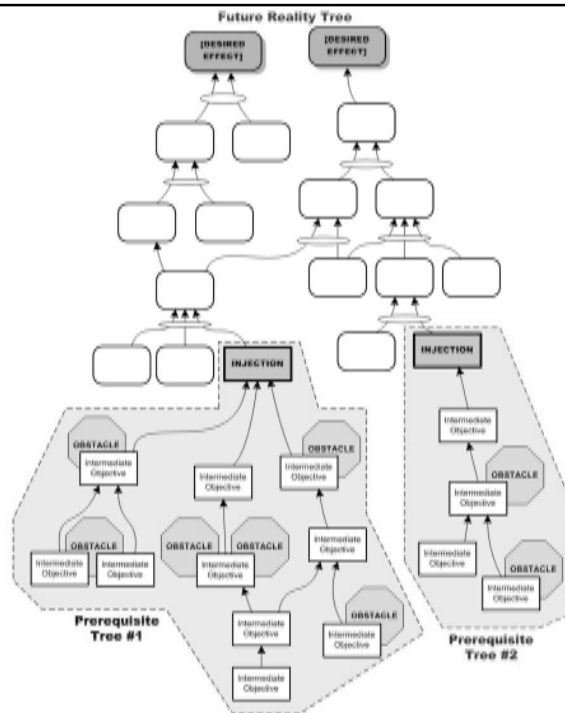
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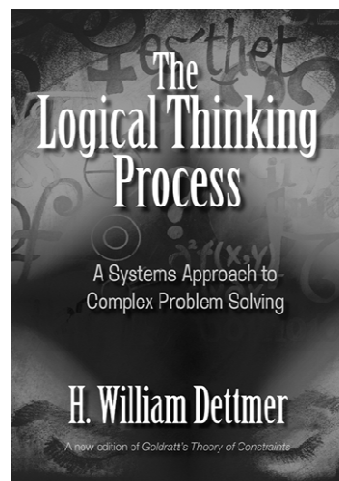
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## The “Big Picture”

- The FRT shows how changes unfold
  - Automatically, like dominoes falling
- The PRTs provide the detailed execution process
  - Discrete action required (Intermediate Objectives)



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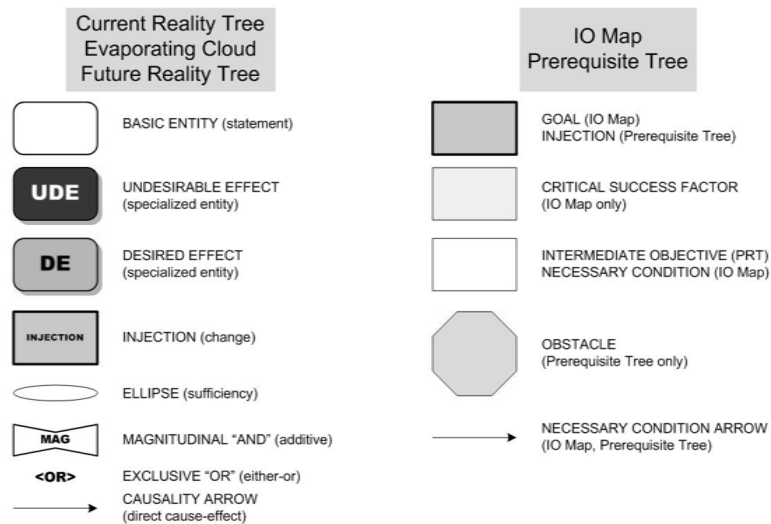
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## Thinking Process Symbolology



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## Categories of Legitimate Reservation

*Let's look at these in a little more detail...*

1. Clarity
2. Entity Existence
3. Causality Existence
4. Cause Insufficiency
5. Additional Cause
6. Cause-Effect Reversal
7. Predicted Effect Existence
8. Tautology (circular logic)

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## Categories of Legitimate Reservation

### *Clarity, Entity Existence, Causality Existence*

#### Examples

1. CLARITY – The complete understanding of what has been said.

The production process is bad.

*What does “bad” mean?*

2. ENTITY EXISTENCE – A valid, complete expression of a single idea.

Water runs uphill.

*Is this really true?*

3. CAUSALITY EXISTENCE – A direct, unavoidable causal connection

...then...

The car's engine stops.

If...

The driver falls asleep.

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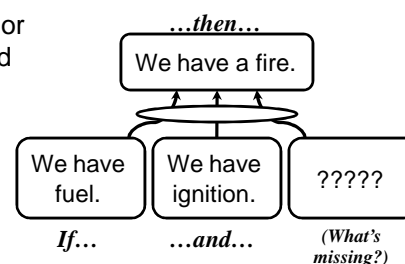
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## Categories of Legitimate Reservation

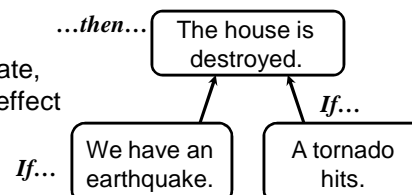
### *Cause Insufficiency, Additional Cause*

#### Examples

4. CAUSE INSUFFICIENCY – Two or more contributing causes required



5. ADDITIONAL CAUSE – A separate, independent cause of the same effect



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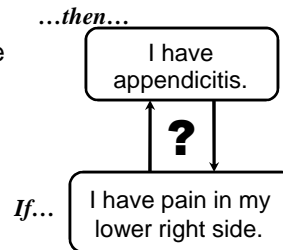
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## Categories of Legitimate Reservation

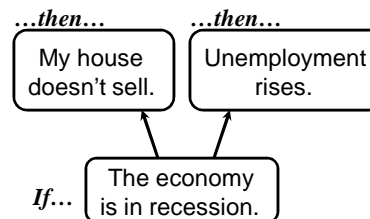
### *Cause-Effect Reversal, Predicted Effect Existence*

#### Examples

6. CAUSE-EFFECT REVERSAL – The cause is really the effect, and vice-versa



7. PREDICTED EFFECT EXISTENCE – A separate, independent effect attributable to the same cause



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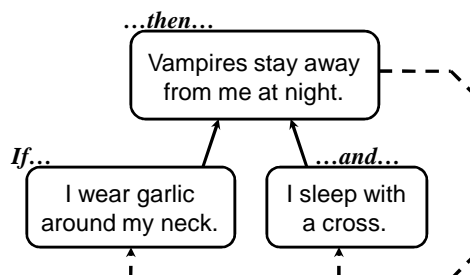
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## Categories of Legitimate Reservation

### *Tautology*

8. TAUTOLOGY (circular logic) – The existence of the effect is offered as the rationale for the causal relationship

#### Example



Q: "How do you know the garlic and cross are the causes?"

A: "You don't see any vampires, do you...?"

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## The Five Logic Trees

*Let's look at these in a little more detail...*

- Intermediate Objectives (IO) Map
- Current Reality Tree (CRT)
- Evaporating Cloud (EC)
- Future Reality Tree (FRT)
  - Negative Branch (NB)
- Prerequisite Tree (PRT)

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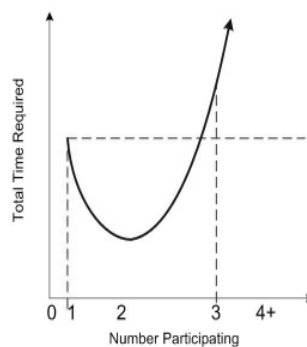
## Constructing the Logic Trees

*Time required...*

- Throwing manpower at it only helps up to a point
  - Two are better and faster than one
  - Three are slightly worse than one
  - More than three slows the pace to "glacial"

*My observation is that whenever one person is found adequate to the discharge of a duty by close application thereto, it is worse executed by two persons, and scarcely done at all if three or more are employed therein.*

—George Washington



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## Intermediate Objectives (IO) Map

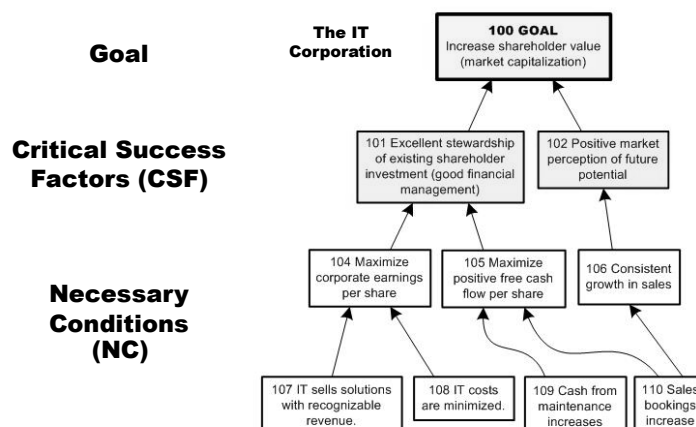
- Reflects the ultimate desired *system* outcomes
  - Goal (as defined by the owners of the system)
  - Critical Success Factors (3-5 key terminal outcomes)
  - Necessary Conditions (key supporting intermediate results)
- Time to construct: 30 – 90 minutes
  - Remember George Washington's admonition!

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## Intermediate Objectives (IO) Map (Example)



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## Current Reality Tree (CRT)

- A “snapshot” of reality—NOW!
- Undesirable Effects (UDE) at the top
  - Specific, verifiable statement of **deviation** between CSF (from IO Map) and what is happening NOW
- Critical Root Causes (CRC) at the bottom
  - Usually a policy or practice that motivates action within the system
- Continuous chain of cause and effect connecting the UDE with the CRC

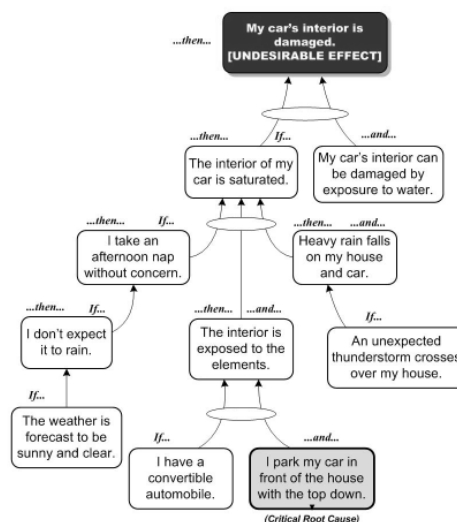
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## Current Reality Tree (CRT)

- CRT indicates **sequence**, not time
- The example shown here is very simple
- The CRT you have in your handout materials (the *Challenger* accident) required 14 years to unfold
- Time to construct: 2-4 hours or more
  - Complexity-dependent



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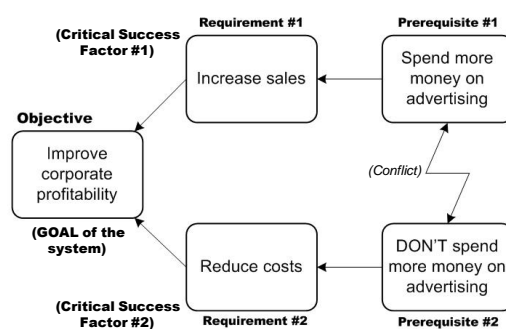
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## Evaporating Cloud (EC)

- Used to resolve conflict or contention
- Normally used when proposed change elicits “push-back”
- Structures and displays opposing positions for easier resolution
- Seeks a “win-win” third alternative
  - Referred to as an “injection”

## Evaporating Cloud (EC)

- Objective of the EC is normally the system goal
- Each Requirement is normally a critical success factor
  - Conditions/outcomes of specific actions
- Each Prerequisite is the *action* (or policy) perceived to satisfy the Requirement
- Time required to construct: 15 -30 minutes



### Underlying principles of the Evaporating Cloud

- Requirements are non-negotiable (“win-win”)
- “There is more than one way to skin a cat”

## Evaporating Cloud (EC)

*The keys to conflict resolution...*

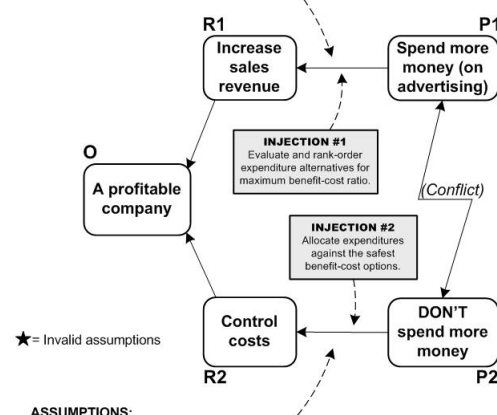
- Assumptions underlie each side of the conflict
  - Assumptions are “hidden” (not obvious)
  - One or more assumptions are *invalid*
- Each side desires to see the conflict resolved
- Solutions (“injections”) often require “outside-the-box” thinking

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- ASSUMPTIONS:**
1. Our markets traditionally respond well to advertising campaigns
  2. Our superior value proposition allows us to avoid competing via price reductions
  - ★ 3. Spending more money on advertising is the **ONLY** way to increase sales revenue
  - ★ 4. Bigger advertising expenditures **ALWAYS** produce more sales
  - ★ 5. Bigger advertising expenditures are **ALWAYS** cost-effective



- ASSUMPTIONS:**
6. Limiting spending is the **ONLY** way to control costs
  7. Not spending more money **ALWAYS** provides cost control
  - ★ 8. Not spending more money **NEVER** has a negative effect on revenue generation
  - ★ 9. No other part of the operation is **EVER** adversely impacted by holding the line on spending
  - ★ 10. Bigger advertising expenditures are **NEVER** cost-effective

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## Evaporating Cloud (EC)

*The completed analysis*

- Invalid assumptions highlighted by “★”
- Prerequisites P2 replaced
- Injections ensure satisfaction of R1 and R2

## Future Reality Tree (FRT)

- A projection of what the future would look like if change is introduced
- A means of “paper” (logic) testing whether proposed changes will actually deliver the desired results
  - Opposite of the Undesirable Effects
  - Satisfaction of the Critical Success Factors (IO Map)
- Safeguards against the unwarranted expenditure of resources in a failed effort
  - If you can’t prove it logically, “go back to the drawing board”
- Time required: 2-3 hours (complexity-dependent)

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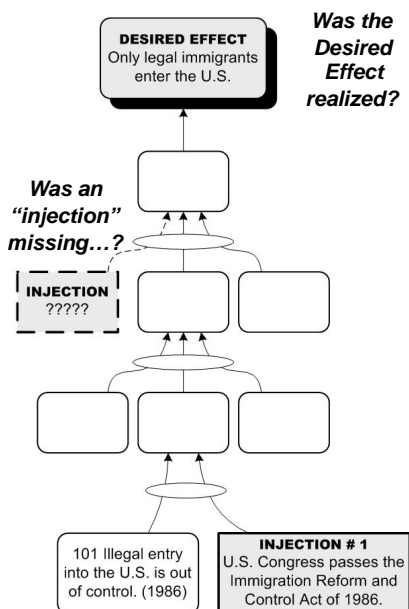
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## Future Reality Tree (FRT)

*Example*

- No FRT was constructed on this law in 1986
  - FRTs didn’t exist then
- What do you think the missing Injection might have been?
  - “Enforcement” perhaps?
- Do you think an FRT was completed for the Comprehensive Immigration Reform Act of 2007?
- Your handout shows an example of a more detailed, real-world FRT



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## Negative Branch Reservation (NB)

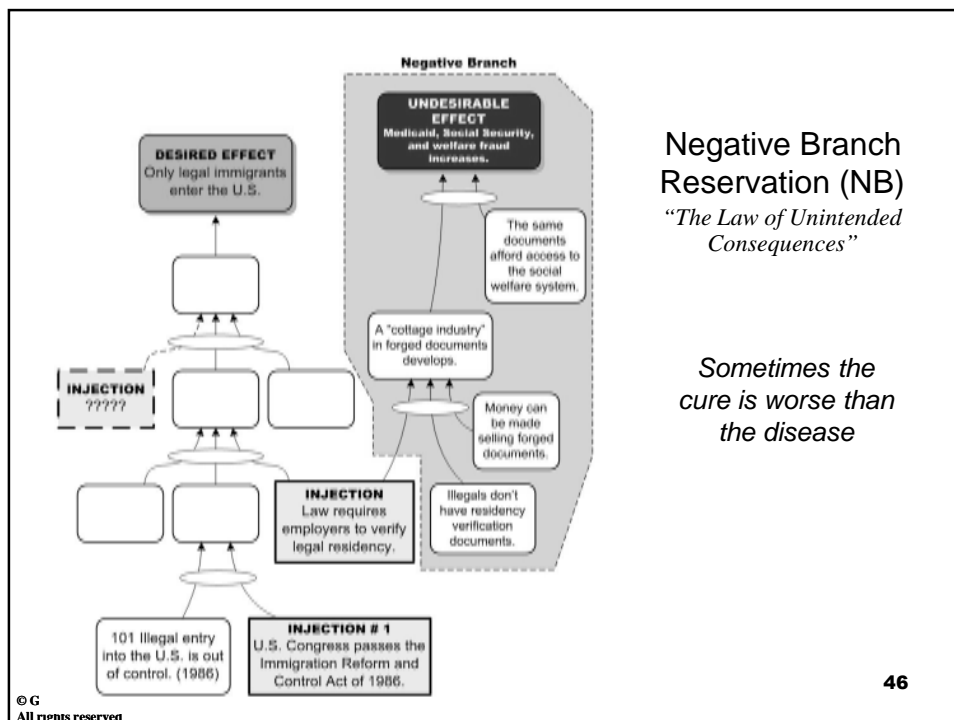
*"The Law of Unintended Consequences"*

- Even when Injections are capable of producing the Desired Effect, they can lead to unanticipated consequences
  - Sometimes new problems, often worse than the original one
- Negative Branch: Part of the FRT process
  - Identify and avoid the "Law of Unintended Consequences"

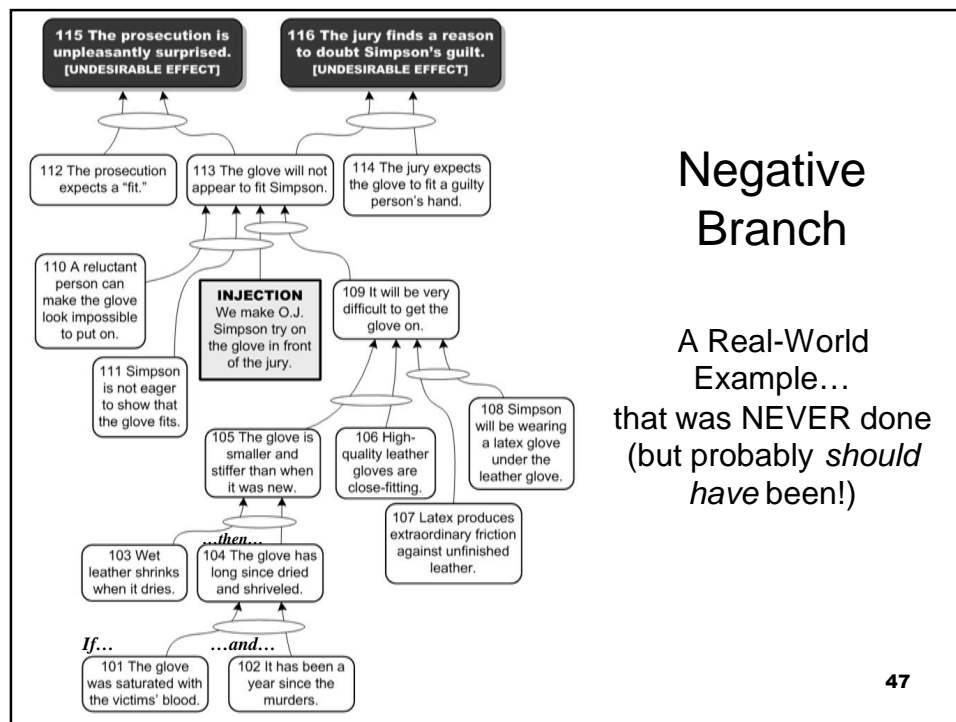
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## Future Reality Tree and Negative Branch

- The FRT is where strategy is developed and tested
- The Negative Branch is a subset of the FRT that helps protect against the “law of unintended consequences”
- The purpose of these two trees
  - Solution mapping and testing
  - NOT implementation

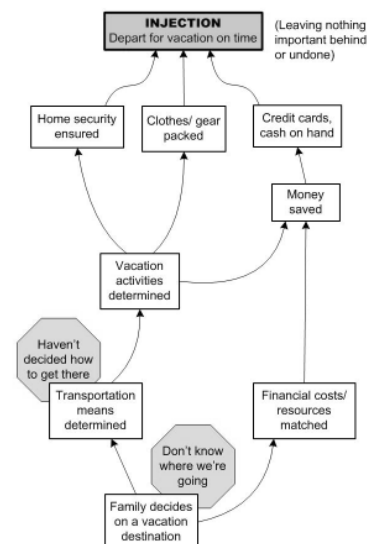


## Prerequisite Tree (PRT)

- Articulates the component tasks in executing/ implementing an Injection from a Future Reality Tree
- Differs from an IO Map
  - In level of the system addressed
    - ❖ IO Map – High system (conceptual) level
    - ❖ PRT – operational (working) level
  - In level of detail
    - ❖ IO Map – Terminal outcomes of major system activities
    - ❖ PRT – short-term tasks and activities
- Time required: 30 – 90 minutes
  - Depending on availability of content knowledge

## Prerequisite Tree (PRT)

- Injection to be implemented
- Obstacles to be overcome
- Intermediate Objectives
  - To support Injection implementation
  - To overcome obstacles
- Extends downward to:
  - The first component activity that must be completed, or...
  - The most basic thing you know how to do, or...
  - The first obstacle to be overcome, whichever is lowest
- Your handout shows an example of a real PRT



*Before we move on to a “hands-on” exercise...*

**Questions...**

*...on what I’ve covered so far?*

## **“Hands-on” Exercises**

- Evaporating Cloud (conflict resolution)
- Negative Branch

## **SAILING A LEAKING BOAT: ROW OR BAIL?**

### ***AN EXERCISE IN CONFLICT RESOLUTION***

“Managing around here is like being in a boat with leak in it... I know I should row or I won't get anywhere, but if I stop bailing then I'm going to sink!”

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## **NEGATIVE BRANCH EXERCISE**

*Anticipating the  
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## The Negative Branch

*Avoiding the “Law of Unintended Consequences”*

- Scenario
  - You are the executive head of your national government
  - You are faced with the imminent threat of terrorist attack
  - Your security establishment has requested a law to make their duties more reliable and effective. Provisions include:
    - ❖ Surveillance video throughout all public places in major cities
    - ❖ National identification cards for every citizen
    - ❖ Arrest and holding of suspects for 21 days without formal charge
    - ❖ Warrantless wire-tapping (phones)
    - ❖ Internet / e-mail screening or tracing without judicial warrants
    - ❖ Increases in numbers of security forces
- You have some troubling concerns about this requested law.

## The Negative Branch

*Avoiding the “Law of Unintended Consequences”*

### Charter:

Construct a Negative Branch leading logically  
to the Undesirable Effects you foresee  
happening if the law is enacted

## Interactive Nature of the TP Tools

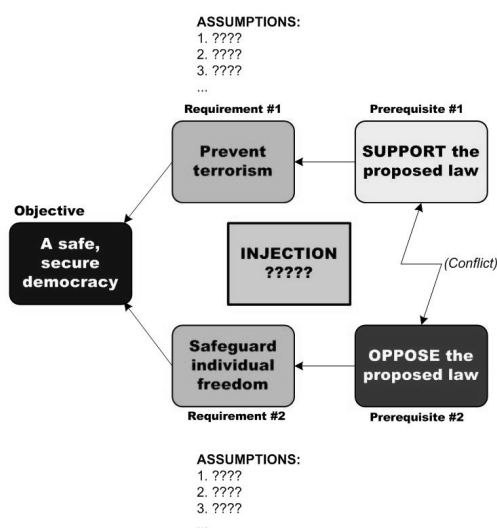
- You have a well-developed Negative Branch on the terrorism law
  - Clearly, it implies some undesirable potential outcomes
  - But clearly, too, it offers some significant potential benefits in improved security
- As a decision-maker, you are faced with a dilemma
  - Support the passage of the law, or
  - Oppose the passage of the law
- It would be irresponsible to reject one side or the other without a viable alternative
- Effective resolution of your dilemma requires a “win-win” solution
  - And the appropriate Thinking Process tool for that would be...?

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## The Evaporating Cloud (applied to REALLY high-level policy issues!)



- Is there ANY doubt in your mind about whether or not YOU could resolve this dilemma in a “win-win” manner...

- IF you had tools like the Thinking Process?
- IF you had access to the content knowledge a national-level decision-maker has?

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## The Logical Thinking Process

### *Summary*

- An analysis and problem-solving tool for complex systems
- Based on the fact that policies rule the operation of systems
  - And constraint what the system may do (performance)
- Can be applied to ALL systems
  - Large or small
  - Political, cultural, or organizational
  - Regardless of goal / mission
- The most powerful complex-system analysis tool ever invented

## The Logical Thinking Process

### *Summary*

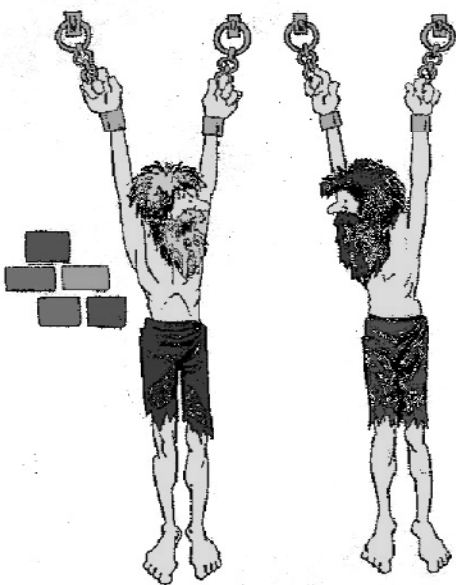
- Use requires:
  - Time investment to learn
  - System knowledge ("bullets to put into the gun")

Without the assistance of a teacher many roads become open to a practitioner, some on the correct path and some on the incorrect path. It is not for everyone to be without guidance—only a few, and they are exceptional, can make a journey to wisdom without a teacher.

You must have extraordinary passion, patience, and self-discipline to make a journey alone. The goals must be understood, and no diversion can be acknowledged or permitted if you are to attain enlightenment within the sphere of a chosen art.

This is a very difficult road to travel and not many are made for it. It is frustrating, confusing, very lonely, certainly frightening, and it will sometimes make you think you do not have much sanity left to deal with the everyday surroundings of your world. Also, there is no guarantee that you will attain perfection. It must all come from inside you without any preconceived notions on your part.

—Miyamoto Musashi (1643)  
(*The Book of Five Rings*)  
Translated by Stephen F. Kaufman, Hanshi 10<sup>th</sup> dan)



*“Oh...so you didn’t use the Thinking Process either?”*

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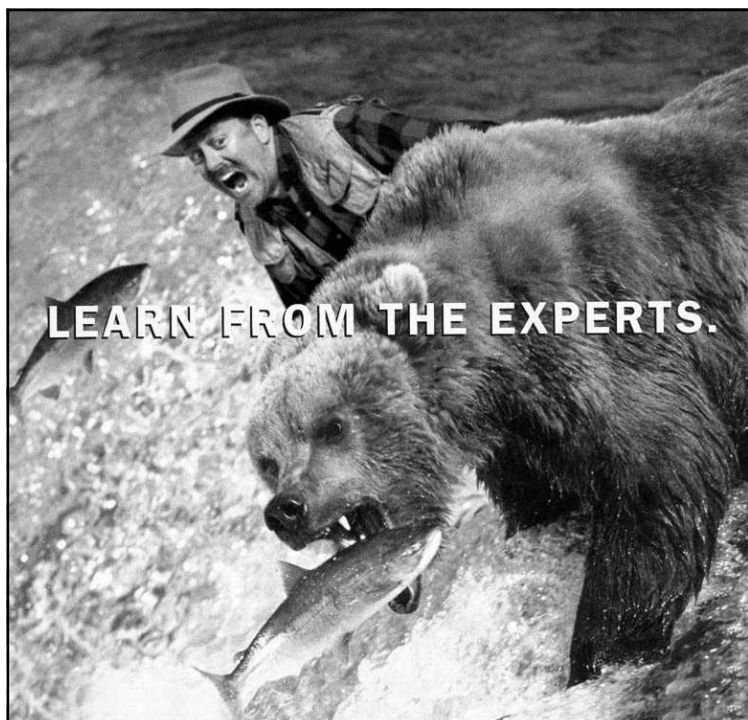
“Last Chance...”

Any questions?

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**LEARN FROM THE EXPERTS.**

*Goal  
Systems  
International*

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*"Constructing and Communicating  
Common Sense"*

T1

11

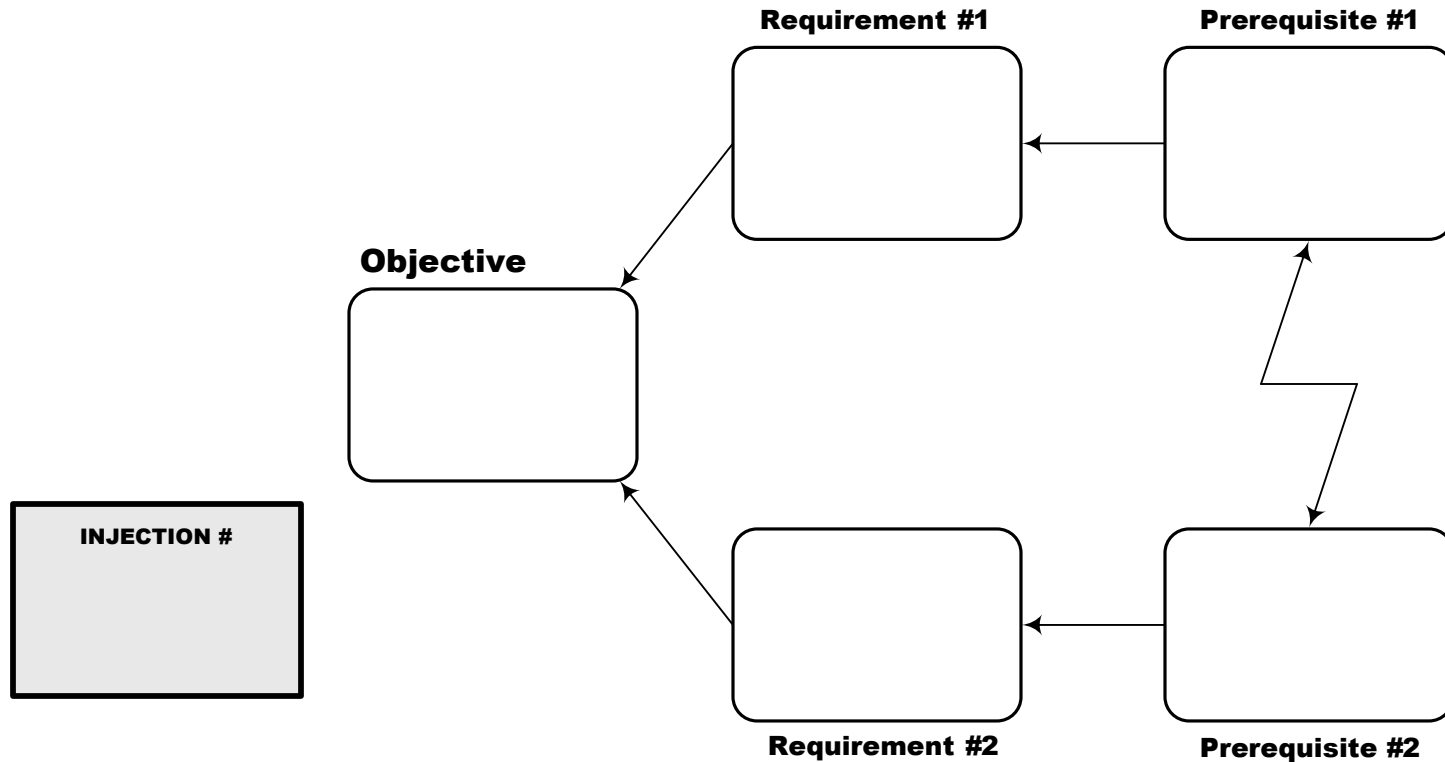
OE1



# “Row or Bail?”

## ASSUMPTIONS:

- 1.
- 2.
- 3.
- 4.



## ASSUMPTIONS:

- 5.
- 6.
- 7.
- 8.

**NEGATIVE BRANCH #1:**  
**“Anti-Terrorism Law”**

**[UNDESIRABLE EFFECT]**

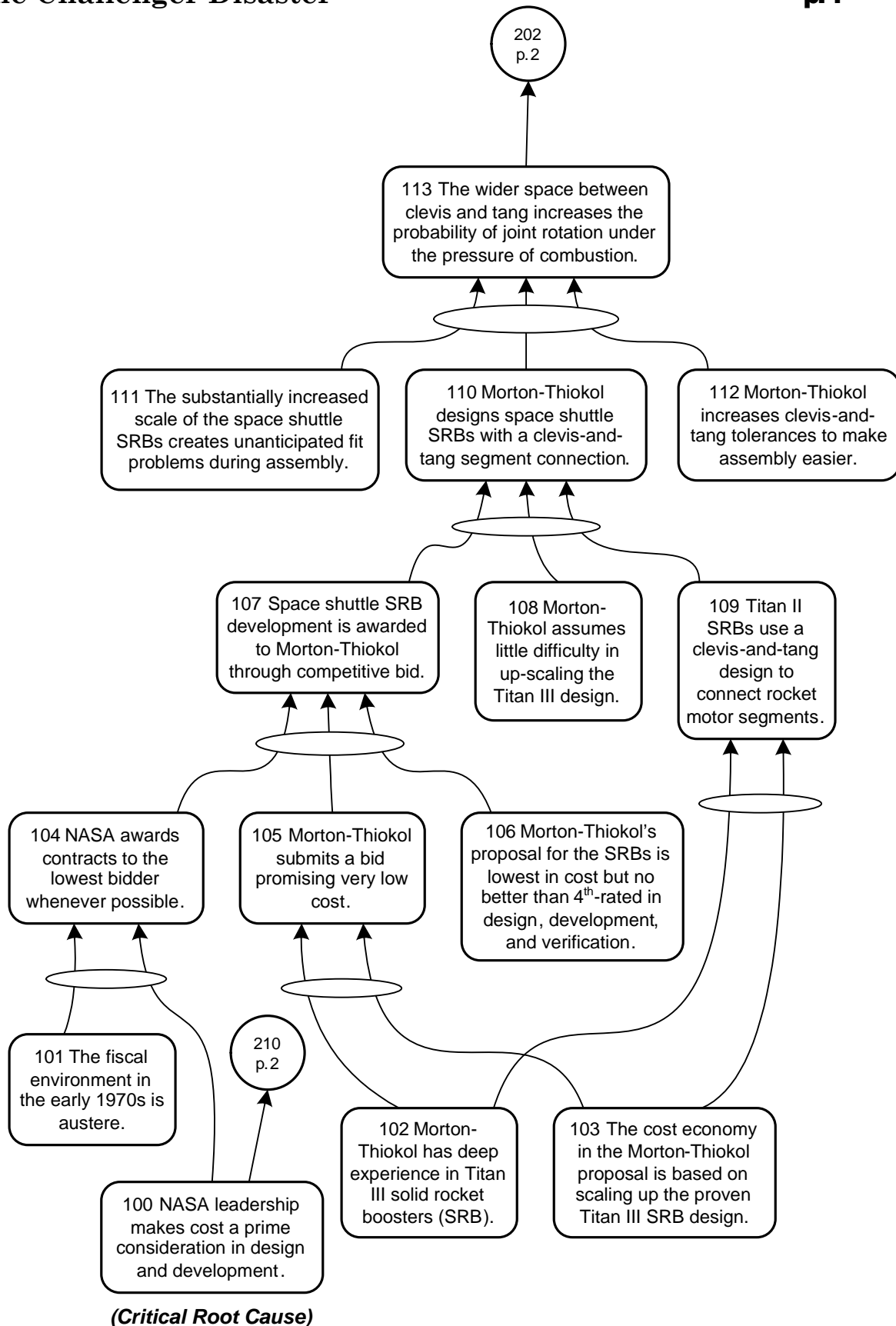
**NB-01** The threat of continuing terrorist attacks in our country is imminent.

**INJECTION**  
Anti-Terrorism Law of 200x is passed.

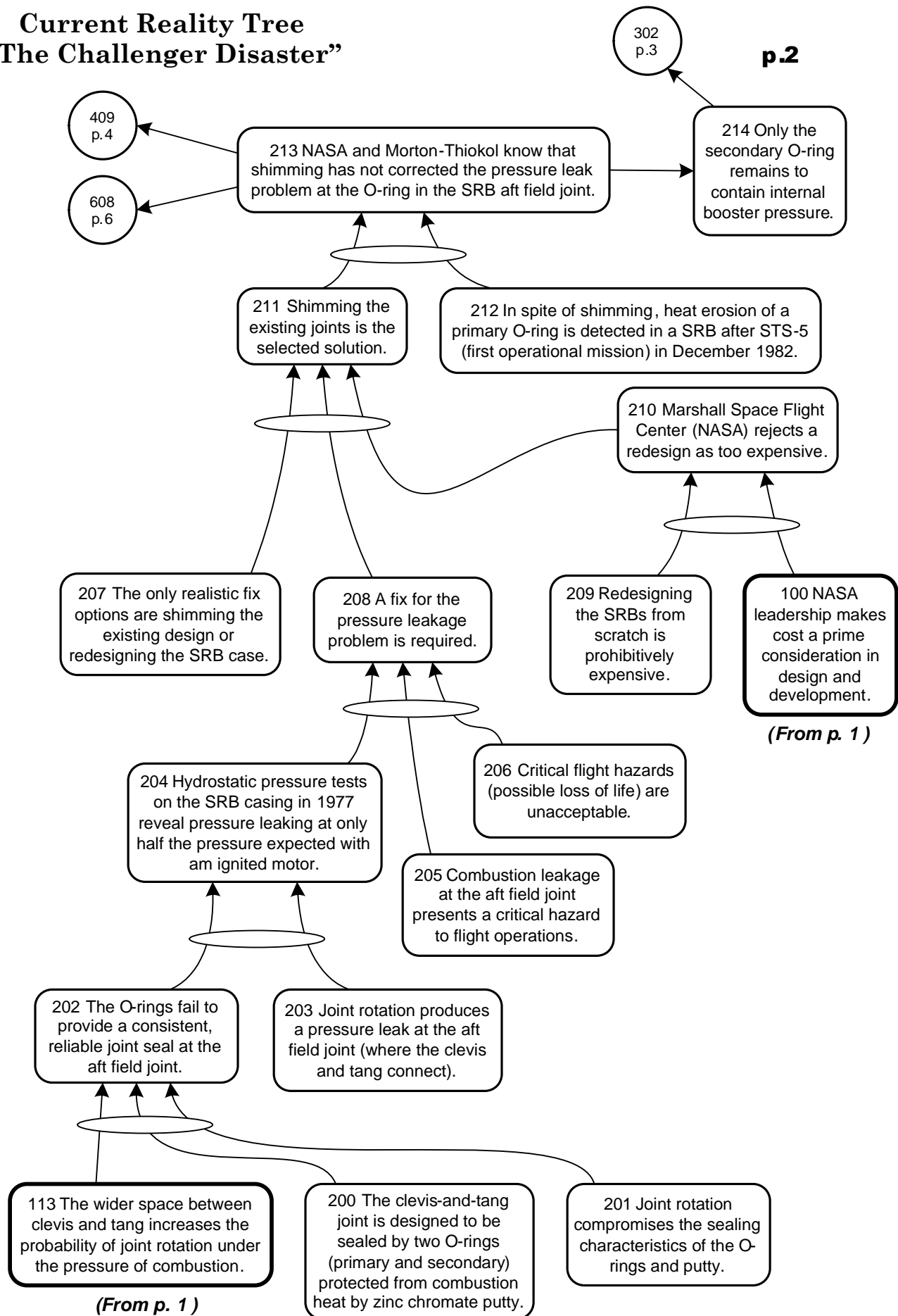
**NB-02** The AT Law of 200x contains a provision to...

# Current Reality Tree “The Challenger Disaster”

p.1

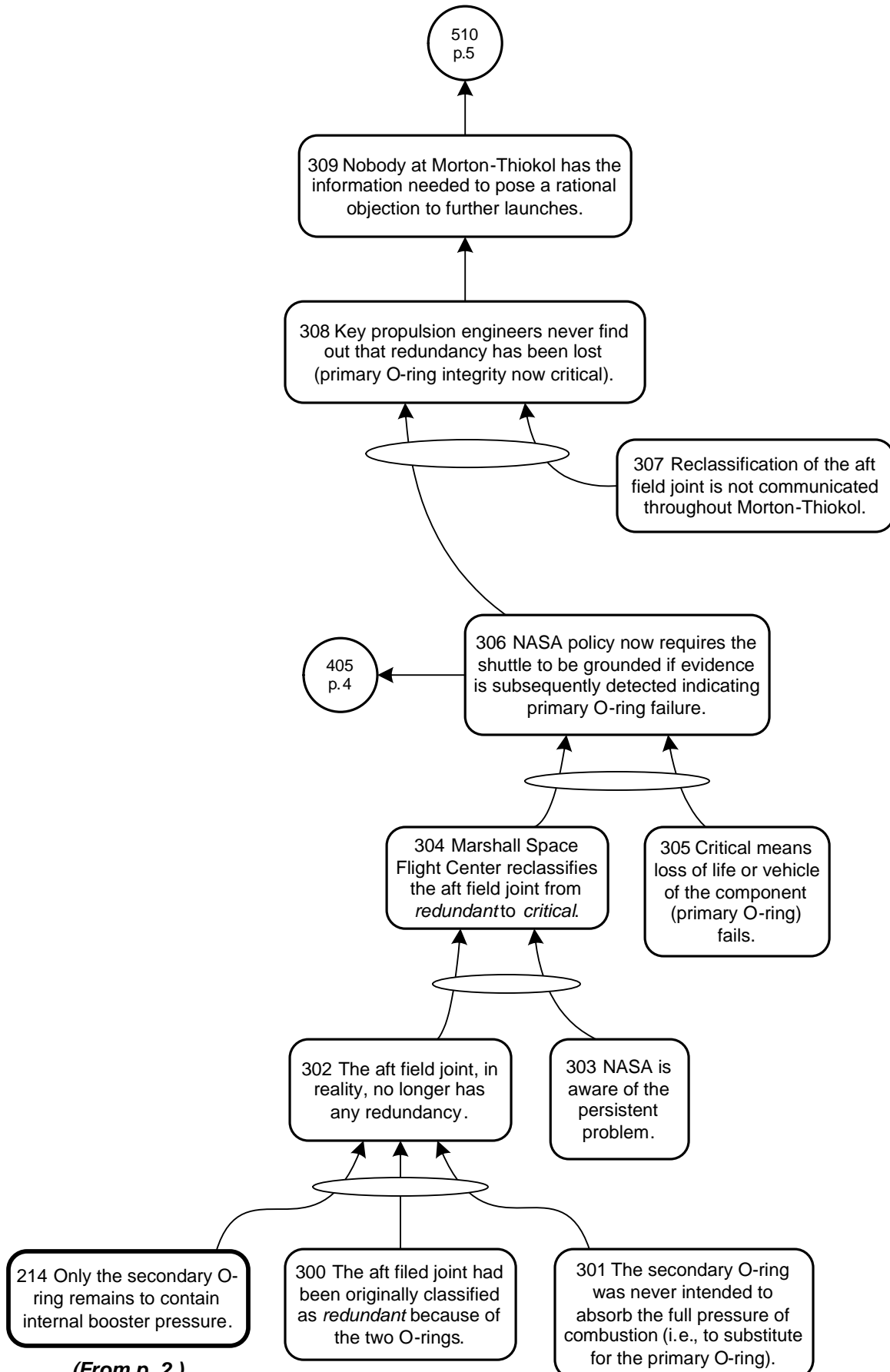


# Current Reality Tree “The Challenger Disaster”



# Current Reality Tree “The Challenger Disaster”

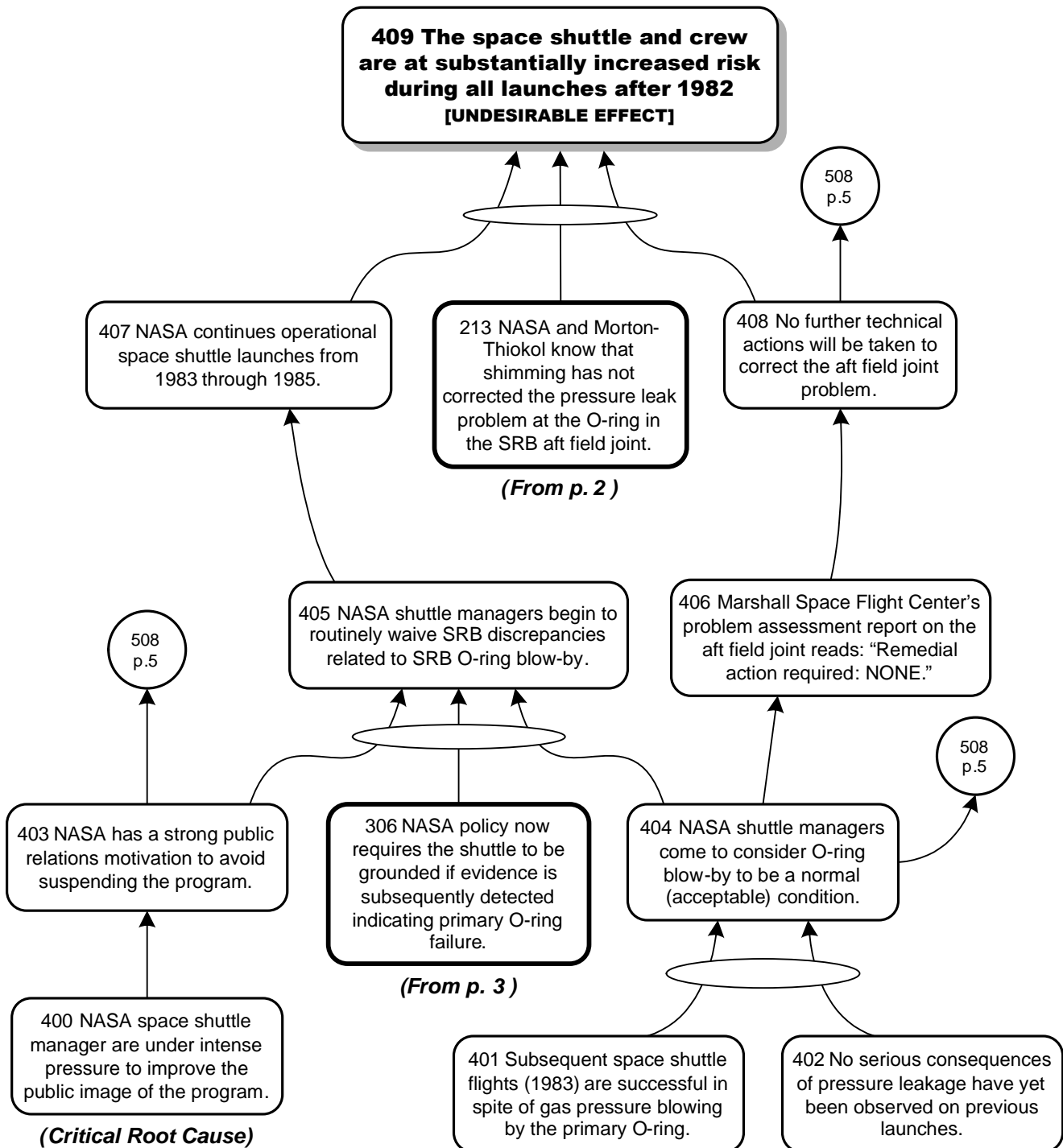
p.3



(From p. 2)

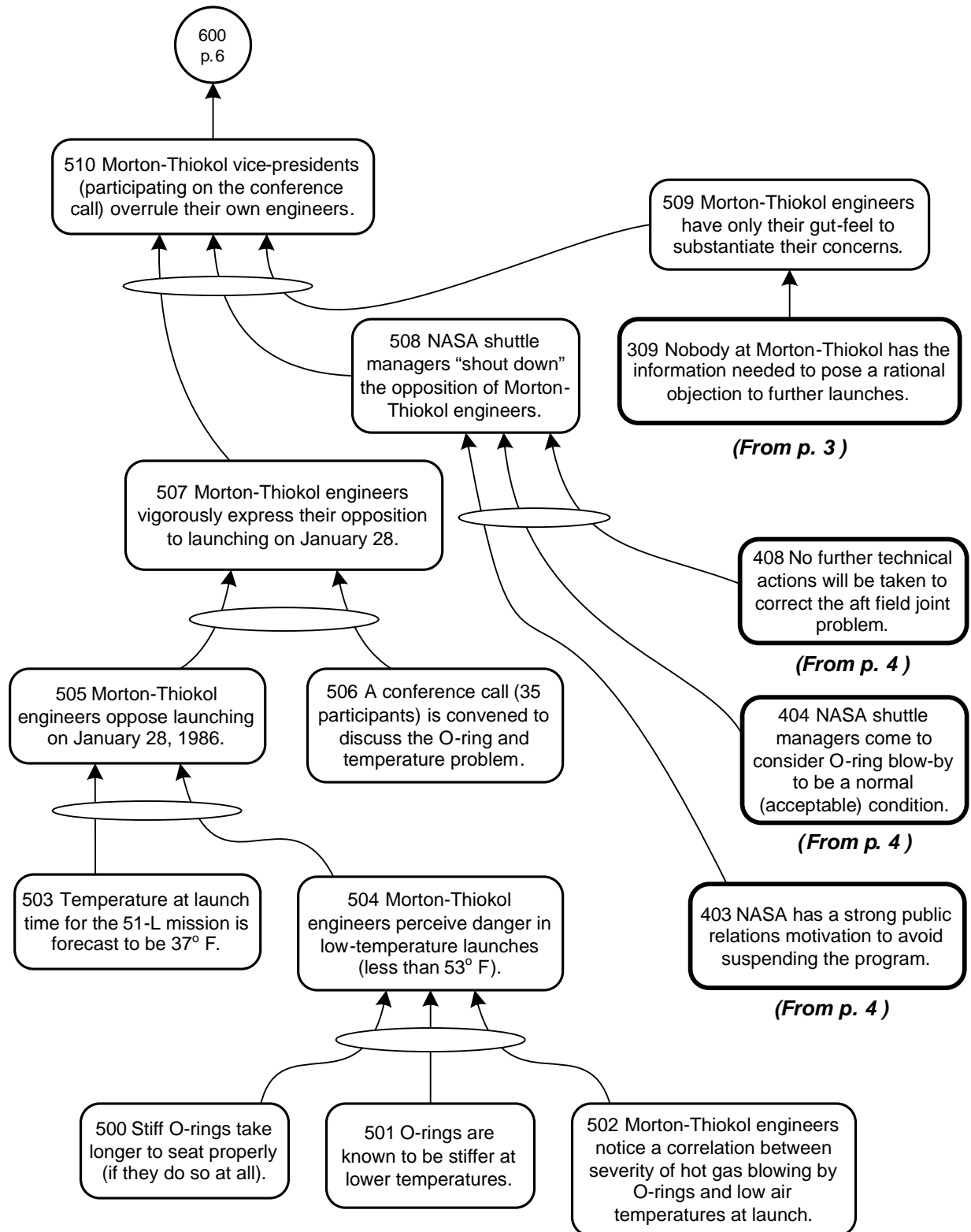
# Current Reality Tree “The Challenger Disaster”

p.4



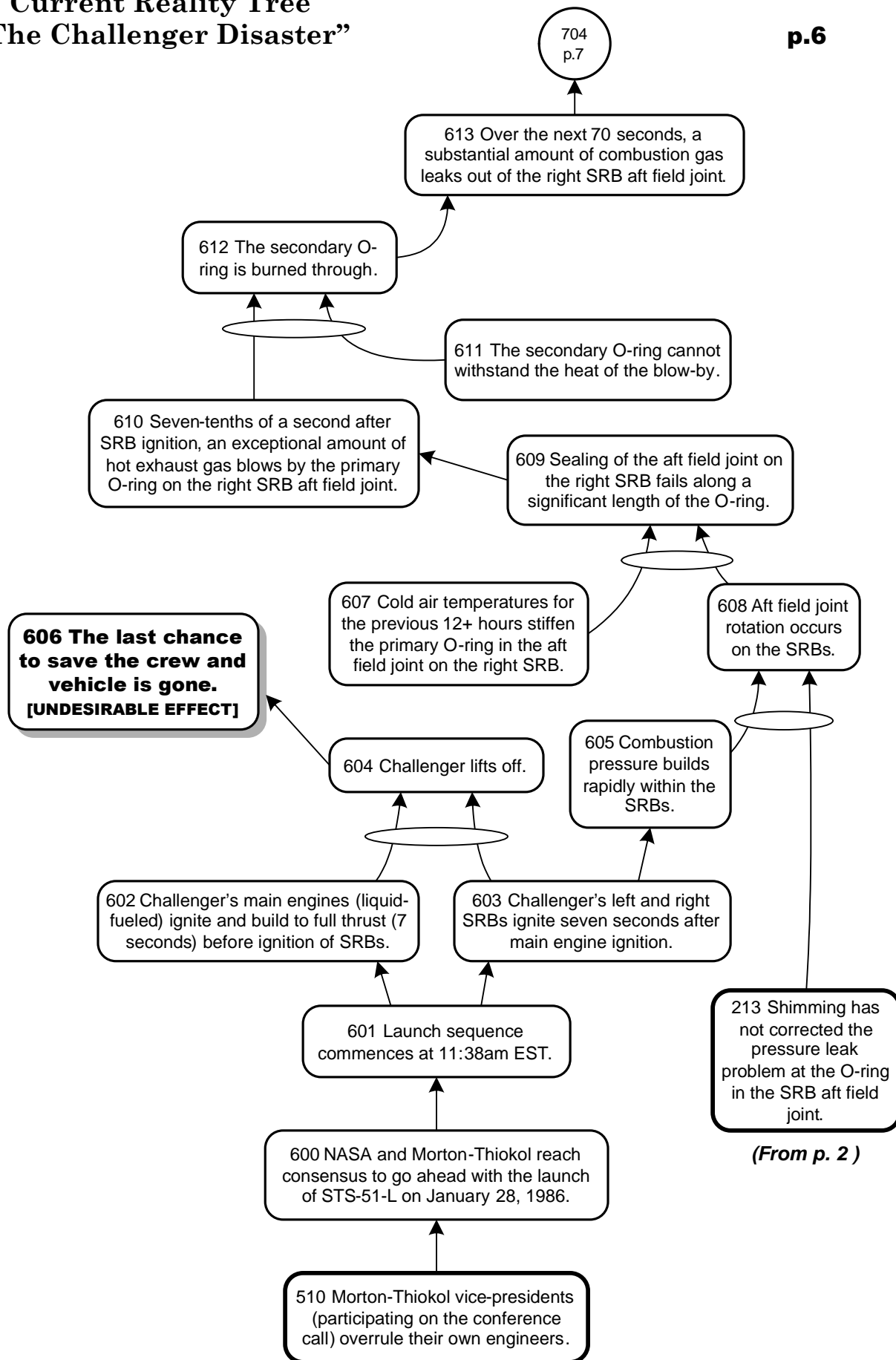
# Current Reality Tree “The Challenger Disaster”

p.5



# Current Reality Tree “The Challenger Disaster”

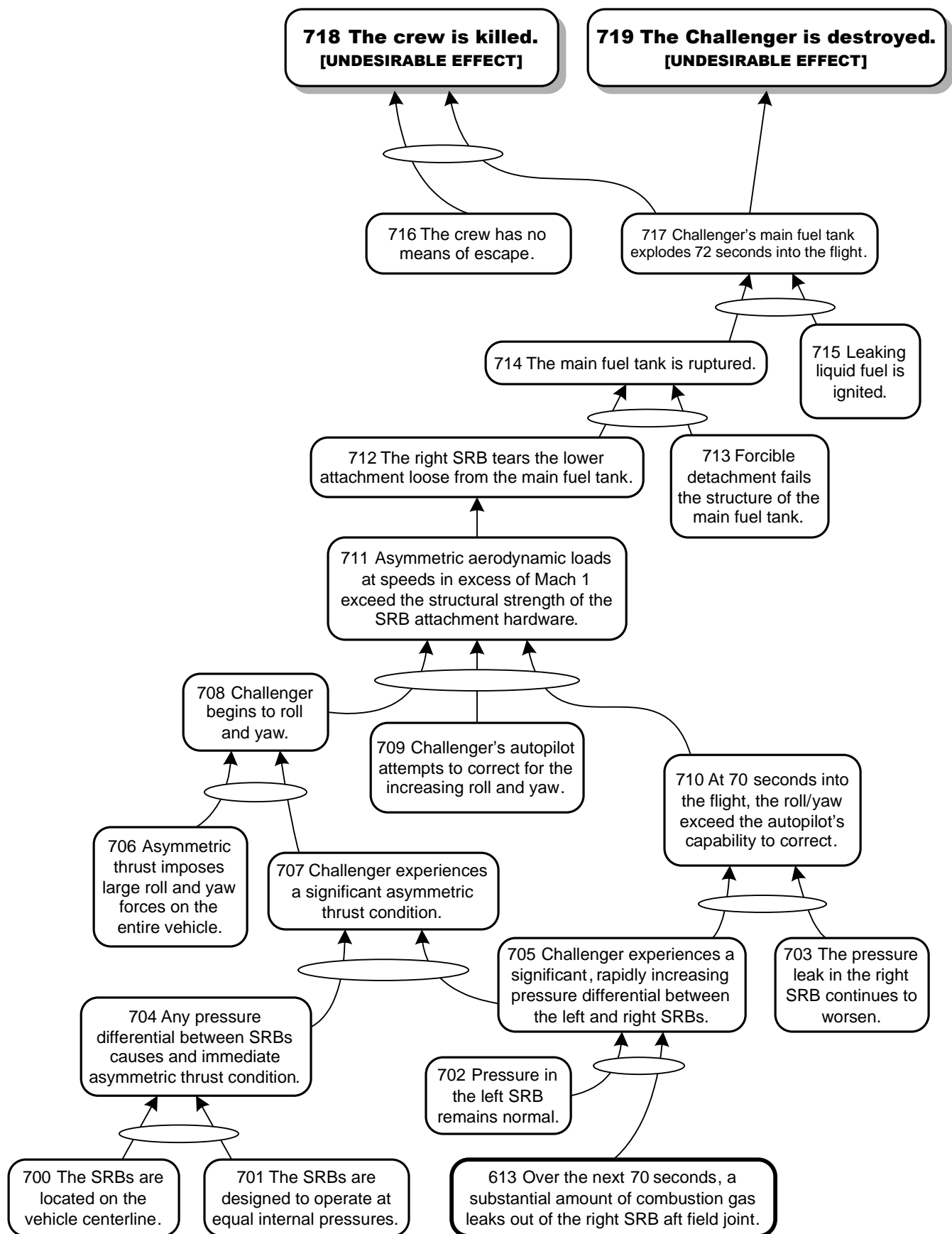
p.6





# Current Reality Tree “The Challenger Disaster”

p.7

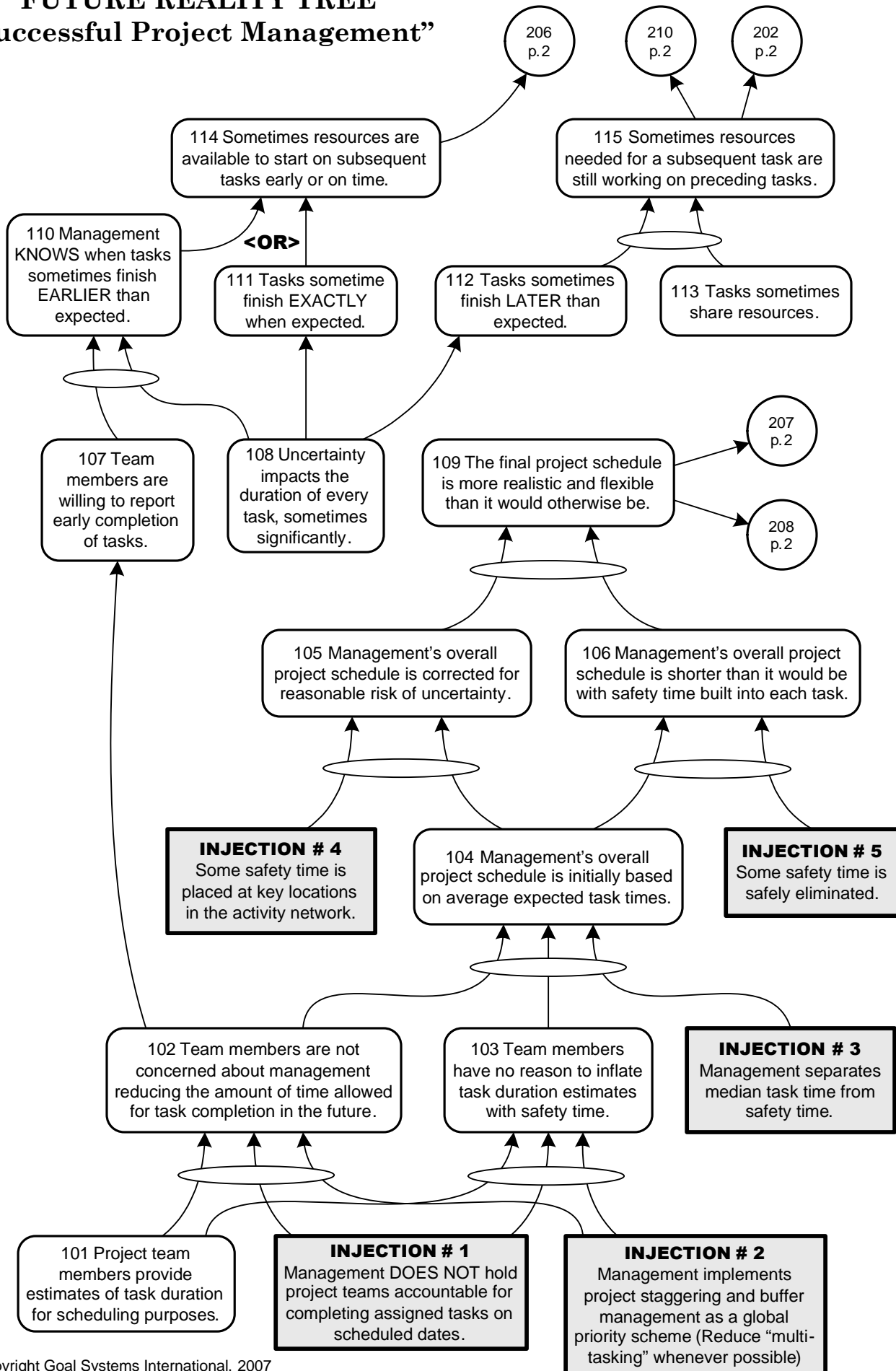


(From p. 6)

# FUTURE REALITY TREE

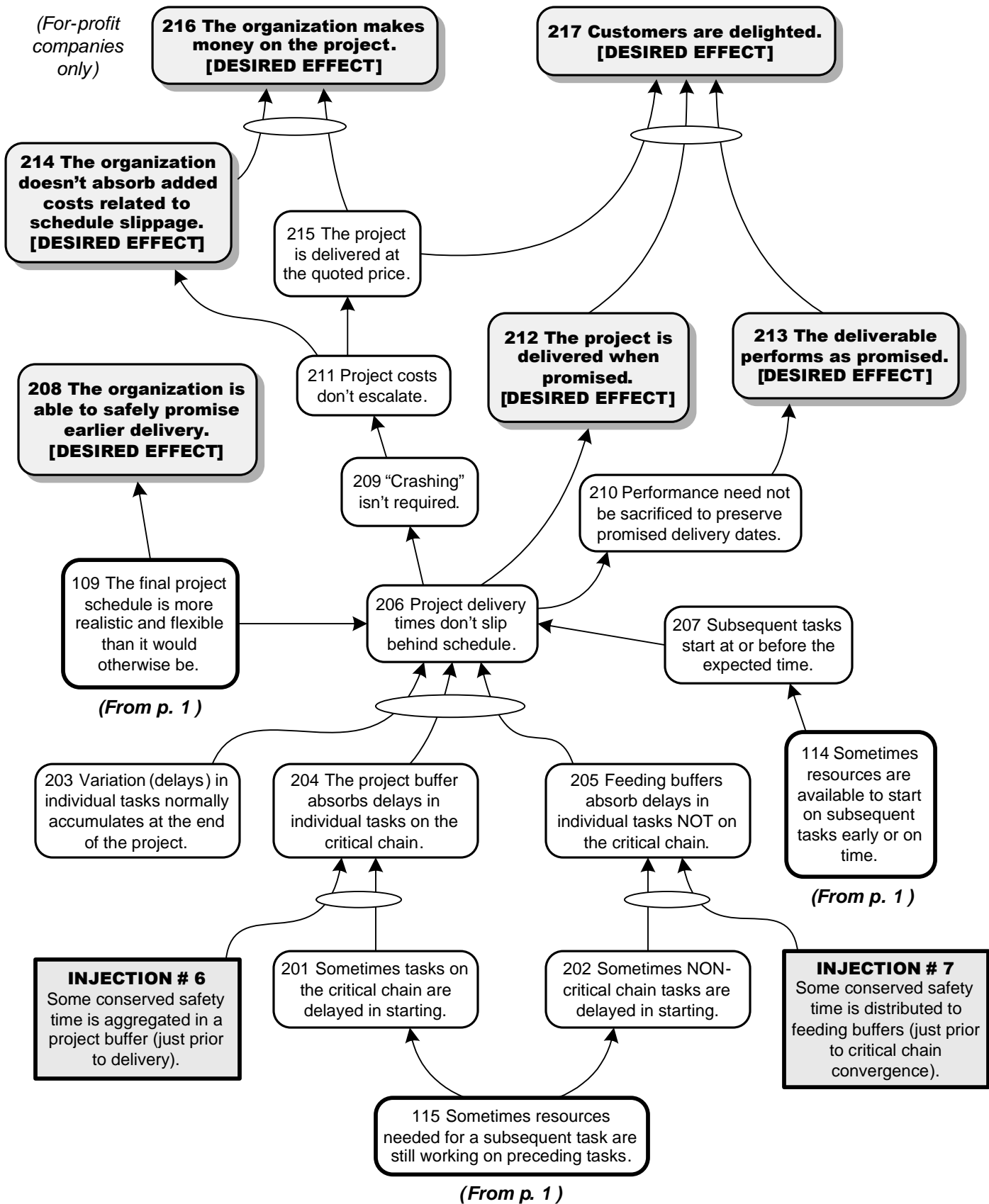
## “Successful Project Management”

p.1



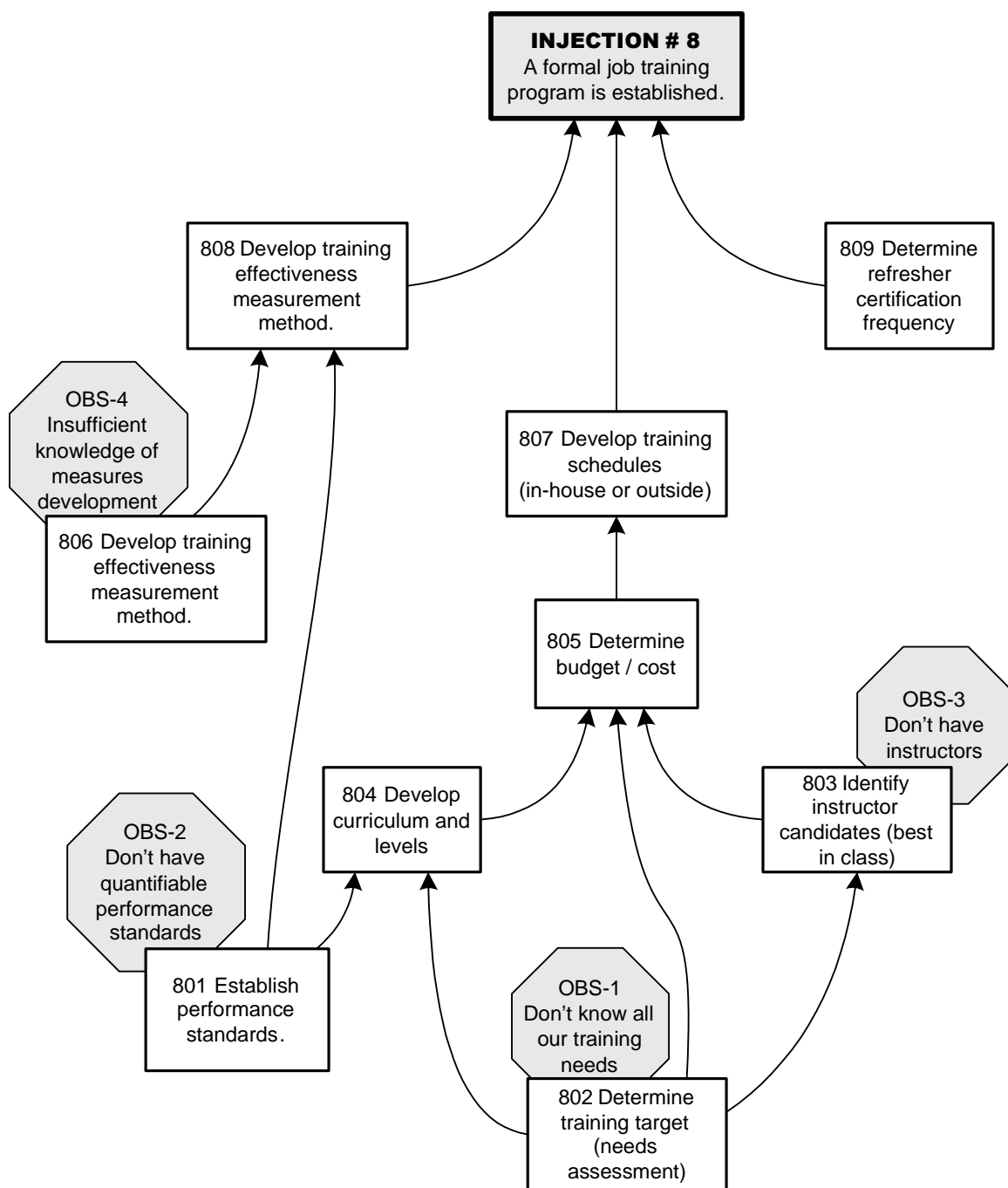
# FUTURE REALITY TREE

## “Successful Project Management”



## PREREQUISITE TREE

### “Wurtzburg Corporation”





# Goal Systems International

"CONSTRUCTING AND COMMUNICATING COMMON SENSE"™

## PROFESSIONAL RÉSUMÉ

**H. WILLIAM DETTMER.** Senior Partner, Goal Systems International.

**Author:** *The Logical Thinking Process: A Systems Approach to Complex Problem-Solving* (ASQ Quality Press, 2007); *Strategic Navigation: A Systems Approach to Business Strategy* (ASQ Quality Press, 2003); *Brainpower Networking Using the Crawford Slip Method* (Trafford Publishing, 2003); *High Velocity Manufacturing: Optimizing Supply Chain Financial Performance* (with Eli Schragenheim), CRC St. Lucie Press, 2000; *Breaking the Constraints to World-Class Performance* (ASQ Quality Press, 1998); *Goldratt's Theory of Constraints* (ASQ Quality Press, 1996); *The Handbook for Quality Management*. Thomas Pyzdek. (Ch. 9, "Constraint Management," by H.W. Dettmer). Tucson, AZ: Quality Publishing, 2000;.

Articles in *Quality Progress* magazine (April 1995, March 1999); *APICS Performance Advantage*, 2001.

Proceedings of the APICS Constraints Management Symposium (1995 - 2001); Proceedings of the APICS International Conference (2003).

Proceedings of the ASQ Quality Management Division Annual Conference (1997, 1998).

**Experience:** Consulting and training on established applications of constraint management tools in both manufacturing and services with Fortune 500 and other companies. Developing new applications for the constraint theory, principles, and tools, including preparation of legal cases for negotiated settlements or courtroom litigation, and the acquisition and turn-around of distressed businesses. Partial client list includes United Health Group; Raytheon Missile Systems, U.S. Air Force Software Technology Center, U.S. Navy Sea Systems Command, Tellabs, Lucent Technologies (both in Europe and the US), Western Digital Corporation, NEC America, Kauffman Products, Inc., Kendall Healthcare Products, Ericsson Cellular, Weyerhaeuser, Boeing, INESA and ICI/Inca Corporations (South America), Orrcon Ltd. (Australia), and Qualiplus, S.A. (Brazil).

Foremost expert in the world in the logical thinking process developed by E.M. Goldratt. Deep experience in logistics, project planning and execution, and contracting/ procurement. Direct responsibility for project management, logistics planning, government contracting, system design, financial management, productivity improvement, idea generation, team building, strategic planning, and customer-supplier relations.

Eight years teaching masters level courses in project management (University of Southern California); systems analysis and problem solving; systems integration; management control systems; managerial economics; human factors in systems; organizational behavior and development; decision analysis; and management of research, development, test, and evaluation (RDT&E) for the University of Southern California's Institute of Safety and Systems Management. Three years delivering professional seminars in constraint management for the American Society for Quality (ASQ).

**Education:** MS, University of Southern California; BA, Rutgers University

### Professional Affiliations:

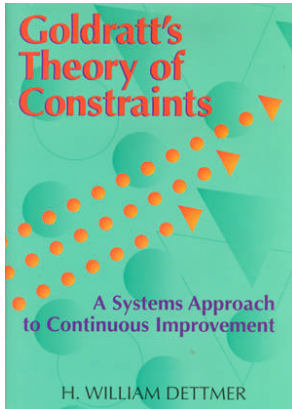
- Founding Board Member, TOC International Certification Organization (TOCICO); certified in the thinking process, holistic strategy, and operations management
- American Society for Quality (ASQ)
- American Production and Inventory Control Society (APICS)



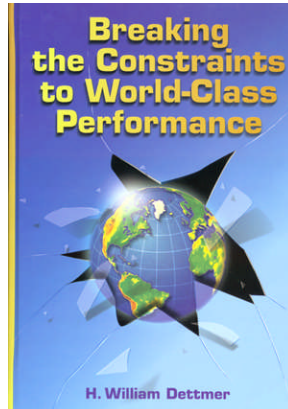
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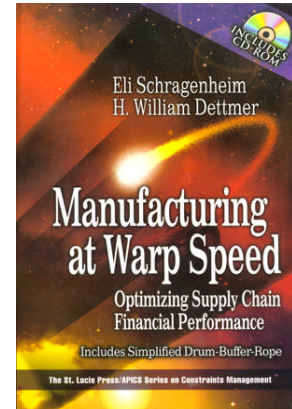
## PUBLISHED BOOKS



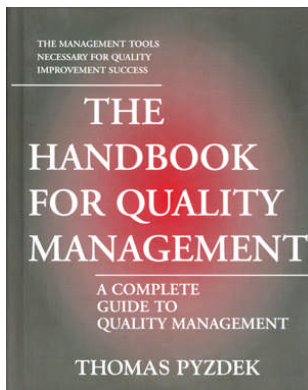
ASQ QUALITY PRESS, 1996



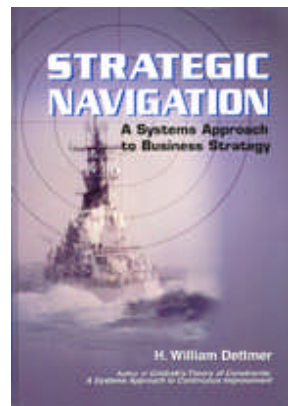
ASQ QUALITY PRESS, 1998



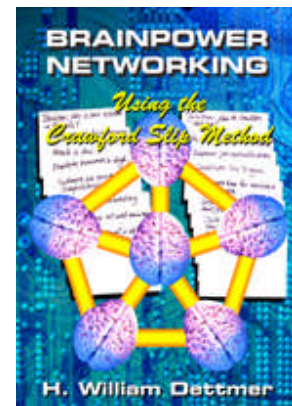
CRC ST. LUCIE PRESS, 2000



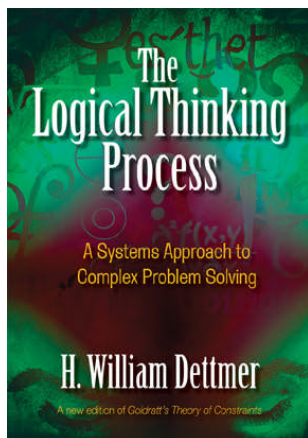
(Ch. 9 only)  
QUALITY PUBLISHING, 2000



ASQ QUALITY PRESS, 2003



TRAFFORD PUBLISHING, 2003



ASQ QUALITY PRESS, 2007

Supply Chain  
Fulfillment  
at  
Warp Speed

AUERBACH PUBLISHING  
(coming in 2008)