EG 2401(a) Engineering Professionalism

Lecture 3

Sem I, AY 2021-22

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Aug/Sep 2021

TOPIC 3 – Ethical Problem Solving Techniques

- ***Objective 1**: upon the completion of this lecture class, we will be able to apply ethical problem-solving methods to hypothetical and real cases.*

- ***Objective 2**: ... and also see how flow-charting can be used to solve engineering ethical problems.*

Reference Reading: *Fleddermann* 4th Ed Chapter 4

TOPIC 3 – Ethical Problem Solving Techniques

- THL3.1 - Preliminaries
- THL3.2 – Types of Issues in Ethical Problem Solving
- THL3.3 – The "Line Drawing" Methodology
- THL3.4 – The "Decision Flow-Charting" Methodology
- THL3.5 - Summary (III)

Reference Reading: *Fleddermann* 4th Ed Chapter 4

Example: Waste Isolation Pilot Plant (WIPP), Carlsbad, NM U.S.A. *[read also Fleddermann Chapter 3]*

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Example I: Waste Isolation Pilot Plant (WIPP), Carlsbad, NM U.S.A. *[read also Fleddermann Chapter 3]*

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WIPP	
 WIPP, a geological repository for radioactive waste	
Country	United States
State	New Mexico
County	Eddy County
Nearest city	Carlsbad

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Shipment of casks arriving at the WIPP

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Example: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116]*

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NUS National University of Singapore

Example II: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116]*

A-7 Corsair II	
	
U.S. Navy A-7E from Attack Squadron 46 (VA-46)	
Role	Attack aircraft
Manufacturer	Ling-Temco-Vought
First flight	26 September 1965
Introduction	February 1967

Close-up of a disc brake on a car

A railroad bogie and disc brakes

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THL3.2 – Types of Issues in Ethical Problem Solving

- ***A first step in solving any ethical problem is to completely understand all the issues involved.***

- ***The issues involved in understanding ethical problems can be split into 3 categories: factual; conceptual; & ethical/moral.***

- ***We will consider each category, and for better consistency, also show application (again) to the WIPP case; and then to the Goodrich A7-D brake case.***

Reference Reading: *Fleddermann* 4th Ed Section 4.2

THL3.2 – Types of Issues in Ethical Problem Solving

- ***Factual Issues**: these involve what is actually known about the case (with ethical implications) --- i.e. what the facts are. (Although the concept is straightforward, but because the cases involved are typically complex, the facts may not be always necessarily clear and may be controversial.)*

- ***Conceptual Issues**: these have to do with the meaning or applicability of an idea/action. While the idea/action itself may be obvious, "conceptually" it must be pondered whether that idea/action will lead to an unethical decision? Again, in complex cases, conceptual issues are not always clear-cut, and will often result in controversy as well.*

THL3.2 – Types of Issues in Ethical Problem Solving

- ***Ethical/Moral Issues*: these involve those matters/observations in the case where there are obviously ethical questions.**

- ***Types of Issues*: for our module, we will simply focus on being able to suitably "identify" these 3 types of issues and note them. For actual "ethical problem solving", we will then move further to look at the rather more-substantive methods of the "Ethics Line Drawing" and "Ethics Decision Flow-Chart". (See later.)**

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THL3.2 – Types of Issues
[Sample Analysis of WIPP...]

	Factual Issues (with ethical implications)
F1	Development of nuclear technology will result in nuclear waste.
F2	Nuclear waste, if left unattended, is dangerous.
F3	A Waste Isolation facility stores nuclear waste safely.

	Conceptual Issues (with ethical implications)
C1	When WIPP was first conceived, was there awareness that there were communities/townships along the planned waste transportation route?
C2	When WIPP was first conceived, were there checks/studies made first about the availability of suitably fortified safe transports?
C3	Were there consultations with the communities/townships, and were there any reasonable/useful proposals/suggestions considered?

THL3.2 – Types of Issues
[Sample Analysis of WIPP...]

	Ethical Issues
E1	Transportation of nuclear waste through the communities/townships presents various dangerous situations for them. *[Rights- & Virtue- Ethics]*
E2	Transportation of nuclear waste violates the civil rules (if these were existing) of transportation of harzardous materials through the communities/townships. *[Rule-Utilitarianism]*

Remark: We will look at the more detailed Goodrich A7-D brake case (after the break) which will show much more detailed examples.

THL3.2 – Types of Issues in Ethical Problem Solving

- ***Types of Issues*: for our module, we will simply focus on being able to suitably "identify" these 3 types of issues and note them. For actual "ethical problem solving", we will then move further to look at the rather more-substantive methods of the "Ethics Line Drawing" and "Ethics Decision Flow-Chart". (See later.)**

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THL3.3 – Ethics Line Drawing

- ***Ethics Line Drawing**: Line Drawing is performed by drawing a line along which various examples and hypothethical situations (also called "scenarios") are placed.*

- ***Ethics Line Drawing**: At one end is placed the "positive paradigm" (PP), an example of something that is unambigously fully morally acceptable. At the other end is the "negative paradigm" (NP), an example of something that is unambigously not morally acceptable at all.*

Reference Reading: *Fleddermann* 4th Ed Section 4.3

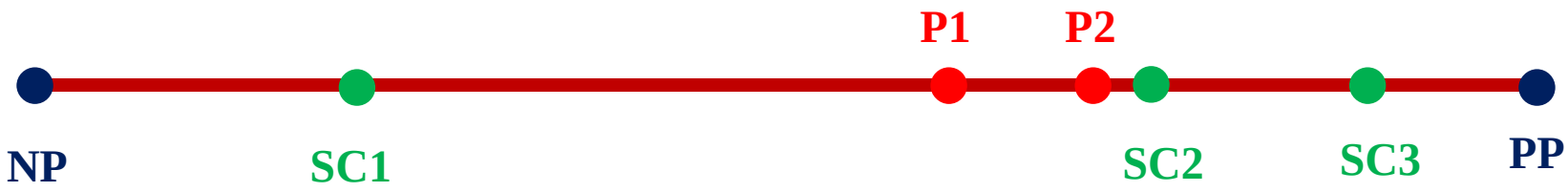
THL3.3 – Ethics Line Drawing

- ***Ethics Line Drawing**: In between is placed the problem(s) under consideration (P1, P2 etc, also referred as the "points under study"), which denotes the actual/ choices that are made.*

- ***Ethics Line Drawing**: Various other examples/scenarios (SC1, SC2 etc; possibly hypothethical) are also given assessment and placed on the Line. Those scenarios that more closely conform to the PP are placed nearer it; while scenarios closer to the NP are placed nearer that (with separating distance loosely using a judgement of "severity").*

Reference Reading: *Fleddermann* 4th Ed Section 4.3

THL3.3 – Ethics Line Drawing



Pt	Ethics Line Drawing, from point-of-view of Party #1	Location from Left
NP	Negative paradigm.	Left point
PP	Positive paradigm.	Right point
P1	Point #1 under study.	Approx p1/10
P2	Point #2 under study… etc	Approx p2/10
SC1	Possible Scenario #1 to be considered.	Approx sc1/10
SC2	Possible Scenario #2 to be considered.	Approx sc2/10
SC3	Possible Scenario #3 to be considered… etc	Approx sc3/10

THL3.3 – Ethics Line Drawing

- ***Ethics Line Drawing*: By carefully examining this continuum and placing the moral problem under consideration in the appropriate place along the line, it is possible to determine whether the problem is more like the PP or NP, and therefore whether it is acceptable or unacceptable.**

Reference Reading: *Fleddermann* 4th Ed Section 4.3

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Example: Waste Isolation Pilot Plant (WIPP), Carlsbad, NM U.S.A. *[read also Fleddermann Chapter 3]*

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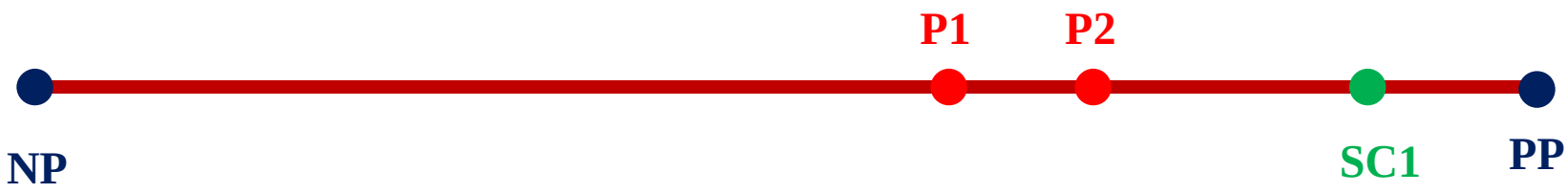
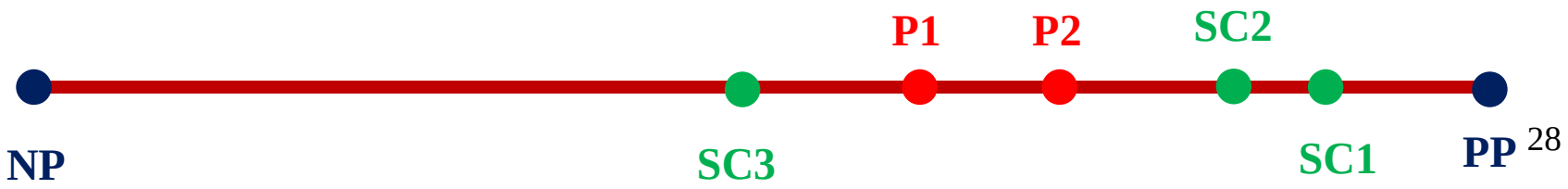


Pt	Ethics Line Drawing, from point-of-view of US nuclear agency	Location from Left
NP	Use most convenient transport for nuclear waste, disregarding concerns of communities/townships and existing rules.	Left point
PP	Properly transport nuclear waste, with suitable transports, with suitable security/safety escorts, and building and using routes which avoids all possible communities/townships.	Right point
P1	Use suitably modified and fortified transports for the nuclear waste.	Approx 6.5/10
P2	Use suitably modified and fortified transports for the nuclear waste, accompanied with suitable security/safety escorts.	Approx 7.5/10
SC1	Use suitably modified and fortified transports for the nuclear waste, and at the same time develop & build alternate routes to be used in the future which avoids all possible communities/townships.	Approx 9/10

Pt	Ethics Line Drawing, from point-of-view of communities/townships	Location from Left
NP	Completely prevent passage of WIPP transports.	Left point
PP	Engage and work closely with US nuclear agency reps, to enable proper transport of nuclear waste, with suitable transports, with suitable security/safety escorts, and building and using routes which avoids all possible communities/townships.	Right point
P1	Allow the use of suitably modified and fortified transports for the nuclear waste.	Approx 6.5/10
P2	Allow the use of suitably modified and fortified transports for the nuclear waste, accompanied with suitable security/safety escorts.	Approx 7.5/10
SC1	Engage and work closely with US nuclear agency reps, to enable use of suitably modified and fortified transports for the nuclear waste, and at the same time develop & build alternate routes to be used in the future which avoids all possible communities/townships.	Approx 9/10
SC2	Seek and obtain Federal budget to support the formation and training of their own security/safety escorts, which will oversee WIPP transportation within their vicinity/jurisdiction.	Approx 8.5/10
SC3	Allow WIPP transport, say, only a once-a-month time window.	Approx 5/10



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THL3.4 – Ethics Decision Flow Charting

- ***Ethics Flow Charting**: This will be helpful for analyzing a variety of cases, especially those in which there is a sequence of events to be considered; or a series of consequences that flow from each decision.*

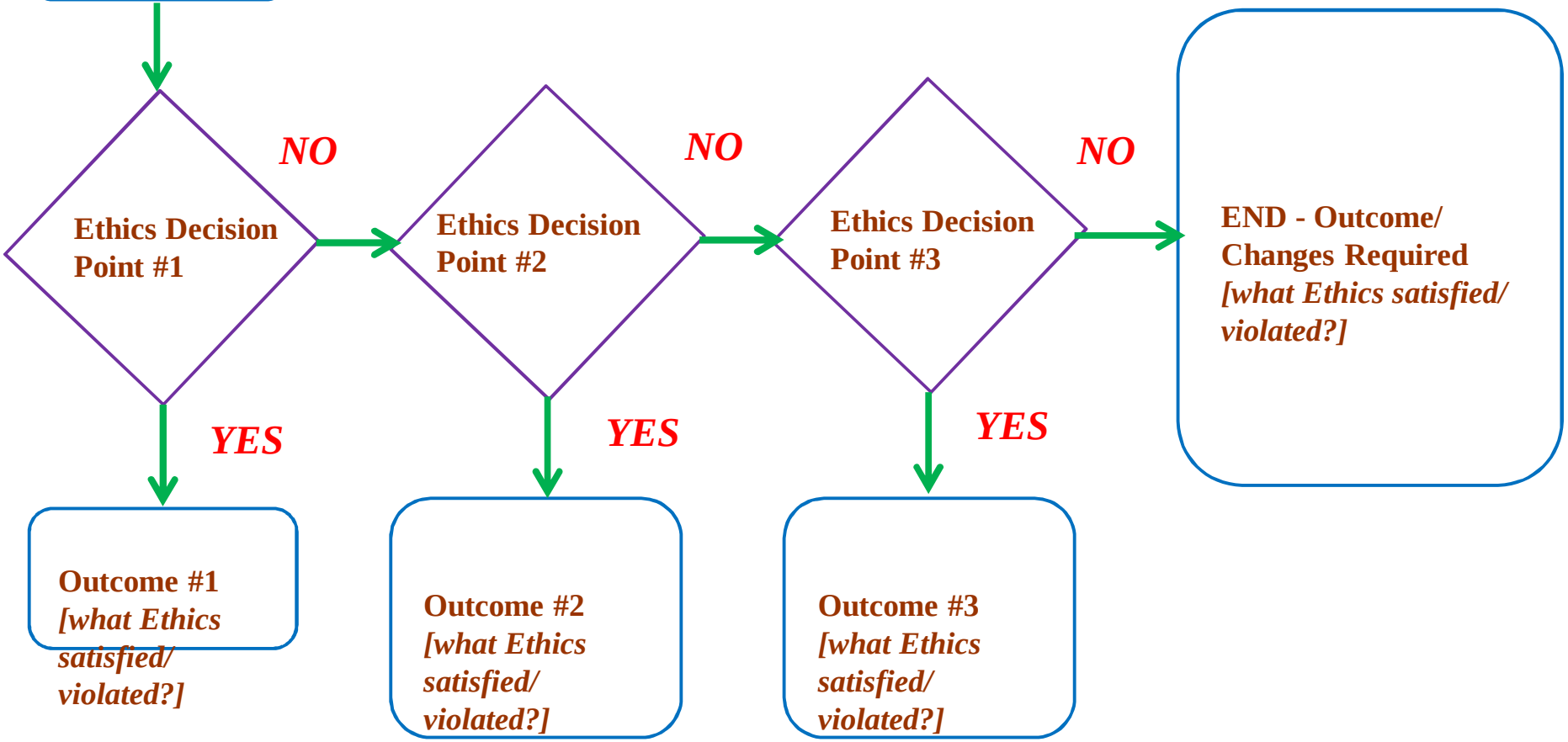
- ***Ethics Flow Charting**: An advantage of using a flow chart to analyze ethical problems is that it gives a visual picture of a situation and allows you to readily see the consequences that flow from each decision. Important to note that there is no such thing as a "unique" flow chart for a given problem!! YOU need to ponder and create the suitably appropriate flow chart!*

Reference Reading: *Fleddermann* 4th Ed Section 4.4

THL3.4 – Ethics Decision Flow Charting

START:
Action/ Choice to be considered by NNN

Ethics Decision Flow-Chart, from point-of-view of Party #n NNN [a general commonly used structure]



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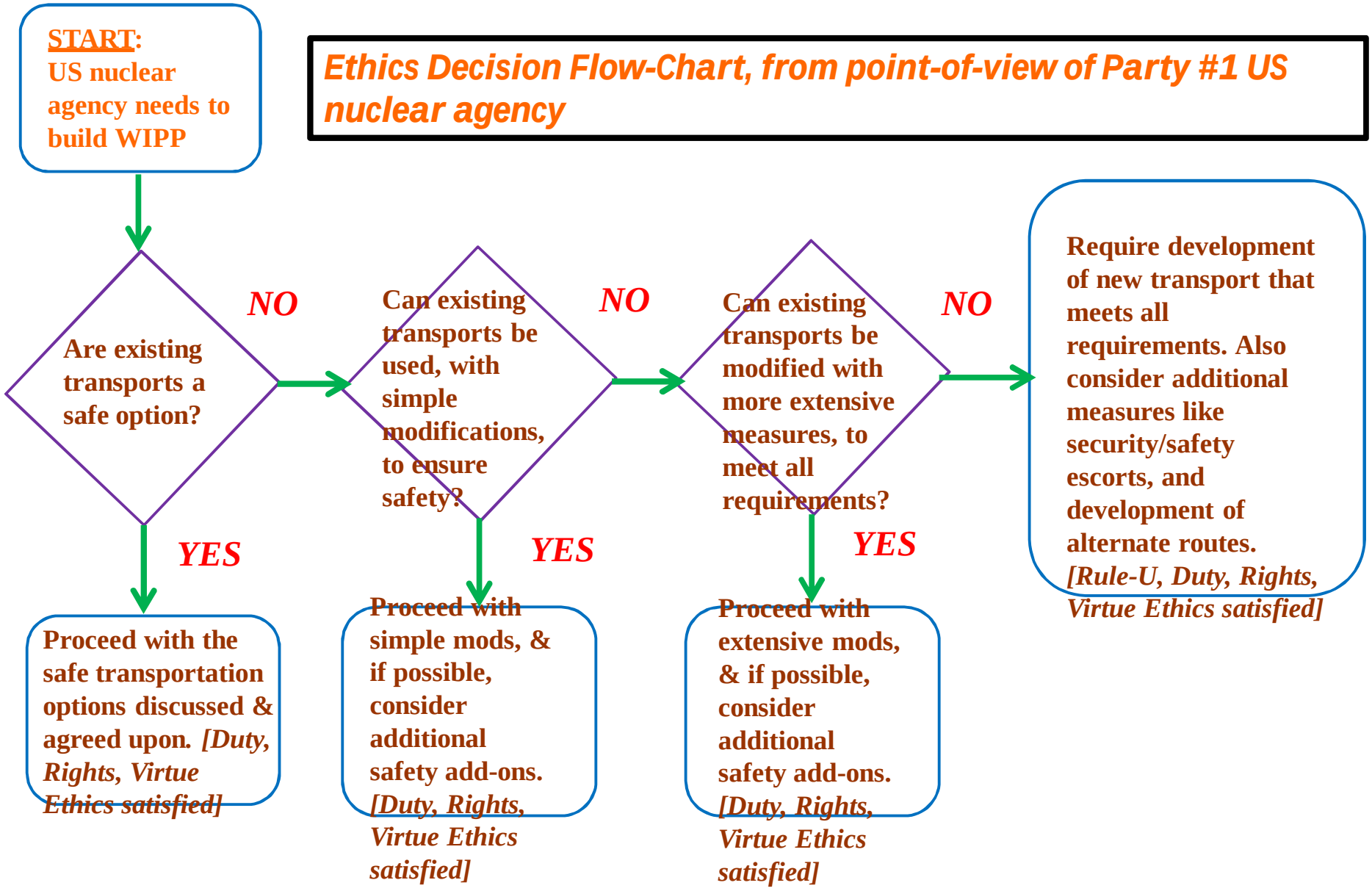
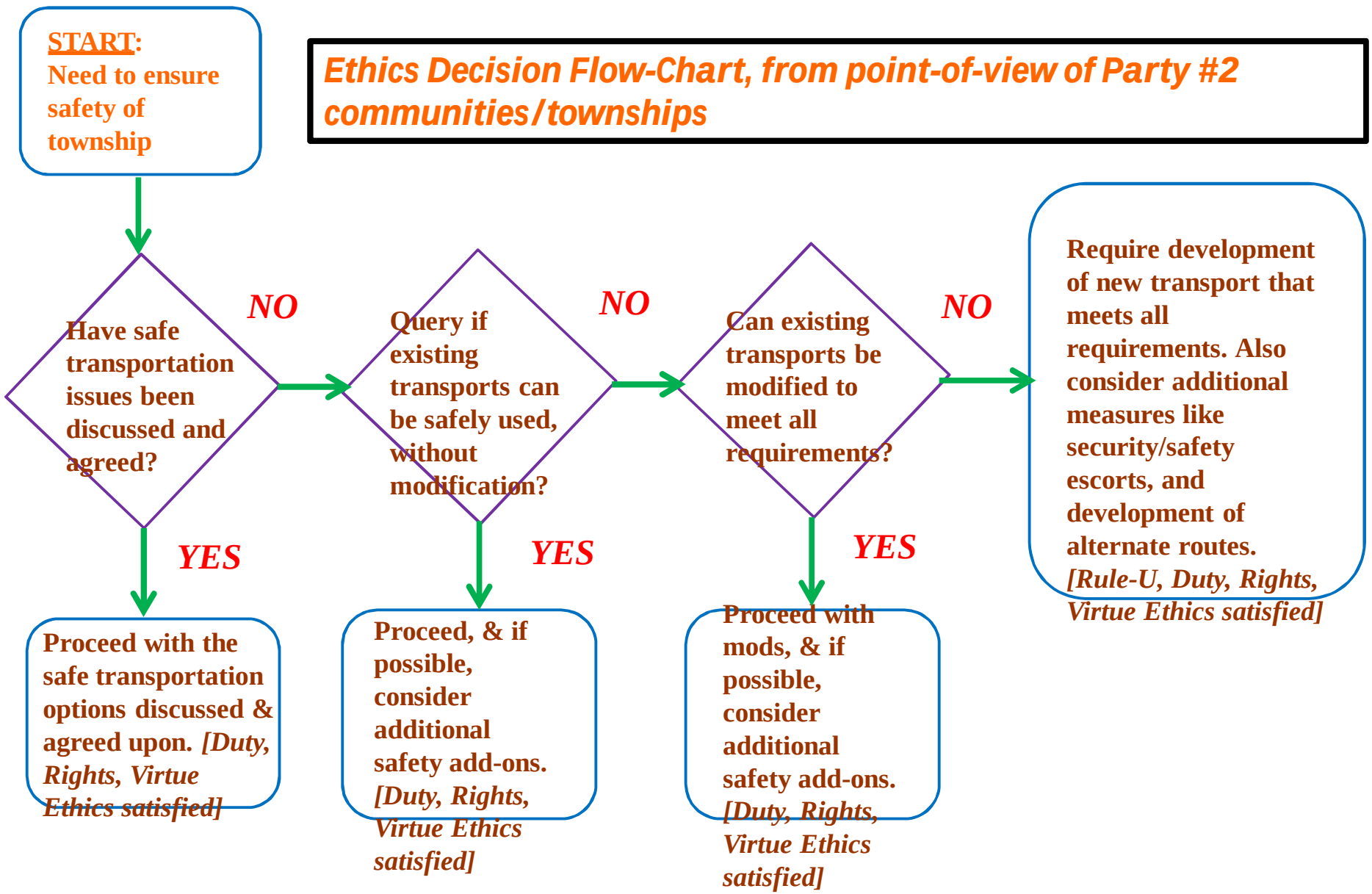
Ethics Decision Flow-Chart, from point-of-view of Party #1 US nuclear agency




START:
Need to ensure safety of township
Ethics Decision Flow-Chart, from point-of-view of Party #2 communities/townships
Have safe transportation issues been discussed and agreed?
NO
YES
Proceed with the safe transportation options discussed & agreed upon. [Duty, Rights, Virtue Ethics satisfied]
Query if existing transports can be safely used, without modification?
NO
YES
Proceed, & if possible, consider additional safety add-ons. [Duty, Rights, Virtue Ethics satisfied]
Can existing transports be modified to meet all requirements?
NO
YES
Proceed with mods, & if possible, consider additional safety add-ons. [Duty, Rights, Virtue Ethics satisfied]
Require development of new transport that meets all requirements. Also consider additional measures like security/safety escorts, and development of alternate routes. [Rule-U, Duty, Rights, Virtue Ethics satisfied]

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THL3.5 – Summary III (Ethical Problem Solving Techniques)

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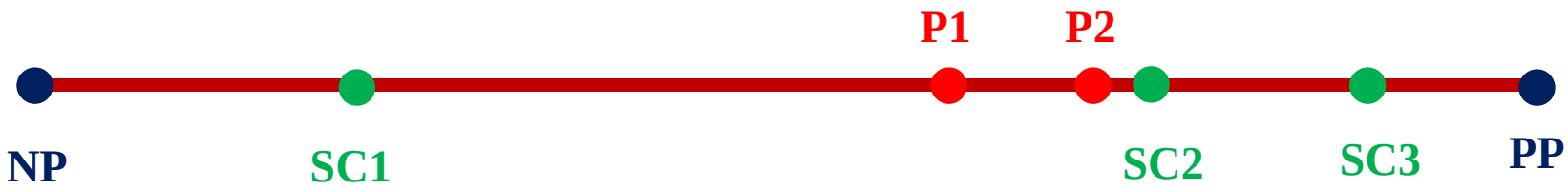

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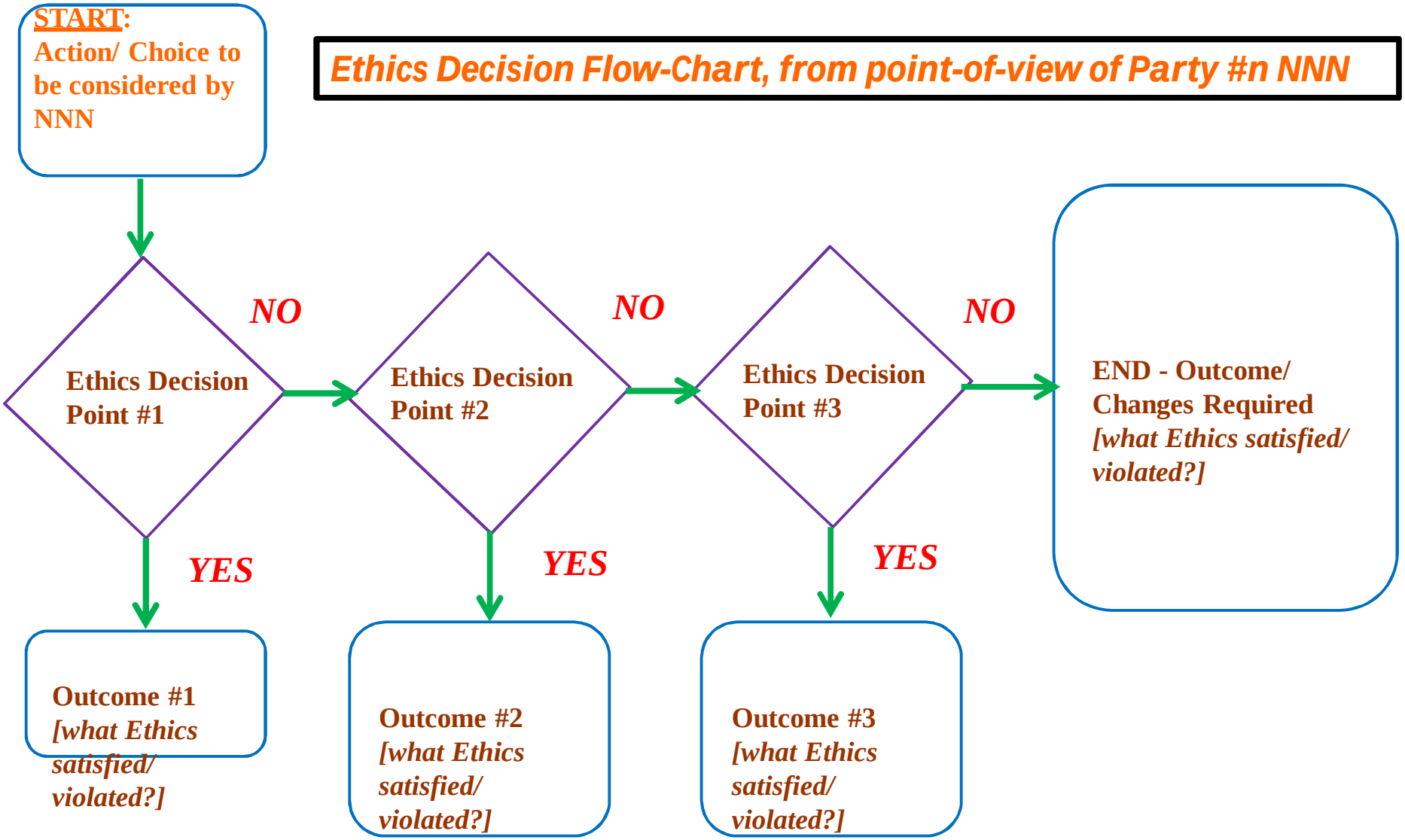

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Additional Practice: the Goodrich A7-D brake case

Example: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116]*

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Role	Attack aircraft
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Close-up of a disc brake on a car

A railroad bogie and disc brakes

© Wikipedia

Example: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116; full text here]*

This case is one that is very often used as an example in engineering ethics texts, especially to study whistle-blowing. In studying this case, it is important to keep in mind that much of the information presented here is derived from the writing of the whistle-blower. An individual who is deeply embroiled in a controversial situation such as this one will have different insights and viewpoints on the situation than will management or other workers. Little is publicly known about what Goodrich management thought about this case.

In the 1960s, the B.F.Goodrich Corporation was a major defense contractor. One of their main defense-related industries was the production of brakes and wheels for military aircraft. This industry was located in Troy, Ohio. Goodrich had developed a new and innovative design: a four-rotor brake that would be considerably lighter than the more traditional five-rotor design. Any reduction in weight is very attractive in aircraft design, since it allows for an increase in payload weight with no decrease in performance.

Example: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116; full text here]*

In June of 1967, Goodrich was awarded the contract to supply the brakes for the A7-D by LTV, the prime contractor for the airplane. The qualifying of this new design was on a very tight schedule imposed by the Air Force. The new brake had to be ready for flight testing by June of 1968, leaving only one year to test and qualify the design. To qualify the design for the flight test, Goodrich had to demonstrate that it performed well in a series of tests specified by the Air Force.

After the design had been completed, John Warren, the design engineer, handed the project over to Searle Lawson, who was just out of engineering school, to perform the testing of the brakes. Warren moved on to other projects within the corporation. Lawson's first task was to test various potential brake-lining materials to see which ones would work best in this new design. This test would be followed by the testing of the chosen linings on full-scale prototypes of the brakes. Unfortunately, after six months of testing, Lawson was unable to find any materials that worked adequately. He became convinced that the design itself was flawed and would never perform according to the Air Force's specifications.

Example: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116; full text here]*

Lawson spoke with Warren about these problems. Warren still felt that the brake design was adequate and made several suggestions to Lawson regarding new lining materials that might improve performance. However, none of these suggestions worked and the brakes still failed to pass the initial tests. Lawson then spoke about these problems with Robert Sink, the A7-D project manager at Goodrich. Sink asked Lawson to keep on trying some more linings and expressed confidence that the design would work correctly.

In March of 1968, Goodrich began testing the brake prototypes. After 13 tests, the brake had yet to pass the Air Force's specification for temperature. The only way to get the brakes to pass the test was to set up cooling fans directed at the rotors. Obviously, brakes that required extra cooling would not meet the Air Force's specification. Nevertheless, Sink assured LTV that the brake development was going well.

Example: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116; full text here]*

Kermit Vandivier was a technical writer for Goodrich who was responsible for writing test reports and was assigned to write the report for the new A7-D brakes. This report would be an integral part of the Air Force's decision-making process. Vandivier was not an engineer, but he did have experience in writing up the results of this type of test. In the course of writing the report on the A7-D brake tests, Vandivier became aware that some of the test results had been rigged to meet the Air Force's specifications. Vandivier raised his concerns about the report he was writing, feeling that he couldn't write a report based on falsified data. His attempts to write an accurate report were not allowed by management, and Goodrich submitted a report using the jury-rigged data. Based on this report, the brake was qualified for flight testing.

Vandivier was concerned about the safety of the brake and wondered what his legal responsibility might be. He contacted his attorney, who suggested that he and Lawson might be guilty of conspiracy to commit fraud and advised Vandivier to meet with the U.S. Attorney in Dayton. Upon advice of the U.S. Attorney, both Lawson and Vandivier contacted the FBI.

Example: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116; full text here]*

In July, the Air Force asked Goodrich to supply the raw test data for review. This request led to efforts at Goodrich to control the damage that would ensue when the real nature of the tests became known. Not being satisfied with the report presented to it, the Air Force refused to accept the brake. Knowing that the four-rotor brake was not going to work, Goodrich began an effort to design a five-rotor replacement. Vandivier continued meeting with the FBI and supplied FBI agents with Goodrich documents related to the A7-D brake tests.

Apparently, Lawson had impressed LTV because after the flight testing was over, LTV offered him a job. Lawson accepted and left Goodrich on October 11, 1968. With the only other person who really knew about the test procedures gone, Vandivier also decided to resign from Goodrich. In his letter of resignation, he included a series of accusations of wrongdoing against Goodrich regarding the brake tests. Vandivier went to work for the *Troy Daily News*, the local newspaper.

Example: The Goodrich A7-D Brake Case *[read also Fleddermann pp 114-116; full text here]*

At the *Daily News*, Vandivier told his editor about the situation at Goodrich. From there, the story made its way to Washington, where it came to the attention of Senator William Proxmire, among others. In May of 1969, Proxmire requested the General Accounting Office (GAO) review the issue of the qualification testing of the A7-D brakes. The GAO investigation led to an August 1969 Senate hearing chaired by Proxmire. By then, the new five-rotor brake had been tested and qualified for use on the A7-D. At the hearing, Vandivier's concerns and the GAO findings were publicly aired. The GAO report confirmed Vandivier's statements about testing discrepancies, though the report also showed that there was no additional cost to the government in obtaining a working brake and that the brake problems didn't cause any substantial delays in the overall A7-D program.

No official action was taken against Goodrich as a result of this incident, and there does not seem to have been any negative impact on the careers of those at Goodrich involved in the A7-D project. Lawson went on to a successful career at LTV. Vandivier later wrote a chapter of a book and an article in Harper's magazine detailing his version of the story.

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	Factual Issues (with ethical implications)// Party #1 Goodrich management
F1a	Goodrich had developed an innovative 4-rotor brake.
F1b	Goodrich was awarded the contract for the brake for the A7-D aircraft.
F1c	Goodrich had only 1 year to provide test results to show that their proposed brake met all necessary qualifications.

	Factual Issues (with ethical implications)// Party #2 Lawson & Vandivier
F2a	Lawson had recently graduated as an engineer. Vandivier was an experienced technical writer. Both of them were employees of Goodrich.
F2b	Lawson's tests on the 4-rotor brake did not achieve successful results meeting Air Force qualifications.
F2c	Lawson & Vandivier consulted the FBI without informing Goodrich.

	Conceptual Issues (with ethical implications)// Party #1 Goodrich management
C1a	When Goodrich (Warren) was informed by Lawson that none of his suggestions to improve performance worked, why did not Goodrich review/reconsider the suitability of the 4-rotor brake?
C1b	Why did Goodrich project manager Sink assure LTV that the A7-D brake development was going well, when he knew it was not?
C1c	*"Any reduction in weight (by the 4-rotor brake instead of the standard 5-rotor) is very attractive in aircraft design, since it allows for an increase in payload weight with no decrease in performance."* (Fleddermann, p.115) In view of the success not achieved by the 4-rotor brake, is this statement (which likely won for Goodrich the contract) still valid?
	Conceptual Issues (with ethical implications)// Party #2 Lawson & Vandivier
C2a	When Vandivier was not allowed to write an accurate report, why did he not go to the next higher authority in Goodrich?
C2b	After Lawson accepted the LTV job and left Goodrich, why did he not do anything further to set matters right at Goodrich?
C2c	

	Ethical Issues// Party #1 Goodrich management
E1a	Goodrich managers added un-allowable test modifications (cooling fans directed at the brake rotors) to appear to satisfy Air Force criteria. *[Virtue Ethics; Rights Ethics]*
E1b	Goodrich submitted a report using jury-rigged data. *[Virtue Ethics]*
E1c	

	Ethical Issues// Party #2 Lawson & Vandivier
E2a	Lawson and Vandivier were party to modification of tests and falsification of results, under pressure from the Goodrich managers. *[Virtue Ethics; Rights Ethics; possibly Duty Ethics]*
E2b	Vandivier was not allowed to write an accurate report. *[Virtue Ethics; Rights Ethics; possibly Duty Ethics]*
E2c	Lawson & Vandivier consulted the FBI without informing Goodrich. *[Virtue Ethics; Rights Ethics; possibly Duty Ethics]*

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Pt	Ethics Line Drawing, from point-of-view of Party #1 Goodrich Management	Location from Left
NP	Submit untruthful test results that meets Air Force qualifications, and supply such-unqualified brake anyway.	Left point
PP	Review and redesign brake for A7-D that meets all Air Force qualifications, and also meeting claims made (of reduced brake-weight, say) which was the basis for being awarded the contract.	Right point
P1	Goodrich tested with different brake materials for their 4-rotor brake design, expecting to find a solution.	Approx 7.5/10
P2	Goodrich managers added un-allowable test modifications (cooling fans directed at the brake rotors) to appear to satisfy Air Force criteria.	Approx 0.5/10
P3	Goodrich changed over to 5-rotor brake design to meet required Air Force qualifications; but likely because the Air Force was not satisfied with their report & refused to accept their 4-rotor brake, and not out of Goodrich's own voluntary preferred course of action.	Approx 9/10
SC1	Keep on testing with different brake materials for their 4-rotor brake design, combined with improved re-design (say, addressing better heat dissipation etc), and fully & properly meeting Air Force requirements.	Approx 9.5/10

Pt	Ethics Line Drawing, from point-of-view of Party #2 Lawson & Vandivier	Location from Left
NP	Assist Goodrich in conducting untruthful tests, and submitting test reports with jury-rigged data to supposedly meet Air Force qualifications.	Left point
PP	Refuse to do any untruthful tests, carrying out only proper ones. Refuse to author any false reports, only reporting accurately. Go through all proper channels to have these issues addressed.	Right point
P1	Lawson tested with different brake materials for their 4-rotor brake design, but could not find a solution. He followed orders from Goodrich management in these tests (different brake materials etc). He also informed Goodrich management that his assessment was that success was not possible with this 4-rotor design.	Approx 7.5/10
P2	Vandivier raised his concerns about the report he was writing, feeling that he couldn't write a report based on falsified data. His attempts to write an accurate report were not allowed by Goodrich management.	Approx 7.5/10
P3	Upon advice of the U.S. Attorney, both Lawson and Vandivier contacted the FBI.	Approx 9/10
SC1	Just do whatever honest work possible according to Goodrich management orders, and ignore all the wrong-doings being carried out (although aware).	Approx 1/10

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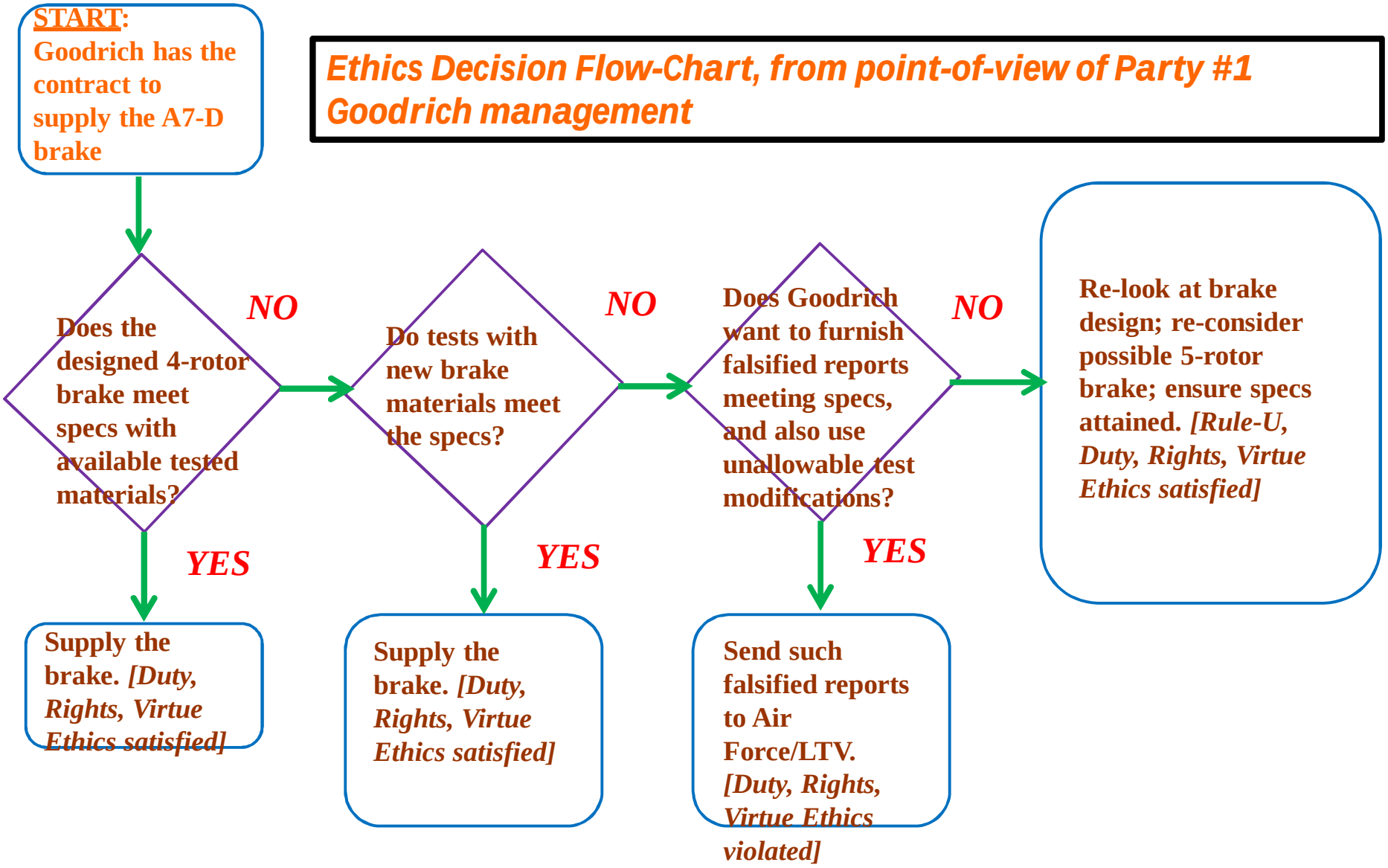
THL3.4 – Ethics Decision Flow Charting



THL3.4 – Ethics Decision Flow Charting

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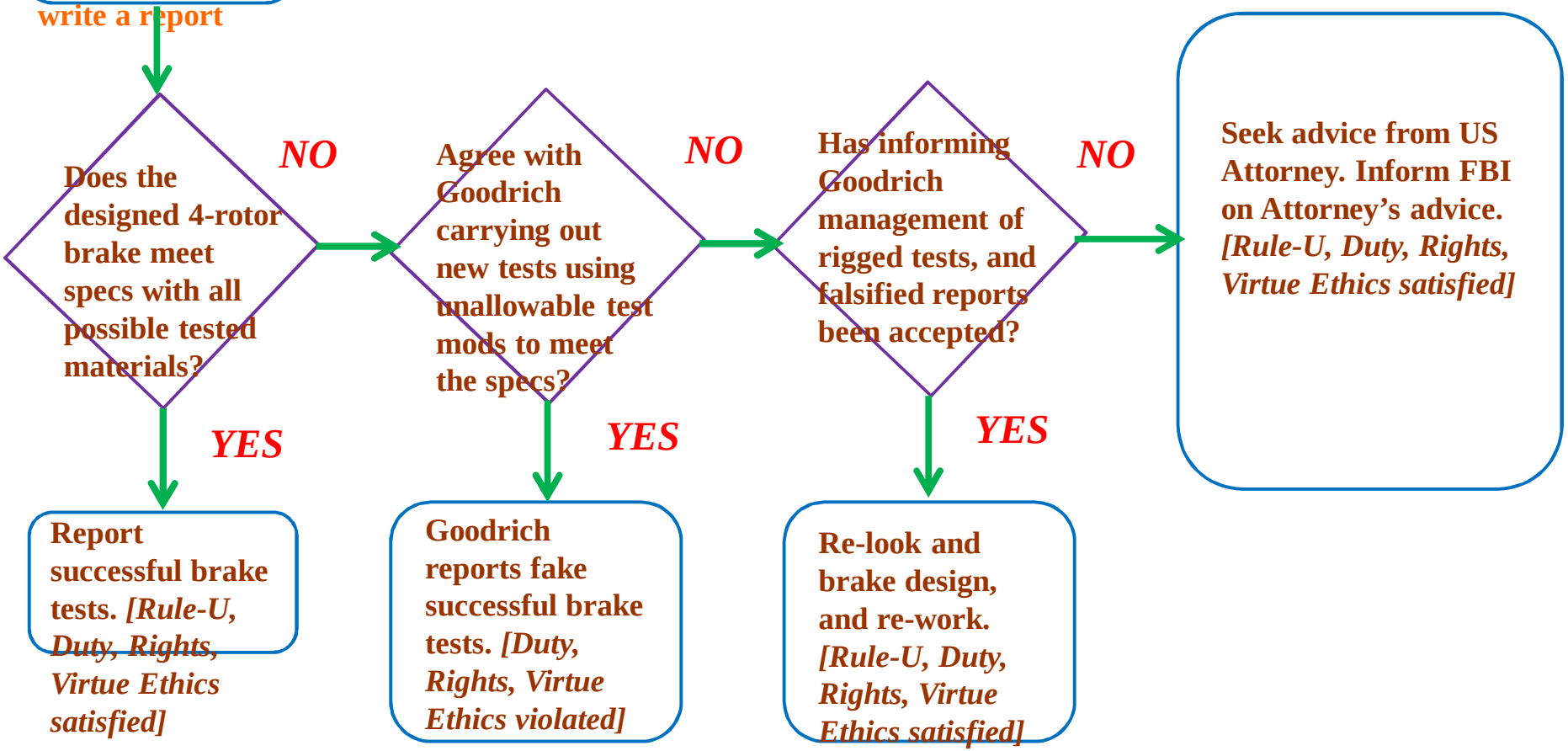
START: Lawson to get success on the brake tests, and Vandivier to write a report

Ethics Decision Flow-Chart, from point-of-view of Party #2 Lawson & Vandivier



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And (looking ahead!!) similar to what I do for all my modules:

Prof T.H.Lee's volunteer ***optional*** extra review/revision classes ---
- on Saturday 23 Oct 2021, 3pm-4.30pm (Week 11, for EG2401a)
- Venue: **ZOOM (I will confirm details again nearer those times!)**

Then, I will review with you all again, the major concepts for my portion of the module (with perhaps detailed descriptions of an additional *new* practice Case Study!!); because by that later time, it is likely that much needs to be illumined again!! :-):-) But note that it is entirely ***optional***, for those who wish to avail themselves of this. And perhaps of greater gravitas now to EG2401a, showcasing samples of how an effective EG2401(a) project can be assembled…

I will remind nearer that time. :-):-)

An appropriate "rejoinder" here...

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"Again lest we forget… professionalism & ethics is not just nice-to-hear only… it is for do-ers!!!"

The story is often told of how the then-new democracy in the new America was formed, naturally paraphrased (by me, lah!!) here. The learned gentleman Benjamin Franklin had just come out of Independence Hall, having spent much time there with his co-workers in formulating the new American Constitution. A lady stopped him outside, and asked, "Pray, tell us Sir; what manner of government have you bequeathed us?" To which the learned gentleman thought for a while, and then replied, "A democracy with respect, rights and equal-opportunity for all, my good lady; but only if you all will yourselves keep it that way."

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