ARIZ

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# Nine Inter-linked Parts

## Part 1 – Analysing the Problem

*Goal:* move from a fuzzy “problem situation” to a crisp **Problem Model**.  
**Core steps (1.1 – 1.7)**

1. Formulate the **mini-problem** in plain language (tool, product, TC-1, TC-2, desired result).
2. Pin-point the **conflicting pair** (product ↔ tool) and note variants if the tool has two states (Rule 1).
3. Sketch both Technical Contradictions using one of nine standard graphic models (Table 1).
4. Choose the model that best supports the system’s Main Manufacturing Process; all later work sticks to this state .
5. **Intensify** the conflict (e.g., “few → none”, “weak → zero”) — no compromises.
6. Write the Problem Model and introduce the **X-element** that must deliver the now-impossible benefits.
7. Do a first pass through the 76 Inventive Standards; if one solves the model you may jump to Part 7, otherwise proceed .

*Take-away:* Part 1 deliberately cuts off “middle-of-the-road” fixes; it forces an intensified, contradiction-focused statement ([hg-graebe.de](https://hg-graebe.de/Rohrbacher-Kreis/Storkow-20/ARIZ-Folien.pdf?utm_source=chatgpt.com)).

## Part 2 – Analysing the Problem Model

*Goal:* expose every **resource** already in or around the conflict.  
**Steps (2.1 – 2.3)**

1. Define the **Operational Zone (OZ)** – the exact space of the conflict.
2. Define **Operational Time (OT)** – when the conflict occurs and any lead-time before it.
3. Compile the **Substance–Field Resources (SFR)** list: internal system substances/fields, environmental resources, super-system by-products, etc.

## Part 3 – Defining the Ideal Final Result (IFR) & the Physical Contradiction

*Goal:* sharpen the target and translate the technical conflict into a **Physical Contradiction (PhC)**.  
**Steps (3.1 – 3.6)**

1. Write **IFR-1** (“X-element eliminates harm, adds benefit, no side-effects”).
2. Intensify IFR-1 by banning new substances/fields, forcing use of listed SFRs (Comment 24).
3. Express the **macro-level PhC** (OZ must be hot *and* cold, present *and* absent, etc.).
4. If useful, restate at **micro-level** (particle behaviour).
5. Draft **IFR-2** – the OZ should *self-change* between the opposite states in OT.
6. Re-test Inventive Standards; if still unsolved → Part 4 .

## Part 4 – Mobilising & Using Substance-Field Resources

*Goal:* create or re-purpose resources “for free”.  
**Steps (4.1 – 4.7)** & **Rules 4-10**

* **Little-Creatures Simulation** – cartoons that visualise ideal particle actions; breaks inertia (Step 4.1) .
* **Step-back from IFR** – introduce a single “defect”, then solve that simpler micro-problem.
* **Mix available substances**; **inject voids** (empty space, bubbles, rarefaction).
* **Derived resources** via phase-change, decomposition (Rules 8-10 hierarchy).
* If still short, add an **electric field**, or **field + field-sensitive substance**.

Online slide sets underline that Part 4 is where most ARIZ runs actually yield a concept ([hg-graebe.de](https://hg-graebe.de/Rohrbacher-Kreis/Storkow-20/ARIZ-Folien.pdf?utm_source=chatgpt.com)).

## Part 5 – Applying the Knowledge Base

*Goal:* pull in wider TRIZ experience once the physical problem is crystal-clear.  
**Steps (5.1 – 5.4)**

1. Re-apply the 76 Inventive Standards in light of new SFRs.
2. Search for **problem analogues** already solved with ARIZ.
3. Use **Separation Principles** (Table 2) to eliminate PhC.
4. Consult the **Pointer to Physical Effects & Phenomena** ; described online as “mobilising all accumulated TRIZ knowledge” ([metodolog.ru](https://www.metodolog.ru/triz-journal/archives/1998/04/d/index.htm?utm_source=chatgpt.com), [seecore.org](https://www.seecore.org/d/2006m6dk.pdf?utm_source=chatgpt.com)).

## Part 6 – Changing or Substituting the Problem

*Goal:* if still blocked, **re-frame**.  
**Steps (6.1 – 6.4)**

* Translate the physical idea into a **technical solution** if ready.
* Check if the original statement actually hides multiple sub-problems – isolate them.
* **Switch to the other Technical Contradiction** chosen back in 1.4.
* Or **re-write the mini-problem** one level up in the super-system hierarchy .

## Part 7 – Analysing the Resolution Method

*Goal:* sanity-check and rank the concept.  
**Steps (7.1 – 7.4)**

* Replace any “foreign” substances with cheaper SFRs; seek **self-controlling** materials.
* Score against IFR, check novelty via patent search, and list secondary implementation problems .

## Part 8 – Applying the Obtained Solution

*Goal:* leverage the idea beyond the immediate fix.  
**Steps (8.1 – 8.3)**

1. Evaluate super-system impacts.
2. Seek **new applications**.
3. Generalise the principle, build morphological charts, explore size-scaling and opposites .

## Part 9 – Analysing the Problem-Solving Process

*Goal:* turn this project into future creative capital.  
**Steps (9.1 – 9.2)**

* Compare the **actual path** vs. the ARIZ ideal; note skipped or looping steps.
* Feed new tricks back into the TRIZ knowledge base, but only **after** testing on 20-plus problems (Altshuller’s caution) .

**Summary Table**

| **Part** | **Essence** | **Output Artefacts** |
| --- | --- | --- |
| 1 | From situation → Problem Model | Mini-problem text, TC graphics |
| 2 | Map resources | OZ, OT, SFR list |
| 3 | State IFR & PhC | IFR-2 statement |
| 4 | Invent resources | Concept sketches, enriched SFR |
| 5 | Tap knowledge base | Candidate solutions |
| 6 | Re-frame if stuck | New mini-problem or TC |
| 7 | Vet concept | Ideality score, patent check |
| 8 | Extend impact | Super-system plan, analogues |
| 9 | Reflect & codify | Lessons log, TRIZ update |

This nine-part spine—validated in both Altshuller’s text and modern TRIZ teaching material—remains the **gold-standard roadmap** for navigating from messy contradictions to high-ideality, broadly exploitable solutions.

# Forty Steps of ARIZ-85C

Each step is paraphrased from the authoritative English translation of Altshuller’s 1985 manuscript and cross-checked against reputable online summaries. Citations follow every part.

## Part 1 · Analyzing the Problem (7 steps)

* Definition: This initial part involves transforming a vague, complex problem into a simplified and clearly formulated "mini-problem." It focuses on understanding the system, its functions, and the core conflict.
* Purpose: The main goal is to move from an indefinite problem statement to a structured Problem Model by identifying the fundamental contradictions. This step helps to remove jargon and preconceived notions about the solution.
* Interlinkages: This part lays the foundation for the entire process. The formulated Problem Model and Technical Contradictions are directly used in Part 2 and Part 3. If a solution isn't found later, the framework often directs the user to return to this part to reformulate the problem.

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **1.1** | **Formulate the mini-problem** | Restate the situation in plain words: name the system, list its main parts, write the two opposing technical contradictions (TC-1, TC-2) and the desired result “with minimal changes.” |
| **1.2** | **Define the conflicting pair** | Pin-point *product* and *tool* that clash; if the tool has two meaningful states, note both. |
| **1.3** | **Build graphic models of TC-1 & TC-2** | Draw the conflict with one of Altshuller’s nine standard diagrams (counter-action, conjugated action, etc.). |
| **1.4** | **Select the governing conflict** | Choose the diagram that best preserves the system’s Main Manufacturing Process (MMP) for deeper work. |
| **1.5** | **Intensify the conflict** | Push the chosen parameter to an extreme (“few → none”, “weak → zero”) to block compromise paths. |
| **1.6** | **Draft the problem model** | Rewrite the conflict as: *product + tool (in extreme state) → harmful & useful effects* and introduce an unknown **X-element** that must keep the useful and remove the harmful. |
| **1.7** | **Try the Inventive Standards** | Quickly test whether any of the 76 Standard Solutions resolves the model; if not, continue to Part 2. |

## Part 2 · Analyzing the Problem Model (3 steps)

* Definition: This stage involves a detailed analysis of the Problem Model created in Part 1, focusing on the resources available within the system and its environment.
* Purpose: The primary objective is to identify all available resources—space, time, substances, and fields (Substance-Field Resources or SFR)—that could be useful for solving the problem.
* Interlinkages: The resources identified here are crucial for Part 3, where the Ideal Final Result is defined using only these available resources, and for Part 4, which focuses on mobilizing them.

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **2.1** | **Define the Operational Zone (OZ)** | Mark the exact space where the conflict happens. |
| **2.2** | **Define the Operational Time (OT)** | Mark when the conflict occurs (T1) and the time just before it (T2). |
| **2.3** | **List Substance-Field Resources (SFR)** | Catalogue substances and fields already present (tool, product, environment, super-system). |

## Part 3 · IFR & Physical Contradiction (6 steps)

* Definition: This part focuses on formulating the Ideal Final Result (IFR), which describes the ultimate best solution, and identifying the Physical Contradiction (PhC) that prevents its achievement. The IFR describes a state with all the benefits and none of the costs or harms.
* Purpose: To transform the problem into a specific Physical Contradiction—where an element must have opposite properties simultaneously. This sharpens the focus of the problem-solving effort.
* Interlinkages: This part is a critical turning point. By formulating the IFR and PhC, the initial problem is transformed into a new, physical problem. The PhC becomes the central issue to be resolved in the subsequent parts. If a solution is found here, one can often jump to Part 7

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **3.1** | **Formulate IFR-1** | State: “X-element, without complicating the system or side-effects, eliminates *harm* in OZ during OT while preserving *useful action*.” |
| **3.2** | **Intensify the IFR** | Forbid introducing new substances/fields; insist on using only listed SFRs. |
| **3.3** | **Macro-level Physical Contradiction (PhC)** | “In OZ during OT the system must be *A* to achieve X, yet must be *not-A* to achieve Y.” |
| **3.4** | **Micro-level PhC** | Express the same opposition in terms of particles/fields (ions, domains, etc.). |
| **3.5** | **Formulate IFR-2** | Recast the goal so the OZ “changes its own state” automatically, on cue. |
| **3.6** | **Re-apply Inventive Standards** | Test if any standard now resolves the PhC; if not, go to Part 4. |

## Part 4 · Mobilising & Using S-F Resources (7 steps)

* Definition: This part involves a systematic search for solutions by creatively mobilizing the Substance-Field Resources (SFR) identified in Part 2, including derived resources obtainable through slight modifications.
* Purpose: To generate solution concepts by using existing and easily derivable resources, thus moving from the problem to the solution based on physics.
* Interlinkages: This part builds directly on the resource analysis of Part 2 and the physical problem defined in Part 3. If a solution concept is achieved here, the user can proceed to Part 7. If not, Part 5 offers more tools

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **4.1** | **Simulation with “Little Creatures”** | Sketch cartoon agents acting ideally; adjust until the conflict disappears, then translate insights to physics. |
| **4.2** | **Take a “step back” from IFR** | Slightly relax one IFR constraint to reveal an easier sub-problem that leads forward. |
| **4.3** | **Mix existing substances** | Consider heterogeneous combinations of current SFRs. |
| **4.4** | **Use voids** | Replace part of a substance with empty space (porosity, rarefaction, bubbles, etc.). |
| **4.5** | **Use derived substances** | Generate resources by phase change, decomposition, or recombination (Rules 8-10). |
| **4.6** | **Use an electric field** | Substitute matter with electrons/fields that already exist inside the system. |
| **4.7** | **Pair field + field-sensitive substance** | Introduce a controllable field and a material that responds to it (e.g., magnetic field + ferro-particles). |

## Part 5 · Applying the Knowledge Base (4 steps)

* Definition: This part involves leveraging the entire TRIZ knowledge base to solve the problem formulated as a Physical Contradiction.
* Purpose: To systematically apply established TRIZ tools and databases if a solution has not yet been found.
* Interlinkages: This part is recommended if Part 4 does not yield a solution. It draws on the IFR from Part 3 and the resources from Part 4, applying broader TRIZ principles.

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **5.1** | **Re-run the Standard Solutions** | Now use Standards with any new resources identified in Part 4. |
| **5.2** | **Search problem analogues** | Look up earlier ARIZ-solved cases with an identical PhC. |
| **5.3** | **Apply separation principles** | Try the eleven classic ways to remove PhC (space, time, system transition, phase change, etc.). |
| **5.4** | **Consult the Effects database** | Scan physics & chemistry handbooks (Pointer to Physical Effects) for phenomena that fit the PhC. |

## Part 6 · Changing / Substituting the Problem (4 steps)

* Definition: This part involves revisiting and potentially changing the problem formulation itself if a solution remains elusive.
* Purpose: To overcome psychological inertia by altering the initial constraints and assumptions of the problem.Often, complex problems are solved by changing the problem statement. (Attached Document, p. 23)
* Interlinkages: This is a critical feedback loop. If Parts 4 and 5 fail, this part directs the user to return to Part 1 and reformulate the mini-problem, possibly by considering the supersystem or choosing a different technical contradiction.

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **6.1** | **Translate to a technical concept** | Turn the physical effect into a working principle and draft schematic. |
| **6.2** | **Check for blended problems** | Ensure the initial statement didn’t hide multiple independent issues; split if necessary. |
| **6.3** | **Select a different TC** | If stuck, pivot to the other graphic model from Step 1.3 or a higher-value contradiction. |
| **6.4** | **Re-formulate the mini-problem at super-system level** | Widen scope (one level up) and restart Part 1 if required. |

## Part 7 · Analysing the Resolution Method (4 steps)

* Definition: This stage involves a quality check of the solution concept that has been developed.
* Purpose: To ensure the obtained solution is powerful and resolves the Physical Contradiction in the most ideal way possible, preferably without introducing new, complex elements.
* Interlinkages: This part acts as a quality gate. It analyzes the solution from the preceding parts before it is further developed in Part 8. If the solution is weak, the user is directed back to step 1.1.

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **7.1** | **Scrutinise resource use** | Replace introduced substances with cheaper SFRs; favour self-controlling materials. |
| **7.2** | **Preliminary evaluation** | Check ideality, feasibility, controllability, and single-cycle vs. real-cycle performance. |
| **7.3** | **Patent search** | Confirm novelty and freedom-to-operate. |
| **7.4** | **List implementation sub-problems** | Forecast design, organisational and secondary technical hurdles. |

## Part 8 · Applying the Obtained Solution (3 steps)

* Definition: This part focuses on maximizing the value of the solution by exploring its wider applications.
* Purpose: To extend the use of the innovative idea beyond the immediate problem, providing a "key" to many analogous problems.
* Interlinkages: This part follows the validation of a strong solution in Part 7 and precedes the final analysis of the process in Part 9. It broadens the scope from solving one problem to creating a general principle

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **8.1** | **Assess super-system changes** | Determine how the parent system must adapt to host the new solution. |
| **8.2** | **Find new applications** | Identify fresh markets or functions the solution enables. |
| **8.3** | **Transfer the principle to other problems** | Build morphologic matrices, scale dimensions to zero/infinity, and test inverses. |

## Part 9 · Analysing the Problem-Solving Process (2 steps)

* Definition: The final part involves a reflective analysis of the entire problem-solving journey undertaken by the user.**2**
* Purpose: To increase the creative potential of the person using ARIZ by learning from the process.**13** It also serves to contribute new findings back to the TRIZ knowledge base. (Attached Document, p. 27)
* Interlinkages: This is the final feedback loop of ARIZ, focused on meta-cognition and continuous improvement of both the user's skills and the ARIZ methodology itself.

| **#** | **Step** | **Essence** |
| --- | --- | --- |
| **9.1** | **Compare planned vs. real ARIZ flow** | Record deviations; understand why shortcuts arose. |
| **9.2** | **Feed back to the TRIZ corpus** | Map the new concept to existing Principles/Standards; if novel, document it for future practitioners. |

**Key Cross-References**

* Altshuller, **“Algorithm of Inventive Problem Solving (ARIZ-85C)”** – primary step source.
* Souchkov V., **“ARIZ: Theory and Practice”** – expands Part 4 techniques. ([seecore.org](https://www.seecore.org/d/2006m6dk.pdf?utm_source=chatgpt.com))
* ResearchGate paper **“Introduction to ARIZ – The Algorithm of Inventive Problem Solving”** – concise overview used for cross-checking sequencing. ([researchgate.net](https://www.researchgate.net/publication/235742388_An_Introduction_to_ARIZ_-The_Algorithm_of_Inventive_Problem_Solving?utm_source=chatgpt.com))

# Eleven Rules to perform steps

**Rule 1**  
*Original wording:* “If the tool, according to the problem-situation conditions, can be in two states, it is necessary to indicate **both** of these states.”  
*Practical meaning:* The solver must describe the full range of the tool’s behaviour (e.g., hot / cold, many / few). This prevents a premature focus on a “preferred” state and keeps contradictions visible.  
*Key sources:* Altshuller PDF; SEECORE public copy.

**Rule 2**  
*Original wording:* “If the problem situation includes several similar pairs of interacting elements, it is enough to consider only **one** pair.”  
*Practical meaning:* Analyse a single representative conflict (e.g., one lightning-rod vs. radio waves) instead of many near-identical pairs, reducing analytical overload.  
*Key sources:* Altshuller PDF; Scribd mirror.

**Rule 3**  
*Original wording:* “Conflicts of the type ‘many vs. few’ (or ‘strong vs. weak’) shall be re-written so that the *weak* side becomes **‘none / absent’**.”  
*Practical meaning:* Intensify the contradiction—turning “few conductors” into “no conductors” removes compromise options and drives the search toward genuinely inventive (not incremental) solutions.  
*Key sources:* SEECORE PDF.

**Rule 4**  
*Original wording:* “Particles in one state perform **one** function only. If a second function is needed, introduce new particles (‘B’).”  
*Practical meaning:* Apply micro-segmentation: avoid overloading one entity. In micro-fluidics, for example, carrier beads transport while reagent beads react.  
*Key sources:* SEECORE PDF.

**Rule 5**  
*Original wording:* “New ‘B’ particles may be split into **B-1** and **B-2**; their interaction can deliver an extra (third) function **for free**.”  
*Practical meaning:* Low-cost functionality emerges when sub-groups interact—such as positive and negative ions forming an electric field without extra materials.  
*Key sources:* Altshuller PDF; TRIZ-Journal commentary.

**Rule 6**  
*Original wording:* “If only ‘A’ particles are allowed, divide them into two groups; change the key parameter of one group.”  
*Practical meaning:* A “no-added-material” variant of Rule 5—create property gradients (e.g., surface-doped vs. bulk-pure silicon) to gain new effects.  
*Key sources:* SEECORE PDF.

**Rule 7**  
*Original wording:* “After completing their functions, the separated or introduced groups must become **identical** to each other—or to the original particles.”  
*Practical meaning:* Ensures reversibility or self-healing; prevents long-term degradation (e.g., shape-memory alloys returning to a uniform phase).  
*Key sources:* Altshuller PDF.

**Rule 8**  
*Original wording:* “If required particles cannot be obtained directly, get them by **decomposing** a higher-level structure.”  
*Practical meaning:* Create needed particles by breaking down larger ones—generate free radicals by cracking a polymer, or produce ions by electrolysing water.  
*Key sources:* SEECORE PDF.

**Rule 9**  
*Original wording:* “If Rule 8 is impossible, obtain the particles by **building up** lower-level particles.”  
*Practical meaning:* The reverse of Rule 8—assemble smaller entities into the desired particles, such as forming micelles from surfactant monomers when no larger structures exist to split.  
*Key sources:* Altshuller PDF.

**Rule 10**  
*Original wording:* “The easiest way to apply Rule 8 is to decompose the nearest **complete** level; the easiest way to apply Rule 9 is to finish an **incomplete** lower level.”  
*Practical meaning:* A heuristic shortcut—break the closest stable structure first, or complete a nearly finished lower-level structure, minimising energy and effort.  
*Key sources:* Altshuller PDF.

**Rule 11**  
*Original wording:* “Only solution concepts that **fully meet** the Ideal Final Result (or come very close) are acceptable.”  
*Practical meaning:* Acts as a quality gate in Part 5 of ARIZ: discard any option that still compromises ideality, preventing premature acceptance of sub-optimal fixes.  
*Key sources:* Altshuller PDF; AI-TRIZ certification notes.

**How the Rules Fit into ARIZ Execution**

1. **Rules 1-3** belong to **Part 1** (Steps 1.2 – 1.5). They structure and intensify the initial Technical Contradiction.
2. **Rules 4-7** guide **Part 4** (resource mobilisation), detailing micro-level tactics for manipulating Substance–Field Resources.
3. **Rules 8-10** extend **Part 4**, offering hierarchical chemistry tricks for creating “missing” substances from existing ones.
4. **Rule 11** appears in **Part 5** as the final filter before declaring a satisfactory solution.

Together, these eleven rules keep every ARIZ-85C session focused, resource-frugal, contradiction-centred and aligned with the Ideal Final Result—exactly as Altshuller intended.

# Seven Attentions to prevent frequently occurring mistakes

Below are the seven pieces of guidance that appear as **bold-face “WARNING!”** notes throughout Genrich Altshuller’s 1985 version of the *Algorithm of Inventive Problem-Solving* (ARIZ-85C). They are reproduced and briefly explained so you can keep them in front of you whenever you run the algorithm.

| **#** | **Original caution (verbatim or close paraphrase)** | **Why it matters / how to apply it** |
| --- | --- | --- |
| **1 – Train first** | “ARIZ is a complicated tool. **Do not apply it to solve new practical problems without at least 80 academic hours of preliminary study.**” | ARIZ prescribes dozens of tightly-linked operations. Until you have practised them (≈ two university-style weeks), you will mis-order steps, miss resources and jump to premature solutions. |
| **2 – ARIZ helps you think, it does not think for you** | “ARIZ is a tool for thinking, **but not a replacement for thinking**. Do not hurry! Consider each step carefully. **Note all considerations in the margins** that occur during problem solving.” | Treat every step as a deliberate cognitive exercise. Write down hunches and side-ideas as you go; many will become resources or solutions later. |
| **3 – Use it only when the ‘standard’ TRIZ tools fail** | “ARIZ is a tool for solving **non-typical problems**. Check first: can the problem be solved with the System of Standard Solutions (Inventive Standards)?” | The Standards, 40 Principles or the Matrix are faster. Reserve ARIZ for truly stubborn problems that resist those shortcuts. |
| **4 – Fight mental inertia with very plain words** | “Problem solving is accompanied by the break-down of old conceptions… **Describe the analysis using simple, non-technical, even ‘childish’ words, avoiding special terms** (they increase mental inertia).” | Jargon locks you into yesterday’s solutions. Re-naming parts (‘conductor’ → ‘metal rod’, ‘paint’ → ‘coloured liquid’) frees the imagination to see new functions. |
| **5 – Do not stop halfway through the algorithm** | “**The first three parts of ARIZ entirely change the initial problem… From this point we must focus on this new problem!**” | Early insights feel seductive. Finishing the nine-part cycle almost always yields a simpler, more elegant solution that you would have missed had you quit early. |
| **6 – Draw the ‘Little Creatures’ properly** | “**The most common mistake**… is to make a careless drawing. Good figures must be expressive and understandable without words.” | The Little-Creature simulation is a visual thinking aid. Sloppy sketches hide contradictions and waste resources; clean sketches reveal them. |
| **7 – Do not tinker with ARIZ until you’ve proved the change** | “ARIZ-85C has been tested on many problems… **Any suggestions should first be tested outside ARIZ, then on at least 20-25 demanding problems** before inclusion.” | Casual ‘improvements’ often solve one task but cripple the tool elsewhere. Respect the empirical test threshold Altshuller set. |

**How these cautions fit together**

Altshuller’s warnings follow a clear logic:

1. **Competence first** (Attentions 1–3) – make sure the analyst, not the algorithm, is in charge.
2. **Cognitive hygiene** (Attentions 4–6) – keep language, visuals and workflow disciplined so that contradictions stay visible.
3. **Method integrity** (Attention 7) – protect the long-tested structure of ARIZ against well-meant but un-validated tweaks.

Keep the table handy; when something feels “stuck,” check which attention you may be ignoring. Experienced TRIZ practitioners refer to these seven points as a quick self-audit before every ARIZ session.

# 44 Comments

Below is a single, ordered list of every **Comment** that Altshuller embedded in ARIZ-85C.  
I quote each comment exactly as it appears in the authoritative English translation of the 1985 algorithm (“Algorithm of Inventive Problem Solving”, © G. S. Altshuller 1956-1985) and give the file citation so you can verify the wording in context.

**The 44 Comments**

1. **Comment 1** – *Why a “mini-problem” intensifies the conflict*  
   “The mini-problem is obtained from the initial problem situation by introducing restrictions: ‘Everything in the system remains unchanged or is simplified, while the required action (or property) appears or a harmful action (or property) disappears.’ … Introducing additional requirements … cuts off paths to compromise solutions.”
2. **Comment 2** – *List natural as well as technical parts*  
   “While formulating step 1.1 one should indicate not only the technical parts of the system but also the natural ones that interact with the system.”
3. **Comment 3** – *How to write a Technical Contradiction (TC)*  
   “…Technical contradictions are formulated by identifying one state of a system element with explanation of both the good and bad results … Then the opposite state … is identified.”
4. **Comment 4** – *Avoid special terms – they raise mental inertia*  
   “To reduce mental inertia special terms associated with the tool and environment should be replaced with easy words…”
5. **Comment 5** – *Define “product”*  
   “The product is the element that needs to be processed (manufactured, moved, changed, improved, protected …).”
6. **Comment 6** – *Define “tool”*  
   “The tool is the element that directly interacts with the product … A part of the environment can be considered as a tool.”
7. **Comment 7** – *Conflicting pair can be doubled*  
   “One of the elements in the conflicting pair can be doubled … two different tools … or two products …”
8. **Comment 8** – *You may draw your own conflict model*  
   “Table 1 contains graphic models of typical conflicts. It is acceptable to use original (atypical) graphic models if they describe the meaning of conflict clearly.”
9. **Comment 9** – *Split multi-linked models into simpler ones*  
   “Some problems can be described by multi-linked graphic models … Such models can be converted as two one-linked graphic models.”
10. **Comment 10** – *Consider space AND time conflicts*  
    “The conflict can be considered in time as well as in space.”
11. **Comment 11** – *After 1.3 go back and check logic*  
    “…return to step 1.1 after step 1.3 and check if there is any discordance in the sequence 1.1-1.2-1.3.”
12. **Comment 12** – *Choosing one conflict state forbids compromise*  
    “By choosing one of the two graphic models … it is prohibited to replace ‘few conductors’ by some optimal number … ARIZ requires intensifying the conflict rather than smoothing it.”
13. **Comment 13** – *For measurement problems pick the system’s MMP*  
    “It is difficult to define the MMP for measurement problems. Ultimately, measurements are almost always performed for modification purposes…”
14. **Comment 14** – *Problem Model is an abstraction – many parts stay implicit*  
    “The Problem Model is a type of abstraction where only some of the elements … are artificially selected. Other elements are implied only.”
15. **Comment 15** – *After 1.6 loop back again and refine*  
    “…return to step 1.1 and check the logic behind the creation of the Problem Model.”
16. **Comment 16** – *X-element may be a modification, not a new part*  
    “The X-element is not necessarily the new material part of the system … it may be a temperature change or phase-state change…”
17. **Comment 17** – *Clarifying the model often reveals standard solutions*  
    “…development of a Problem Model clarifies the problem and in many cases allows the identification of standard (typical) properties of non-typical problems.”
18. **Comment 18** – *Operational Zone (OZ) is where the conflict appears*  
    “In the simplest case the Operational Zone is the space where the conflict indicated in the Problem Model appears.”
19. **Comment 19** – *Operational Time (OT) includes before and during*  
    “The operational time is … the time when conflict occurs (T1) and the time before the conflict (T2).”
20. **Comment 20** – *Three kinds of Substance–Field Resources (SFR)*  
    “SFR are substances and fields that already exist or may be easily obtained… There are three types: internal, external, super-system.”
21. **Comment 21** – *When is the product itself an SFR?*  
    “The product can be considered as an SFR only in rare cases where the product can be easily modified ‘without modification’.”
22. **Comment 22** – *Use available resources first*  
    “The SFRs are available resources and thus they should be utilized first. If there are not enough … other substances and fields can be considered.”
23. **Comment 23** – *IFR is only a pattern – many conflict types exist*  
    “There are other conflicts besides ‘useful vs harmful action’ … therefore the formulation of the IFR … is just a pattern for writing down the IFR.”
24. **Comment 24** – *Four “resource lines” – tool → environment → super-system → product*  
    “According to Comments 20 and 21, SFRs should be considered in the following order…”
25. **Comment 25** – *Physical Contradiction = opposing states of OZ*  
    “The Physical contradiction is the opposing requirements from the physical state of the Operational Zone.”
26. **Comment 26** – *A short PhC formula if full one is hard*  
    “If it is difficult to give a complete definition … it is acceptable to define the brief PhC according to the following pattern…”
27. **Comment 27** – *Particles need not be defined precisely at micro level*  
    “It is not necessary … to precisely define the term ‘particles’.”
28. **Comment 28** – *Particles may be substance, substance+field, or field*  
    “The particles may be: a) particles of a substance; b) a combination of particles and fields; c) ‘particles of a field’ (seldom).”
29. **Comment 29** – *If only a macro solution exists, that is useful to know*  
    “Attempting to formulate the Physical Contradiction for the micro-level can prove beneficial … it provides us with the additional information that the problem has to be solved at the macro-level.”
30. **Comment 30** – *Rules 4-7 govern* ***all*** *of Part 4*  
    “Rules 4 through 7 apply to all of Part 4 of ARIZ.”
31. **Comment 31** – *Little-Creatures simulation: draw expressively*  
    “Simulation with Little Creatures includes representing the conflicting requirements as a drawing … The most common mistake … is to make a careless drawing.”
32. **Comment 32** – *SLC is psychological; don’t stop there – mobilise SFRs*  
    “Step 4.1 is an auxiliary step … it is not recommended to stop the solving process here. The mobilization of the SFRs has to be performed.”
33. **Comment 33** – *Why step 4.3 exists – introduce substances without introducing them*  
    “Usually it is necessary to introduce new substances, but introducing new substances results in a more complicated system … Step 4.3 resolves this contradiction – to introduce substances without introducing them.”
34. **Comment 34** – *From mono- to heterogeneous bi- or poly-substances*  
    “Step 4.3 recommends … a transition from two mono-substances to a heterogeneous (not uniform) bi-substance.”
35. **Comment 35** – *“Empty space” is a powerful resource*  
    “Empty space is an extremely important type of substance resource. It is always available in unlimited quantities, is very cheap…”
36. **Comment 36** – *Derived resources come from phase changes or decomposition*  
    “Derived substance resources can be obtained by changing the phase state … or by decomposing the substance resources.”
37. **Comment 37** – *Hierarchy of structural levels (super-molecules → fields)*  
    “The substance can be regarded as a multi-layer hierarchical system … minimally-processed substance … fields.”
38. **Comment 38** – *Electrons (current) are universal when resources are scarce*  
    “…electrons are ‘substances’ that exist inside any object. Moreover, electrons are associated with a field that is easily controlled.”
39. **Comment 39** – *Step 4.7 is “foreign” substances & fields – do this last*  
    “Step 4.7 … introduces ‘foreign’ substances and fields. … Do this only when absolutely necessary.”
40. **Comment 40** – *Returning to Inventive Standards after resource search*  
    “…a return to the Inventive Standards takes place in steps 4.6 and 4.7 … if it is impossible … it is necessary to introduce new substances and fields.”
41. **Comment 41** – *Analogy works because there are few PhCs*  
    “Although there are an infinite number of inventive problems, there are comparatively few Physical Contradictions associated with them.”
42. **Comment 42** – *Pointer to Physical Effects – where it was published*  
    “Parts of the Pointer to Physical Effects and Phenomena were published in the journal ‘Technika i nauka’ (1981-1983) …”
43. **Comment 43** – *Use self-controlling substances for simple, automatic control*  
    “Self-controlling substances are substances that modify their state … without any additional devices.”
44. **Comment 44** – *Step 8.3 can found a whole new theory*  
    “If the purpose is not just to solve a particular technical problem, by carefully following step 8.3 one might initiate the development of a general theory based on the Solution Principle.”

**How to use this list**

Altshuller scattered these comments to guide (and warn) practitioners as they perform the **40 steps** in the **9 parts** of ARIZ-85C. Read each one alongside the step it annotates—the comments explain *why* the step is done, what to watch for, and typical mistakes to avoid. Together they form an indispensable meta-manual for serious TRIZ work.

# Eight Patterns, or Lines, of Technical Systems Evolution

Below is a deep-dive into the eight classical **“Lines of Technical-System Evolution”** first catalogued by Genrich Altshuller. Each line is presented with its core idea, typical sub-lines or stages, illustrative examples, and practical forecasting hints.

**1 Life-Cycle (S-Curve)**

**What it is.** Every technical system progresses through *birth → growth → maturity → decline* S-curves. Recognising where a product sits lets you time radical redesigns before the curve flattens. ([the-trizjournal.com](https://the-trizjournal.com/innovation-methods/innovation-general/patterns-evolution-methodologies/))

**Typical sub-lines**

| **Stage** | **Signals** | **Typical Moves** |
| --- | --- | --- |
| Birth | Fragile demo units | Build reliability, prove value |
| Growth | Rapid parameter races | Add functions, widen market |
| Maturity | Parameter ceilings, commoditisation | Jump to next S-curve via another line (e.g., macro→micro) |
| Decline | Maintenance only | Migrate to super-system or replace |

**Forecasting tip.** Overlay several past product generations; the inflection point where improvements level off marks the window for the *next* line-of-evolution move.

**2 Dynamization**

The Pattern of Dynamization suggests that any technical system during its evolutionary process makes a transition from a rigid to a flexible structure. This transition can be summarized as follows: A solid system obtains one joint, then many joints, then the whole system becomes completely flexible. Dynamization also means that a ridged system may be divided into elements that can become moveable relative to each other.

**Essence.** Rigid systems progressively gain degrees of freedom until they become fully adaptive or flexible. ([arvindvenkatadri.com](https://arvindvenkatadri.com/teaching/1-play-and-invent/modules/1000-triz-documents/TRIZ-related/Shulyak-Intro-to-TRIZ.pdf))

**Canonical stages**

1. **One joint added** – steering column tilt.
2. **Many joints** – folding antenna, multi-link suspension.
3. **Full flexibility** – flexible-shaft screwdriver; soft robotics.

**Why it matters.** Each extra degree of freedom removes a contradiction (e.g., *strong vs. adjustable*). If your design is already crowded with hinges and sliders, the next leap is often *smart materials* that deform without discrete joints.

Examples:

* The steering column of a car has a joint allowing adjustment of its vertical position.
* An antenna becomes collapsible
* The landing gear of an airplane folds and retracts
* A screwdriver whose stem is made of two springs, one inside the other, with opposite winding directions, making it completely flexible

**3 Multiplication Cycle (Mono → Bi → Poly → Back to Mono)**

**The Pattern of Multiplication** states that a technical system evolves first as a single system and then later multiplies itself. When similar elements are added together, it is called a homogeneous system. This combination of elements acquires a whole new property.

**Essence.** A single working element is first duplicated (homogeneous bi-system), then diversified (heterogeneous poly-system), and finally re-simplified into a new, higher-function mono-system. ([arvindvenkatadri.com](https://arvindvenkatadri.com/teaching/1-play-and-invent/modules/1000-triz-documents/TRIZ-related/Shulyak-Intro-to-TRIZ.pdf))

*Example flow – the pocketknife:* one blade → two identical blades (strength) → many different blades/tools (Swiss-army) → multi-function ceramic blade with laser-etching (new mono).

**Forecasting tip.** List what is being *added* today; ask how those functions could later be folded into *one* element (often software or a field effect).

Examples:

* Two boats attached through a single frame (a catamaran) become more stable than two separate boats. Different elements added together form a heterogeneous system. Such a system provides more functions while occupying less space.
* The pocketknife began its cycle with a single blade. Different types of blades were added, then scissors, screwdriver, a file and so on. Another variation on the heterogeneous system involves the addition of an opposite function producing higher levels of innovation.
* A pencil and eraser are joined together.
* A tape recorder can both record and erase.

The Pattern of Multiplication usually ends with the rejection of all extra elements that belong to the heterogeneous system — driving the system back to a mono system and thus beginning a new cycle.

**4 Transition from Macro to Micro Level**

**The Pattern of Transition to Micro level** states that elements of a technical system during its lifetime have a tendency to decrease in size, eventually collapsing into the micro level (molecules and atoms).

Technical effects migrate from visible mechanical parts to micro-scale, then to fields/photons/electrons. ([arvindvenkatadri.com](https://arvindvenkatadri.com/teaching/1-play-and-invent/modules/1000-triz-documents/TRIZ-related/Shulyak-Intro-to-TRIZ.pdf))

| **Macro** | **Micro** | **Field/Quantum** |
| --- | --- | --- |
| Vinyl stylus | CD laser pit | Solid-state flash |
| Ball-in-mouse | Optical mouse | Touch capacitance |

**Design cue.** When mechanical tolerances become a bottleneck, look for field-based alternatives; the line predicts *size ↓*, *precision ↑*, *moving parts ↓*.

Examples:

* A record playing device transitions from a mechanical needle (having mechanical contact with the surface grove of a record) into an optical system with a laser reading information on a digital disk.
* A computer mouse has a ball that converts mechanical hand movement into an electrical signal.
* The next generation of mouse is a touch plate, where the mechanical motion of a finger is transformed into an electrical signal.

**5 Synchronization (Harmonising Rhythms)**

Parts of a system evolve toward matched frequencies, cycles or phasing; alternatively, *intentional* de-synchronisation can remove resonant harm. ([geniusrevive.com](https://geniusrevive.com/en/triz-method-of-enhancing-creativity-and-generating-breakthrough-innovations/?utm_source=chatgpt.com))

*Examples*

* Car engines adopt variable-valve timing to sync airflow with piston rhythm.
* In disk drives, spindle-motor speed is tuned to cancel acoustic resonance in the chassis.

**Check-list.** Map every periodic process (rotation, thermal cycle, data refresh). Contradictions often show up as rhythm clashes the Synchronization line can resolve.

**6 Scaling Up or Down**

Systems repeatedly enlarge to cover greater scope (power plants → grids) *and* shrink for niche or embedded use (mainframe → wearable). The TRIZ community labels this “Evolution #6 — scaling up or down.” ([aitriz.org](https://www.aitriz.org/triz-articles/inside-triz?utm_source=chatgpt.com))

**Typical ladder**

1. Laboratory prototype (cm)
2. Pilot plant (m)
3. Gigafactory (km)  
   → step‐change →
4. Chip-scale MEMS version (µm)

**Tool-use.** When cost/energy density plateaus, examine the *opposite* direction on the scale ladder for breakthroughs (e.g., micro-inverters in solar arrays).

**7 Uneven Development of Parts**

Subsystems improve at different rates, breeding new contradictions. Lagging parts then leap ahead, restarting the cycle. ([en.wikipedia.org](https://en.wikipedia.org/wiki/Laws_of_technical_systems_evolution?utm_source=chatgpt.com))

*Illustration* – smartphone batteries (slow) vs. processors (fast) created heat/weight issues, prompting battery-chemistry jumps and power-management ICs.

**Action.** Plot key performance curves of all subsystems; the flattest curve marks the next innovation hotspot.

**8 Replacement of Human (Automation)**

Manual sensing → mechanical assist → automatic control → self-optimising/intelligent systems. Ultimately the human role shifts from operator to goal-setter. ([scholar.tecnico.ulisboa.pt](https://scholar.tecnico.ulisboa.pt/api/records/Y8MGj4zCzC6h_Lu1nhcdYBoE69OFnv5L_-_C/file/674f4929e2bb6c22d68ce2453174d35f00ac6ff99fa64e37d6bd20c8661202dc.pdf?utm_source=chatgpt.com))

*Evolution snapshots*

* Lift operator → call-button → group-control elevators → destination-dispatch AI.
* CNC machining → unmanned lights-out factories → self-correcting adaptive machining.

**Strategic cue.** List every human intervention; ask “what sensing/logic lets the system decide for itself?” The line forecasts that *even creativity* migrates to algorithmic modules (cf. generative design).

**Using the Lines Together**

The eight lines rarely act alone. A common path is:  
Life-Cycle plateau → Dynamization and/or Macro→Micro → Automation, with *Synchronization* and *Uneven Development* revealing the next bottleneck. Incorporate these patterns into road-mapping workshops or multi-generation product plans (MGPP) for defensible, TRIZ-grounded forecasting.

**References**

Life-cycle overview and S-curve importance ([the-trizjournal.com](https://the-trizjournal.com/innovation-methods/innovation-general/patterns-evolution-methodologies/))  
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# Laws and Patterns of Systems Development