

Components of an DARPA Program

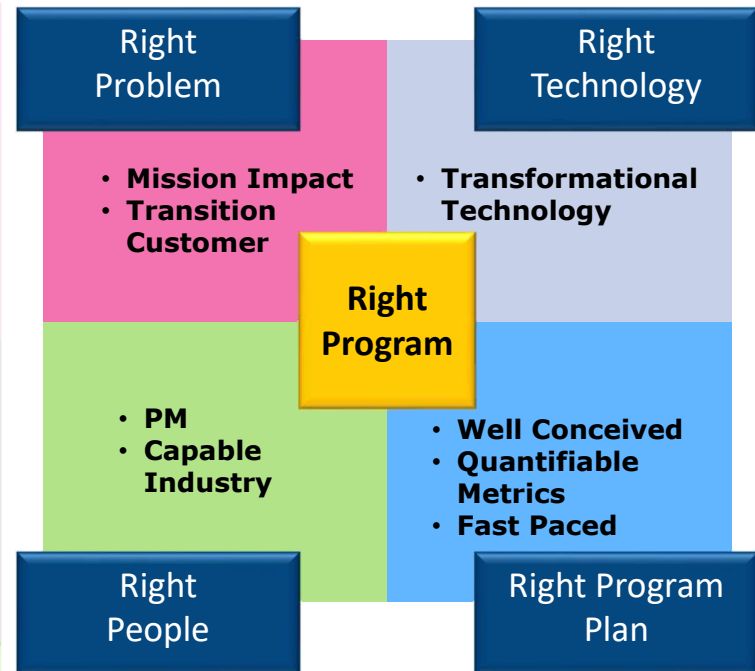


Key Elements:

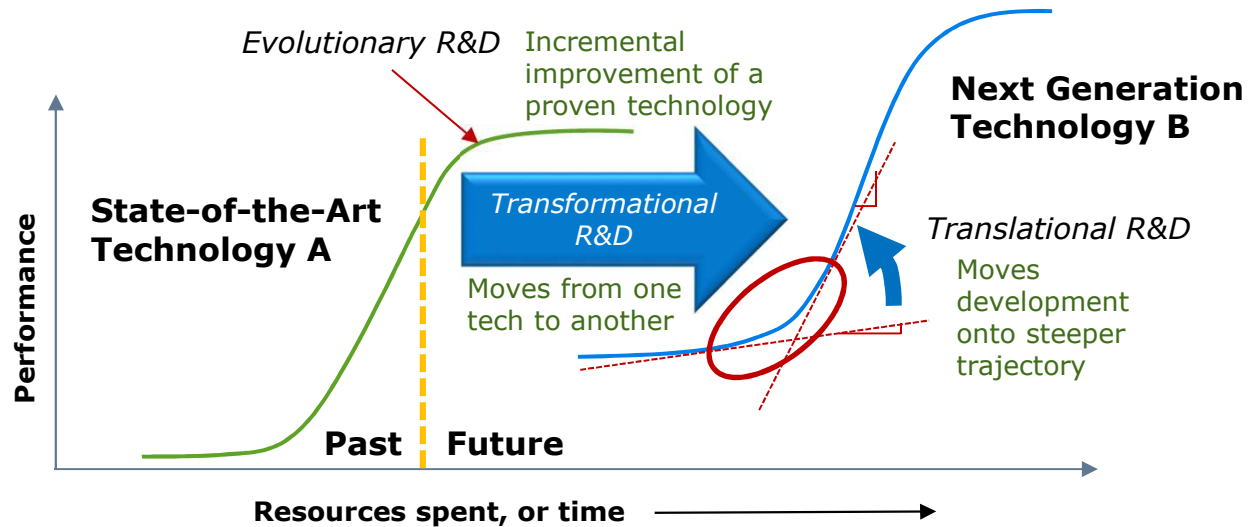
- Has sufficient mission impact that fulfils a transition partner mission
- Able to demonstrate a prototype that is realistic enough and has enough new capabilities that transition partners will be interested
- Technologies with the potential for breakthrough performance substantially better than the current technology, or have a greater potential to continually improve in the future
- Positive impact on agency mission if technology is successfully developed
- Technology can be transitioned to the next stage developer
- Motivated PM with vision and technical capability

- Industry with available facilities and technical expertise

- Well conceived program plan with quantifiable and measureable metrics, milestone phased
- Keep fast-paced and concentrate on DARPA-hard part(s)
- Clear understanding of developmental risks vs. budget and potential pay off and barriers
- Fail fast and learn in the process



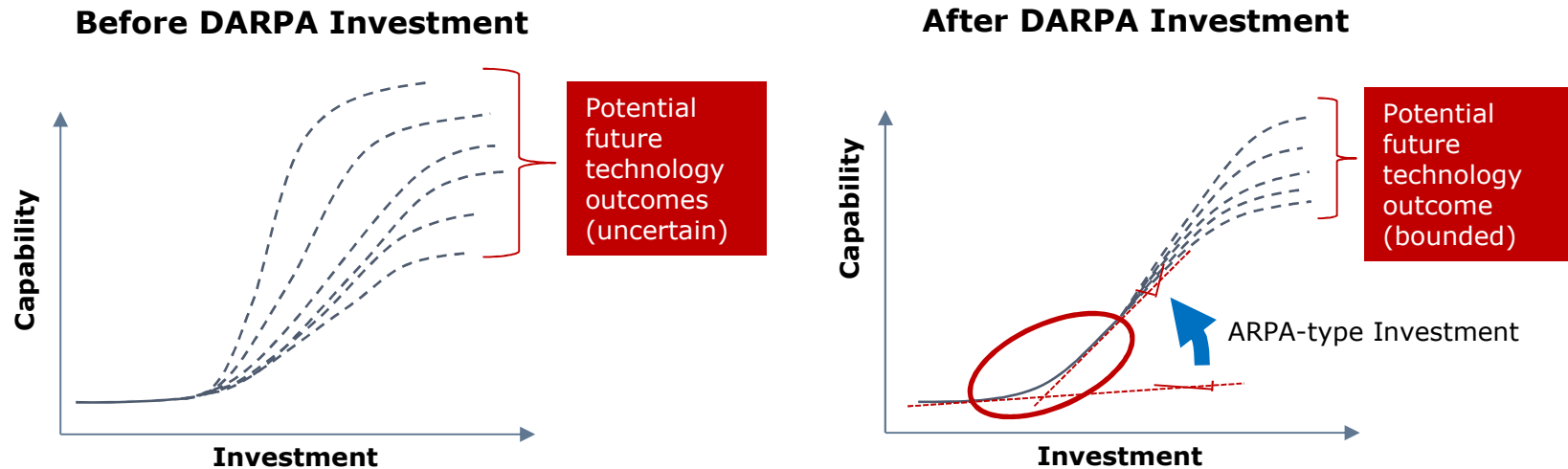
Why does Rice play Texas? (Not because its easy, but because its hard)



- Evolutionary R&D is well defined and low risk, but offers diminishing returns. End user is more likely to invest in Evolutionary R&D because their immediate mission limits their developmental time horizon and capability to accept risk
- Translational R&D is risky because the return on investment (ROI) is difficult to define since the ultimate potential of the technology is unknown
- Transformational R&D is difficult to justify since it is unclear when or whether the new technology could supplant the state-of-the-art

Transformational & Translational R&D offers opportunity for large gains but significant barriers exist

DARPA Programs are both Transformational & Translational



- Alternative technologies have significant uncertainty about their potential and about their real-world suitability. Uncertainty acts as a major barrier to future development partners. This uncertainty causes end-user developmental partners to invest in evolutionary improvements of previous generation technology
- DARPA-type investment reduces risk and required investment for technology development partners
 - Reduces the number of potential future outcomes by developing the technology farther up the “S” curve
 - Increases the slope of developmental progress by demonstrating the technology through a prototype in real-world environments
- Prototype demonstrations are often required to convince end-users to switch R&D resources from evolutionary development of the previous technology
- After a successful Transformational/Translational R&D program, development partners can more reasonable invest in the final R&D and incorporate the new technology in future products

The goal of an DARPA Program is to move breakthrough technology R&D onto the mainstream path of normal development and application

Structure of an DARPA Program



Director initiates program



Phase II Go/No-Go decision

- Go/No-Go decision based on**
- Continued technical feasibility
 - Continued business case for development
 - Meeting or exceeding pre-defined quantifiable and measurable performance metrics
 - Assessment of future program plan/budget
 - Updated assessment of programs value to office portfolio

Program Manager facilitates and oversees performer activities using pre-defined metrics and regular program reviews

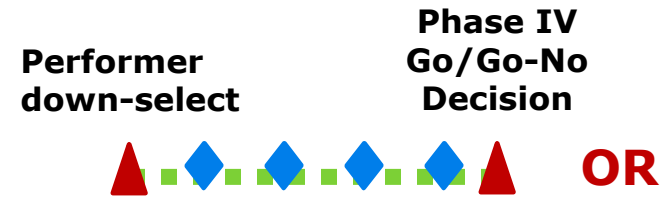
Performers competitively down-selected



Phase III Go/No-Go decision

Phase I activities	[Bar]		
Phase II activities		[Bar]	
Phase III activities			[Bar]
	Phase I	Phase II	Phase III
		Go/No-Go Decision	Go/No-Go Decision

Tasks should NOT be carried over from one phase to the next. Allows for a clean phase transition decision. All tasks must be planned to have a logical conclusion at the end of each phase. Decision points should be only 12-18 months apart, otherwise risk is not being managed.



Transition program to a more conventional R&D group for further maturation

Keeping Programs Efficient and Fast Paced



- Minimize R&D cost and effort by omitting lower risk elements of prototypes which would otherwise be included in a real system
- Showing feasibility and new capability, but not optimizing all factors that will need to be included in the final system
- Remain undeterred in the face of the occasional strike-out that inevitably accompany success
- Remain flexible enough to quickly explore the opportunity with the greatest potential and to exit those areas that prove to be less promising; A well-conceived program has off ramps at each phase that provides mission benefit
- Take the time to develop a good program plan early on because programmatic aspects are tightly interconnected and changes to a program schedule and budget can take much effort to re-plan and renegotiate
- Minimal connection to the standard acquisition process
- Avoid long coordination and approval chains

Learn Quickly and Cull the Weak



- Only start programs which meet all requirements of an ARPA-type program
- Emphasize studies early in the program plan to identify ideas/programs which are likely to fail
- Concentrate technology development on the hardest part of the concept
- Focus on a demonstration, not just a study. Force the program to put up or shut up
- Use quantifiable metrics throughout the lifecycle of a program to measure the progress of the hardest technology toward a demonstration
- Use phased programs with quantifiable gates to give off-ramps if goals are not being met
- Don't be afraid to kill a program when it becomes clear that it will not have a transformational effect
- Common reasons for not funding and idea or killing a program include
 - Failure of technical progress, solution cost, program budget, lack of transition interest, performance no longer meets mission goals, or any combination of the above

Try to Fail Fast

Lifecycle of an DARPA Program



Ideas come from many sources. Procedures must be clearly understood in order to handle them all and encourage them all. Good ideas are the life blood of an DARPA Office

- **Office Generated** – Part of portfolio planning and sometimes necessary to meet transition customer requirements. PM is usually hired for that focus area
- **PM Generated** – Usually the best programs. High motivation, technical competence, and well conceived program plans
- **Center Generated** – Maybe allow the centers to bid efforts. Need to either match with existing PM or have Center provide one
- **Open BAA** – Have an open solicitation at all times as a large net for ideas. Should ask for a combination of top level mission goals of Office and near term focus areas of existing PM staff
- **Unsolicited** – Should avoid if possible and send through open BAA so as to meet competitive reward requirement

PM should listen to all comers

Lifecycle of an DARPA Program



- Studies are used to scope the goals and metrics of a possible program and the resultant solicitation
 - Workshops, industry meetings, RFIs, and customer involvement are additional avenues
- Having a potential performer conduct a study of a concept could potentially restrict their ability to bid to a subsequent solicitation - this concern will keep industry from submitting good ideas
- If the exploration of a concept is done with this in mind OCI can be avoided

Possible Study Types	Who
<ul style="list-style-type: none"> • Tech solutions <ul style="list-style-type: none"> - Subsystem Demo/Study - Trade Study 	<ul style="list-style-type: none"> - Performer - Langley, FFRDC, SETA
<ul style="list-style-type: none"> • Metric Definition <ul style="list-style-type: none"> - Subsystem Demo/Study - Trade Study 	<ul style="list-style-type: none"> - Performer - Langley, FFRDC, SETA
<ul style="list-style-type: none"> • Schedule, Budget 	SETA, PM
<ul style="list-style-type: none"> • Mission Effect - Gov Study 	Langley, FFRDC, SETA, transition customer

Through this approach no potential performer has a preview of the system level requirement and therefore will not be OCIED and out of future competition

It's the PM's responsibility to ensure well run studies that maintain a future full and fair competition

Lifecycle of an DARPA Program



Decision Authority

- Compares the described program impact against the agency mission and strategy
- Determines whether the program promises enough impact to justify the investment
- Compares the program opportunity against others vying for limited resources
- Compares the transformational technology against the needs of potential transition customers
- Verifies the program meets the rigorous criteria of a well thought-out plan dealing with all the complexities required in transformational R&D. All the Heilmeier questions have been answered
- Determines if the Program Manager has outlined a robust program strategy and transition approach
- Verifies the proposed budget and schedule are realistic and support a fast-paced program with the flexibility to adjust to unforeseen opportunities
- Ensures the right people are identified and available to execute the program plan

Things to remember:

- The multi-year budget for the program is registered in the agency budget system so that the funds are available to support the life of the program
- Funding is reserved for programs which can be fully outlined by a Program Manager
- The program creation effort can take weeks or months (up to a year) depending on the complexity and the PM's work load

During this step, the final goals, metrics, and budget for the program are set

Lifecycle of an DARPA Program



The original solicitation puts you in a box for the life of that effort. Must be well drafted, and reviewed by management and General Counsel

- Although RFPs are sometimes appropriate, DARPA Offices work best using BAAs
 - OT authority for commercial ventures would be beneficial
- Outcome oriented, not technology approach
- Defined at top level requirements - at a level so as not to preclude a solution
- Structure program to maintain competition as long as possible
- Well define evaluation criteria to include Tech Approach, Contribution to Agency Mission, Program Plan, and Team Capability at a minimum
 - Allow program-dependent criteria to enhance decision making

PM/Director/GC ensures full and fair competition with well-organized solicitation goals and evaluation criteria

Lifecycle of an DARPA Program



- Well thought-out Source Selection Plan is critical to a successful process
 - Must be followed to the letter but not lead to an absurd or sub-optimum result
- The Program Manager designs and executes the competition and selection phase to achieve the optimal combination of projects to meet the program objectives
- Source Selection Board – should be lead by the PM and include technical specialist(s) from outside the Office, and if possible a representative from a potential transition customer. Contracting Officer should monitor the boards activities.
- Proposals are graded but not ranked (BAA)
 - Define good mix of solutions for funding not necessarily in order of grading
- The selected approach may have a completely different technological solution then was originally presented to the Director. That should be fine as long as the top level requirements meet important mission goals
 - The Program Manager is held accountable for the program’s outcome and mission impact, usually not for the specific technology mix
- DARPA-style agencies are more likely to need the full flexibility given by law in designing and executing each competition to satisfy the program’s unique requirements

Source Selection Authority ensures that selection process was fair and followed the Source Selection Plan

Lifecycle of an DARPA Program



- PM works closely with the Contracting Officer (CO) and the General Counsel (GC) to embody the correct elements of the program strategy in the individual contracts
- ARPA organizations utilize a variety of contracting vehicles to speed obligation of funds
- PM ensures the necessary tasks and deliverables are captured in the SOW
- PM must negotiate rights to provide as much flexibility for execution and future production as possible

Funding Documentation

- Agency-wide process for documenting the information underlying a funding decision and recording both the Program Manager's request and the Office Director's approval
- Comptroller must also agree that the funding documentation shows funds are consistent with the agency appropriation and within the funds delegated to the Office for that program

Lifecycle of an DARPA Program



- PM assembles a government oversight team. Combination of SETA, consultants and government personnel. Allows for nimble execution as program requirements change
- Push performers to explore the possibilities early on, not just polish the idea proposed
- Be prepared to change direction and goals as technical and mission opportunities present themselves
- Hold program to metrics. Allows dispassionate view of progress/potential
- Flat management structure - periodic management review necessary, but PM should be left to execute and then held accountable
- PM should run multiple programs so that he/she is not tied to any single one. PM will voluntarily kill efforts that are not working
- Remember, competition is your friend

Lifecycle of an DARPA Program



- **Technology Transition Planning** in an ARPA organization occurs throughout the full technology development and deployment life cycle
 - Identifying future barriers that will prevent the technology from reaching its full potential for impact on an agency mission area
 - All programs must have a credible plan for transition before funding
 - It is not in the Government's best interest to continue investing in a technology beyond the point where a transition partner can take-over
- **Transition Partners**
 - Transition criteria is different for different partners
 - Programs may need to be tailored to address transition partner concerns, such as intellectual property, cost share, and maturity of any technical prototypes
- **Types of Transition Partners**
 - Service Partner
 - Other R&D Orgnaization
 - Industry for commercial development

Transition is the ultimate measure of success, although not ultimately under total control

Responsibilities in the Process



- Director provides insight into agency gaps and funding priorities
- Program Manager finds technological opportunities that provide a significant impact on the agency mission
- PM identifies technical barriers preventing new technology adoption
- PM explores the needs of potential transition partners
- PM develops program strategy
 - Technology opportunity,
 - Define desired outcome (mission goal),
 - Realistic budget and schedule providing flexibility to recover from failures and exploit opportunities,
 - Quantifiable and measurable metrics to aid in oversight ,
 - Milestones / Deliverables (i.e. demonstrated subsystem capability, technical prototype maturity at completion),
 - Transition strategy (i.e. intellectual property, cost sharing, partnerships)
 - Competition strategy, and
 - Contracting strategy (agents, timeline)
- PM presents the program to the Director

The Program Managers are Critical

Characteristics of a Successful DARPA Program Manager



Superior Knowledge and Experience

- Typically highly sought-after technologists (10-20 yrs experience)
- Able to identify problems early and find solutions
- Understands that technology success is not just technical
- Able to identify how far a concept needs to be developed to secure a transition partner
- Able to identify immature technologies which offer sufficient mission impact to justify investment

Transformational Vision

- Entrepreneurial spirit
- Willing to bet their careers on creating and managing breakthrough technology programs
- Able to look beyond technological improvements to new transformational technologies

Capable Manager

- Transformational R&D management experience is highly desirable
- Able to identify the right strategies to development new technologies
- Intellectually honest about all aspects of their programs to ensure a proper assessment of risks
- Ethical and fair, and with high standards
- Able to work with and motivate a team of people with diverse skill sets
- Delivery-oriented

Communication/Team Building Ability

- Excellent communicator of vision and able to recruit and manage technologists to ensure the program succeeds and remains funded
- Able to define and communicate the significance of a program to the agency's mission
- Interactive with contractors to remain aware of successes and problems

Role of a Successful DARPA Program Manager



Program Concept/Planning

- Determine the key technical uncertainties that currently prevent industrial investment and define a feasible R&D program with end-state technical goals that will go from the current state beyond the transition threshold
- Assess the programs costs and probable outcome with the potential benefit of the transformational technologies and other R&D investment opportunities
- Explain how large the impact of the new technology will be and why this represents a significant, transformational leap forward
- Ensure competition regulations are followed

Program Execution

- Help performers overcome barriers (i.e. access to specialized equipment, additional funds for specific additional tasks, adding new key performers)
- Manage program budgets and schedules as well as day to day SETA support activities
- Conduct regular program reviews to provide oversight and opportunity for adjustments in execution
- Maintain a set of quantifiable, measureable metrics to help assess and manage performer progress
- Ensure legal reporting and financial regulation are followed

Transition

- Understand the factors that support or impede transition into the targeted industry and use that information to plan and facilitate future transition by holding regular meetings with the target industry and refining requirements for end of program prototypes to build industry confidence
- Understand the nuances of the target transition partner in order to devise a strategy that addresses their needs in areas such as intellectual property rights, cost share, and maturity of technical prototypes

Attracting and Retaining Good Program Managers



Where to look for Potential Program Managers

- Industry
- Not-for-profit/National laboratories
- Universities
- Other federal agencies

Attracting

- Establish a reputation for the office as a flexible, nimble organization that is open to new ideas
- Provide PMs with career enhancing experience and opportunities. Word of mouth will assist in future recruiting
- Would help to move to a more flexible HR system and request legislative relief to gain special hiring authorities
- Term appointments need to be of sufficient length to provide PMs with the security of knowing they will have the time needed to develop and execute a program idea before having to re-enter the job market

Retaining

- Empower the PM while simultaneously holding them accountable
- Minimize bureaucracy and time consuming processes
- Use Government agency Contracting Officers to free PM to focus on higher level program aspects
- Consider a bonus/incentive system
- Reward Program Managers who take appropriate risks and manage those risks prudently with increased portfolio responsibility



Back-up

DARPA "Grand Challenges"



The **2007 DARPA Urban Challenge** required teams to build an autonomous vehicle capable of driving in traffic, performing complex maneuvers such as merging, passing, parking and negotiating intersections. Teams from around the world were whittled down through a series of qualifying steps, beginning with technical papers and videos, then advancing to actual vehicle testing at team sites. Of the 89 teams to initially apply, 35 teams were invited to National Qualifying Event (NQE), a rigorous eight-day vehicle testing period. Eleven teams qualified for the Final Event.

- 1st Place: \$2,000,000 (Tartan Racing)
- 2nd Place: \$1,000,000 (Stanford Racing Team)
- 3rd Place : \$500,000 (Victor Tango)



The **DARPA Network Challenge**, was a competition designed to explore the roles the Internet and social networking play in the timely communication, wide-area team-building, and urgent mobilization required to solve broad-scope, time-critical problems. The challenge was to be the first to submit the locations of 10 moored, 8-foot, red, weather balloons at 10 fixed locations in the continental United States. The balloons were in readily accessible locations and visible from nearby roads.

- 1st Place: \$40,000 (MIT Red Balloon Challenge Team)

- The goal is mission outcome NOT technical approach
- Desire is to have many performers both traditional and non-traditional demonstrate a solution
- Best used when goal does not require significant investment or facilities

Role of a Successful Office Director



- Provide strategic leadership for the agency
- Establish a reputation for the agency as a flexible, nimble organization that is open to new ideas
- Gain awareness and trust of technical community so they bring transformational R&D ideas
- Explain the significance and progress of each program to NASA management and Congressional oversight committees
- Establish a culture of brutal honesty
- Ensure an exceptionally high standard of conduct for the agency's individuals and processes
- Guide program initiation
- Execute high level oversight of programs and thrusts; Report on program progress against self-defined metrics
- Act as the portfolio manager for the agency's investments; Plan the agency budget to allow financial flexibility to create programs in the most promising areas
- Identify promising areas and hire PMs to explore and develop them
- Reward PMs who take appropriate risks and manage them prudently
- Establish necessary support functions within the agency; contracting, general counsel, and HR
- Institute processes with sufficient controls and documentation, but as light-weight as possible to maintain the non-bureaucratic, nimble functioning of an ARPA organization

DARPA TTO Lessons Learned



What has worked for DARPA TTO

- Maintain close communication with thought leaders from industry, academia, government and other labs (including commercial products)
- Strict tailoring of mission assurance, reliability, and redundancy for first articles/demos
- Simplification of launch and demonstration decision authority
- Use of end customer as acquisition agent for project
- Flat organizational structure, simplified program approval chain and progress reviews
- The ability to source and redirect funds quickly
- Recruit for innovation

Recruit for innovation

- Truly game changing ideas often come from outside your organization
- DARPA leadership and PMs are all "temps"
- Tenure clock generates a "time to market" urgency
- Lack of "corporate memory" doesn't prejudice new ideas with "we tried that before"

Summary

- For over 50 years, DARPA has operated in "collaborative tension" with the Military Services
- DARPA's focus is usually beyond the horizon of service requirements, architectures, and roadmaps
- DARPA has the mission, resources, and organizational agility to pursue game-changing technologies
- Technical capabilities demonstrated by DARPA can (and often does) result in Services, OSD, and Congress directing radical changes to plans and programs for services' capabilities
- The minimization of acquisition processes contributes strongly to DARPA's organizational agility
- The desire is to use future partnerships with NASA to explore greater opportunities

Heilmeier Questions



1. What are you trying to do? Articulate your objectives using absolutely no jargon.
2. How is it done today, and what are the limits of current practice?
3. What's new in your approach and why do you think it will be successful?
4. Who cares?
5. If you're successful, what difference will it make?
6. What are the risks and the payoffs?
7. How much will it cost?
8. How long will it take?
9. What are the midterm and final "exams" to check for success?

Top Twelve Rules of Project Management



Rule 12 - Avoid arbitrary or imaginary constraints

Separate the real from the imaginary

Test perceived limits "*what's wrong with having more than 10 rules?*"

Everything is negotiable, if you have a clear understanding of the goal AND the reasons behind it

The one who set the constraint is usually the one less certain about its validity

The overall objective needs to be in the head of the whole team all the time, and it is your job to keep it there

Rule 11 - Chaos before order

Allow 5-10% of the schedule at the beginning to brainstorm, experiment, and allow random thinking

Involve the entire project team and strive for complete communication of all ideas, questions, etc.

Encourage 3-sigma views, but settle on an approach with consensus of the majority

Rule 10 - Don't be afraid

Don't be afraid to ask stupid questions (you'll be surprised how many others wanted to know but were afraid to ask)

Don't be afraid to start

Don't be afraid to stop and replan

Fear makes idiots of us all

Rule 9 - Attack the toughest problems first

Their solution will usually provide the most economic solution for the project

The earlier problems are found, the cheaper the resolution

If you can't find a solution, better to know that early to either kill the effort or replan

Just because you're paranoid, doesn't mean they're not really out to get you.

Rule 8 - Freeze Systems Design Progressively

All should be rubber at first; Iterate to define balanced design

Freeze mission (requirements/payload) first; Must understand goal and focus on it

Freeze powerplant second; Most complex, costly, problematic, critical subsystem

Freeze airframe third; Must match to mission/propulsion

Freeze secondary subsystems last; Less impact on design balance

Top Twelve Rules of Project Management



Rule 7 - Dedicate people to the team

Highest morale
Gives best design integration
One worker, one boss
Complete one project before starting next; Best way to apply learning from prior results
Minimizes spin-up, file management costs
Minimizes scheduling, communication, management time
Minimums interfaces per full-time-equivalent
Bring in experts if needed to train/review
Only have dedicated people on critical path.

Rule 6 - Keep a simple organizational structure

Match Work Breakdown Structure (WBS)
Design WBS to minimize number of interfaces required for good decision-making
Each level in management hierarchy manages interfaces between direct reports

Rule 5 - Delegate effectively

Delegate authority as well as responsibility - Delegate the right to make mistakes
Put the person closest to the problem closest to the solution
Delegate to lowest possible level for good decisions
Delegation is NOT abandonment
You must share all you know - You must encourage others to share

Rule 4 - Communicate

Rule 3 - Learn from mistakes

Every failure is a chance to learn
You learn more from failures than from successes... failures teach you what you didn't know, success only reinforces your prior assumptions, and it may be just luck!
Giving up means you've quit learning

Top Twelve Rules of Project Management



Rule 2 - Practice the scientific method

Single events are data points, they do not prove a hypothesis

Study the cause, it may trigger an analysis that can show a mistake in assumptions, processes, or designs

Draw conclusions with restraint

Measure twice - cut once

Refine procedures

Rule 1 - Practice the golden rule

Nobody intentionally screws up

If you don't have problems, you're not doing much

Encourage good risk taking

Okay to crash when pushing limits

Not okay to crash due to careless mistakes