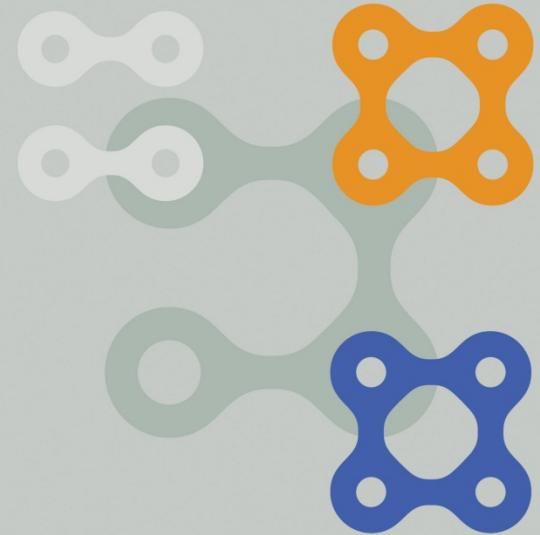


Business-Technology Roadmapping for Ammonia Fuel

*Tenth Annual NH₃ Fuel Conference
September 23, 2013*



ALLIANCE CONSULTING GROUP

We make strategy work.

Agenda

- What is a business-technology roadmap and why is it important?
- Recent work
- Moving forward

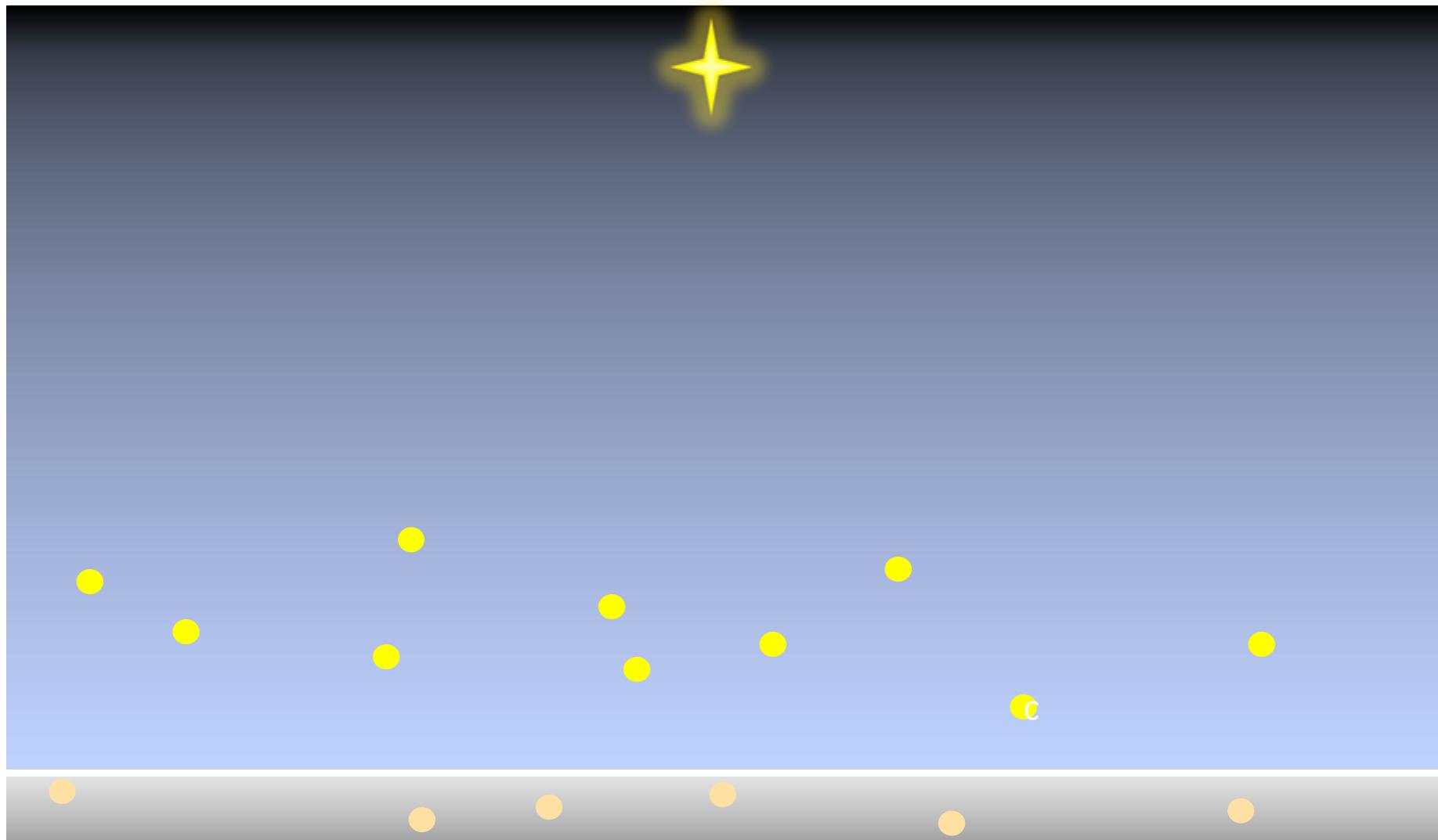
Business-Technology Roadmapping: Definition

- Business-technology roadmapping describes what needs to happen between the appearance of new technology and its widespread adoption

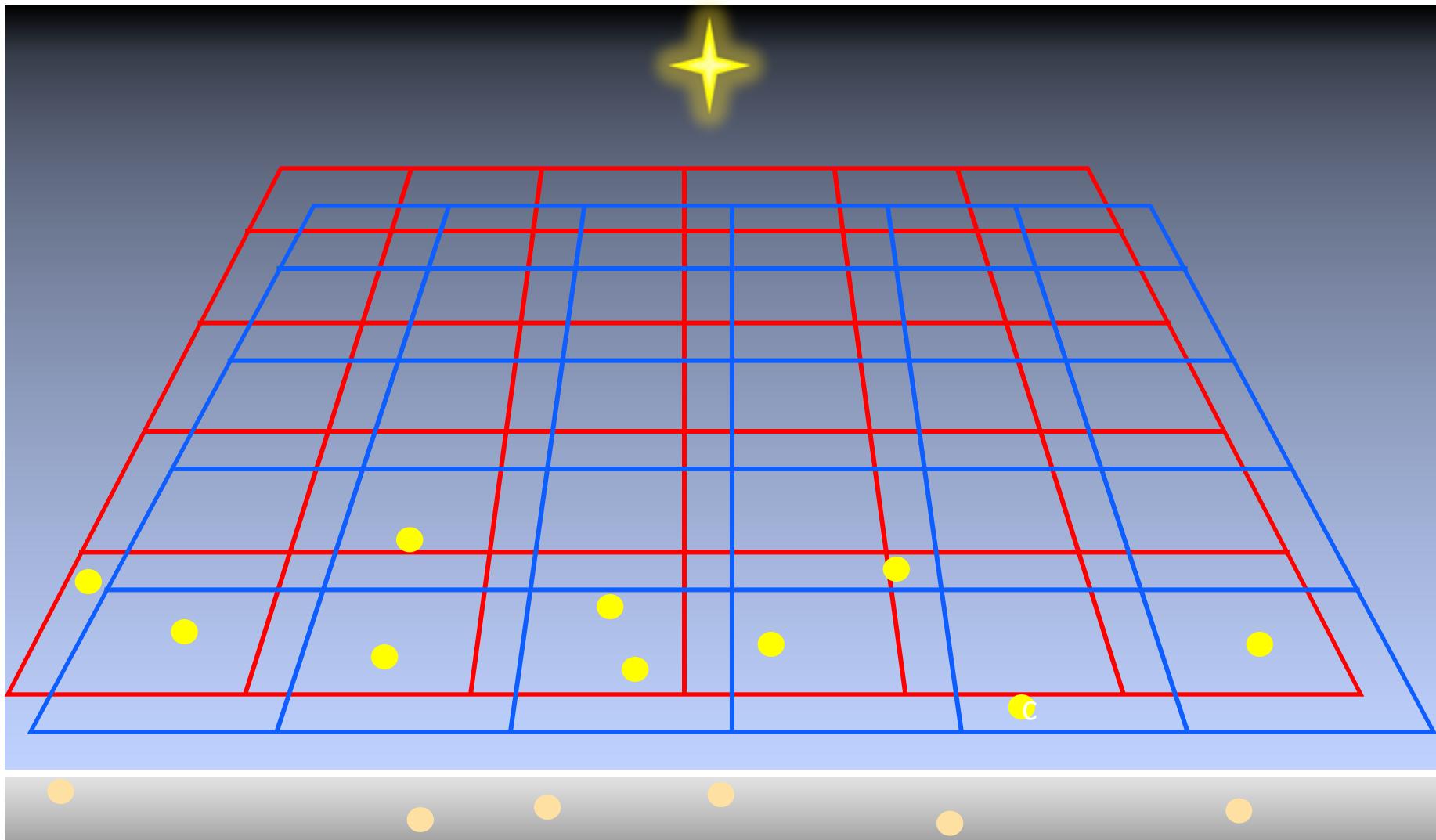
Why It is Important

- Those with resources to invest will tell you: the world is full of solutions
 - Some even appear to be significant and cogent
- Therefore essential to convince decision-makers:
 - Not just that our solution addresses a significant challenge
 - Not just that our envisioned end state is cogent, comprehensive, and benign
 - But also that our end state can be created with a series of practical steps that start in the here-and-now

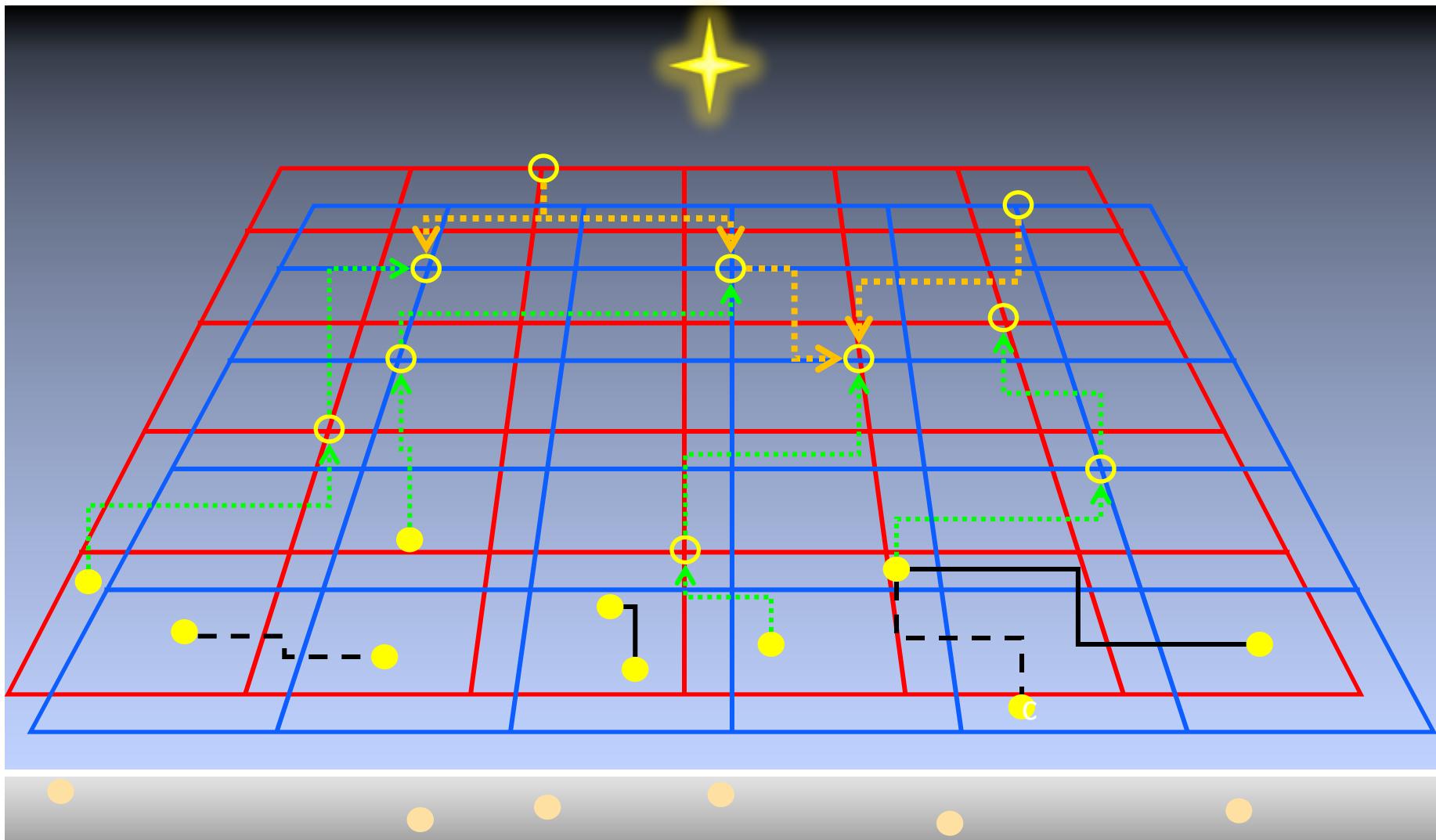
Business-Technology Roadmap in Concept



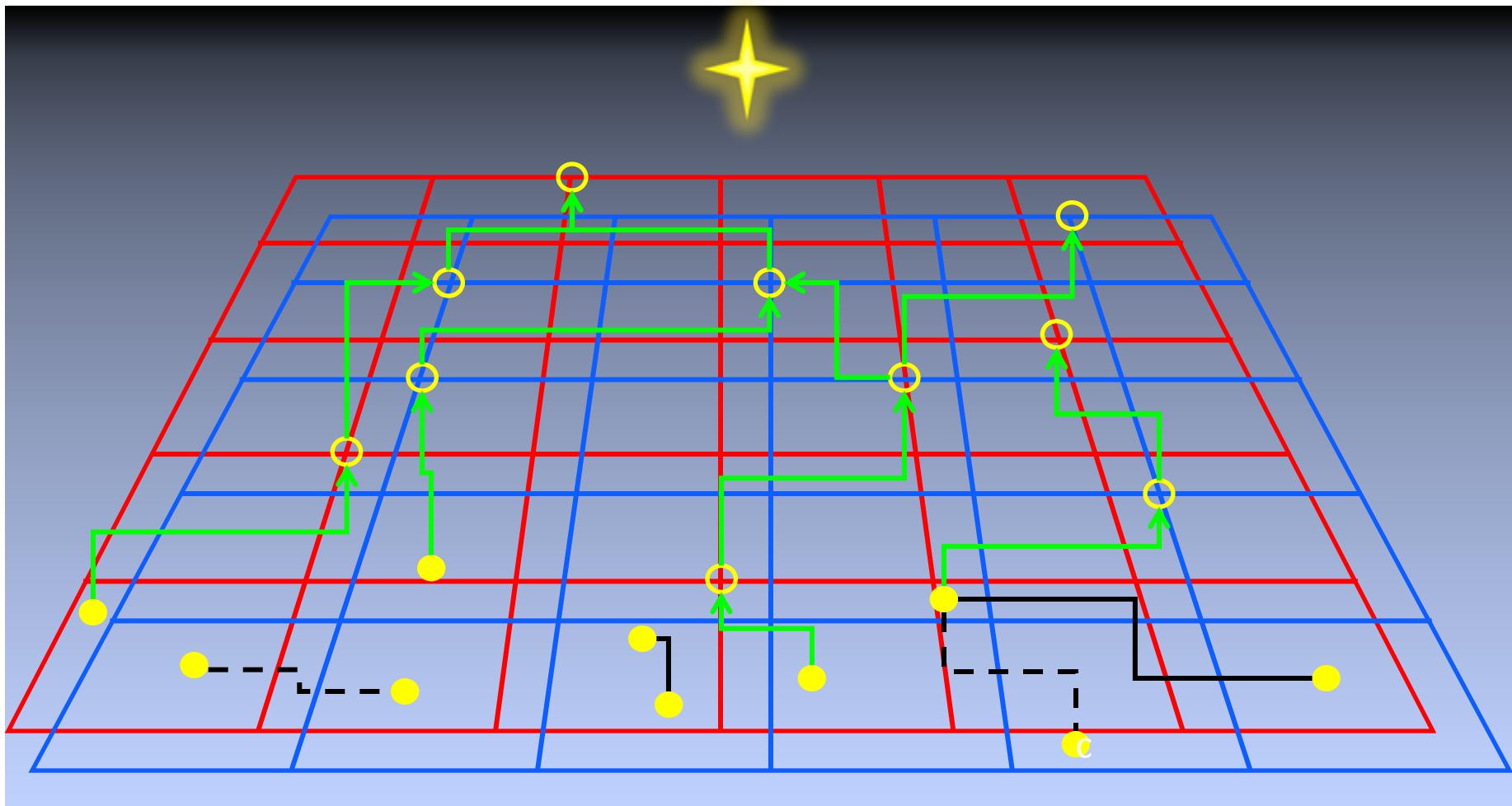
Business-Technology Roadmap in Concept



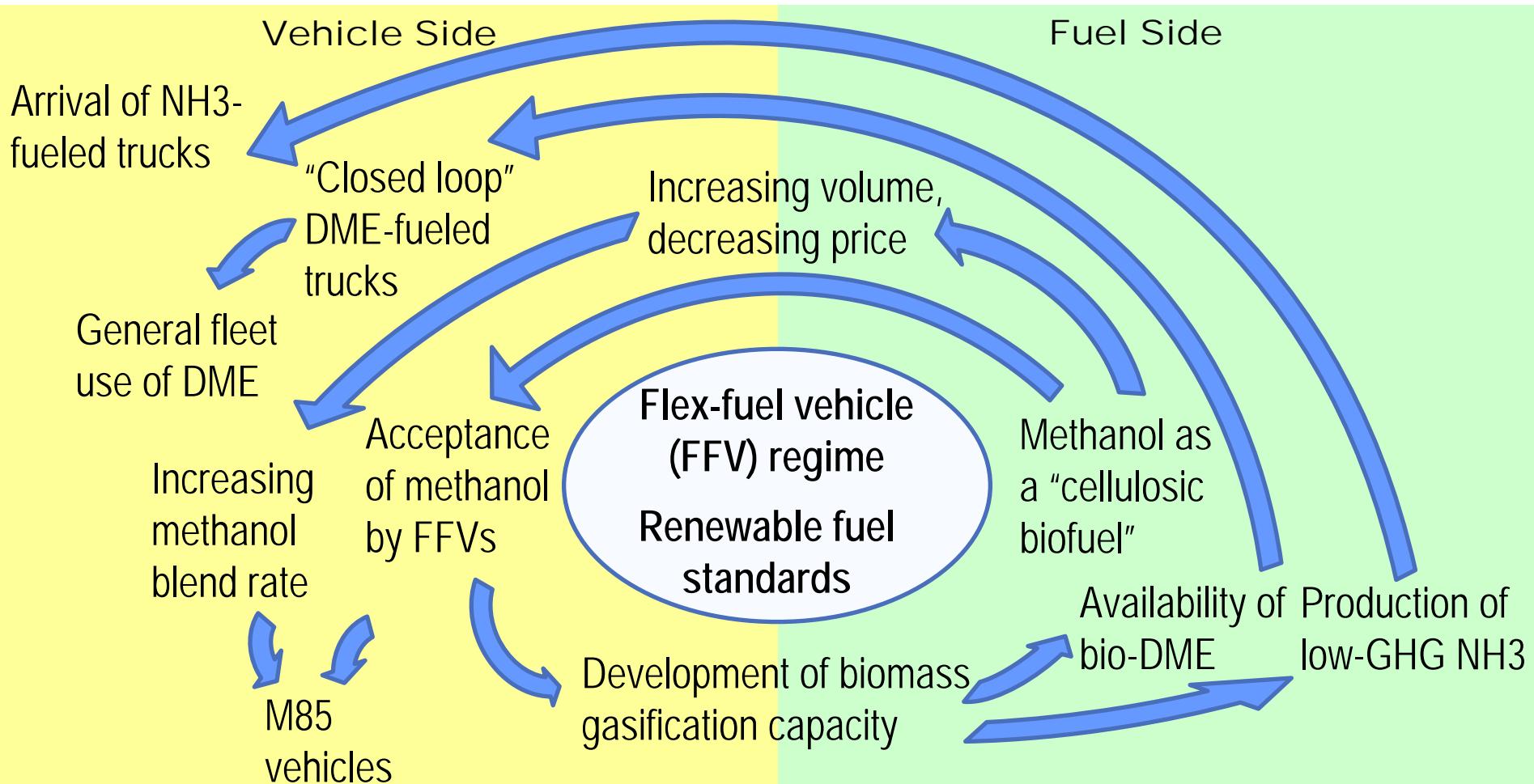
Business-Technology Roadmap in Concept



Business-Technology Roadmap in Concept



Breaking the Alt Vehicle/Fuel Impasse



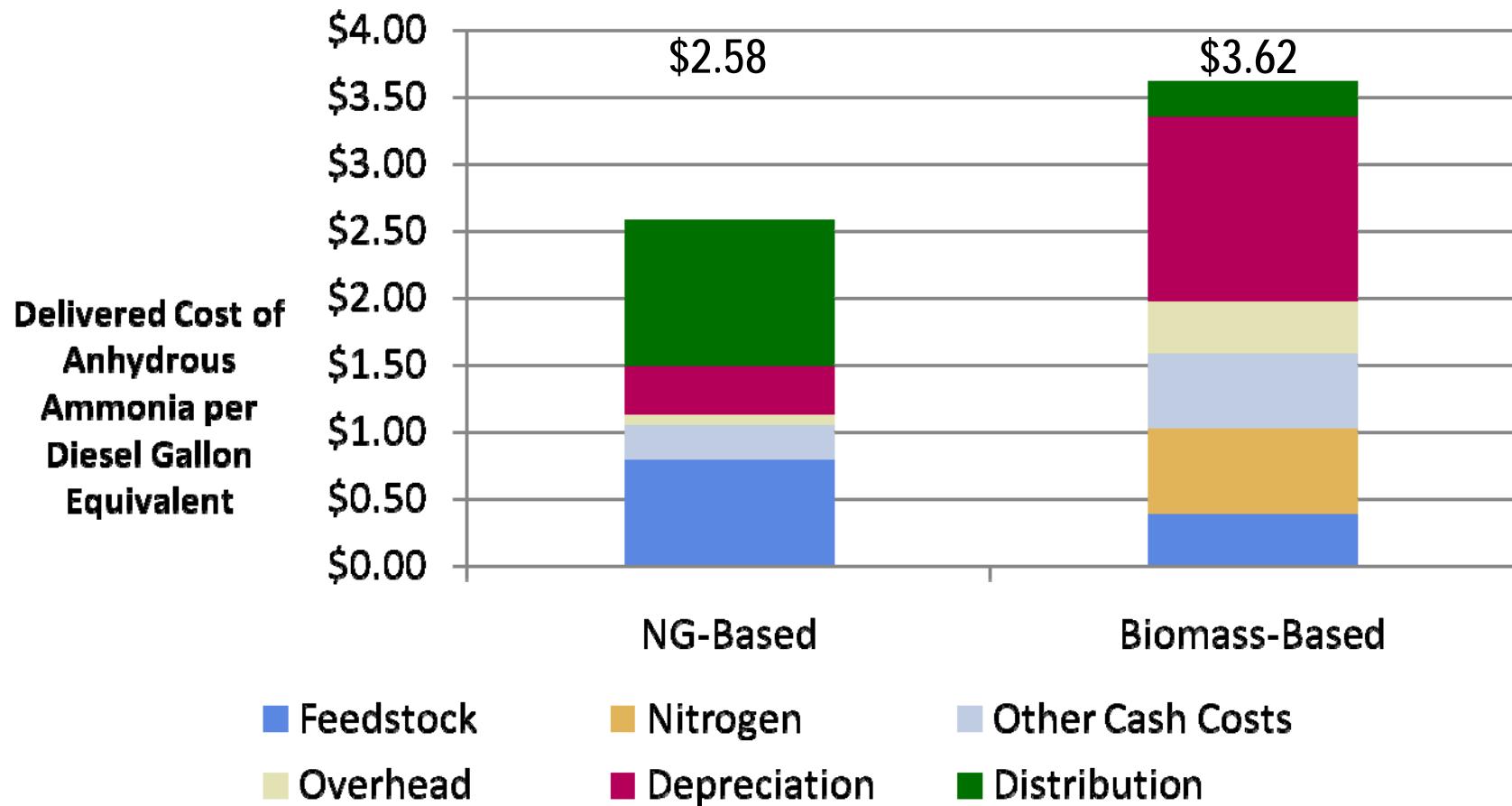
Core Challenge - 1

- Every step must be assessed against the ultimate litmus test: given real-world motivations and constraints, is it:
 - Doable
 - Sufficient
 - Not dependent on miracles
- **Doability:** *Within the step itself*, is the reward commensurate with the investment?
- **Sufficiency:** Does the step create a favorable cost position, involve other sources of advantage and value, and/or embody accessible market entry points?
- **Miracle independence:** Does the case avoid assumed benefits from factors outside the advocates' control?

Core Challenge - 2

- Realistic assessment against the criteria of the litmus test is easier to make for early steps, harder for later steps
- Modeling is required

Competitive Cost Comparison NH3



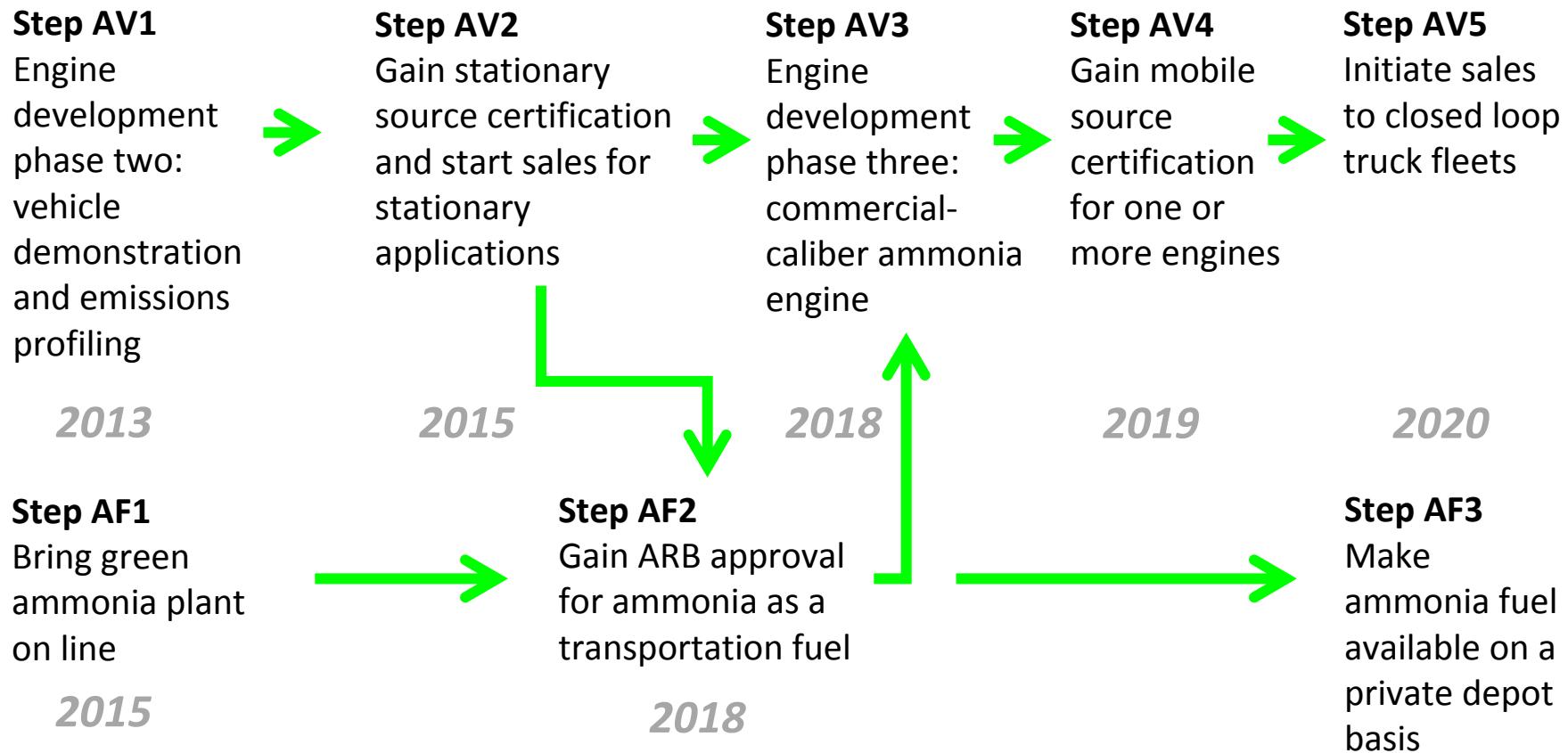
Process

- Cross-stakeholder consultation
- Work along multiple dimensions simultaneously
- Propose-critique-refine-propose-etc.

Ammonia Fuel Advisory Group

Member	Title	Organization
Bill Ayres	New Projects Manager	R3 Sciences, LLC
Dave Drury	Director of Advanced Development	Sturman Industries
James Grieve	Chief Scientist	Delphi Corporation
John Bøgild Hansen	Senior Scientist, Advisor to Chairman	Haldor Topsoe A/S
John Holbrook	Chief Executive Officer	NHThree, LLC
Jeff Newman	Staff	California Business, Transportation, and Housing Agency
Norm Olson	Biomass Energy Conversion Center Facility Manager	Iowa Energy Center
Jeff White	Senior Manager, Technology Planning and Research Department	Denso International America

Steps to Ammonia Fuel Commercialization



Step AV1

Step AV1

Engine development phase two

- Goal: Deploy an ammonia engine in a conventional vehicular application (e.g., a class 5-8 delivery vehicle) AND profile the engine's emissions
- Effect: A case can be started for the approval of ammonia fuel by regulatory authorities

Players and Actions

- Engine technology companies such as Sturman Industries, Eliminator Products, and Hydrogen Engine Center have developed all necessary components and systems and are prepared to deploy them in a phase two project

Note

Engine development phase one has already been completed through the independent efforts of several technology developers, with special notice going to SAVIA in Italy.

Third Leg of the Stool

- Business-technology roadmapping is the third leg of the NH3 fuel stool
- It is THE challenge of the moment for the NH3 fuel movement and should be a key focus of the next phase of our work
- What will be needed
 - A core effort
 - Broad support
 - A common mindset, not necessarily on the content but definitely on the importance of the undertaking

Thank you!

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