

Debrief of Dr. Whelan's TRL and Aerospace & R&D Risk Management

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Purpose of TRL Briefings

- The TRL methodology was introduced to the ARIES project a year ago and the project immediately embraced the concept.
- In March of 2008, an ARIES team briefed OFES who then wanted to introduce the concept to FESAC
- Mark Tillack and David Whelan, Chief Scientist for Boeing defense branch presented the TRL methodology, capabilities and Boeing utilization to FESAC
 - FESAC was very interested in the TRL approach and stated that several Research Needs Workshops (ReNeW) are applying this methodology in their technology assessments

Technology Readiness Levels and Aerospace R&D Risk Management

Dr. David Whelan

Chief Scientist

Boeing Integrated Defense Systems

Presented to Department of Energy
Fusion Energy Science Advisory Committee

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Role of R&D in BCA



- **Description:** Boeing, a World leader in commercial aviation
- **Mission:** Provide products and services to allow passengers to fly where they want to go, when they want to go
- **Strategy:** Deliver superior design, efficiency, and support to customers and passengers
 - Continuous improvement
 - Insertion of new technologies
 - Adapt technologies from Phantom Works to commercial aerospace environment



Role of R&D in IDS



- **Description:** Combine weapons and aircraft with intelligence, surveillance, communications, architectures, and integration.
- **Mission:** Understand needs, provide solutions
- **Strategy:** Use technology to improve existing solutions and deliver new solutions
 - Continuous improvement
 - Insertion of new technology
 - Adapt technology from Phantom Works to military environment





Role of R&D in Phantom Works



- **Description:** Boeing advanced R&D unit
- **Mission:** Provide solutions that improve aerospace products and services.
- **Strategy:** Two team types
 - Technology teams: engineering, information, and manufacturing
 - Strategy teams: new business
 - Both examine technologies for fit with Boeing business or potential business
 - Selected technologies matured to “flight-quality”



Aerospace R&D Management before TRL's

- **Features**
 - Unique procedures per company and division
 - Product maturation in terms of passing tests
 - Which tests, in what order, was matter of experience
- **Benefits**
 - Worked well enough once teams experienced
- **Drawbacks**
 - Terms not well defined and no common terminology
 - Numerous In-Scope vs Out-of-Scope debates
 - Considerable learning curve
 - Innovation reset learning curve

Impact of Implementing Immature Technologies

1. Late technology maturation raises expected cost
2. Late maturation stretches planned schedule
3. Costs skyrocket, Schedule loses meaning, Technology maturation fails to follow plan, Changes ripple through project design late in program cycle
4. Failed technologies replaced by fall-backs
5. Project (often) fails to meet requirements
6. Program (often) canceled

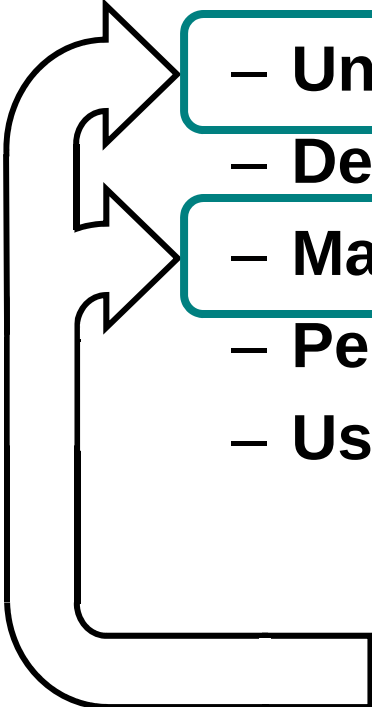
Managing Innovation in Development

Managers must know:

- **Current TRL of needed technologies**
- **Time to get to desired TRLs**
- **Risks to reaching desired TRLs**
- **Consequences of failing to reach TRLs**
- **Mitigation of risks**

TRLs in Definition and Risks

- Program Definition and Risk Reduction (PDRR) of a major development effort is characterized by:

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- Understanding “What” and “How”
 - Defining requirements to fill urgent user need
 - Maturing and incorporating new technologies
 - Performing on an aggressive schedule
 - Using success-oriented budgetary projections

TRLs facilitate these steps

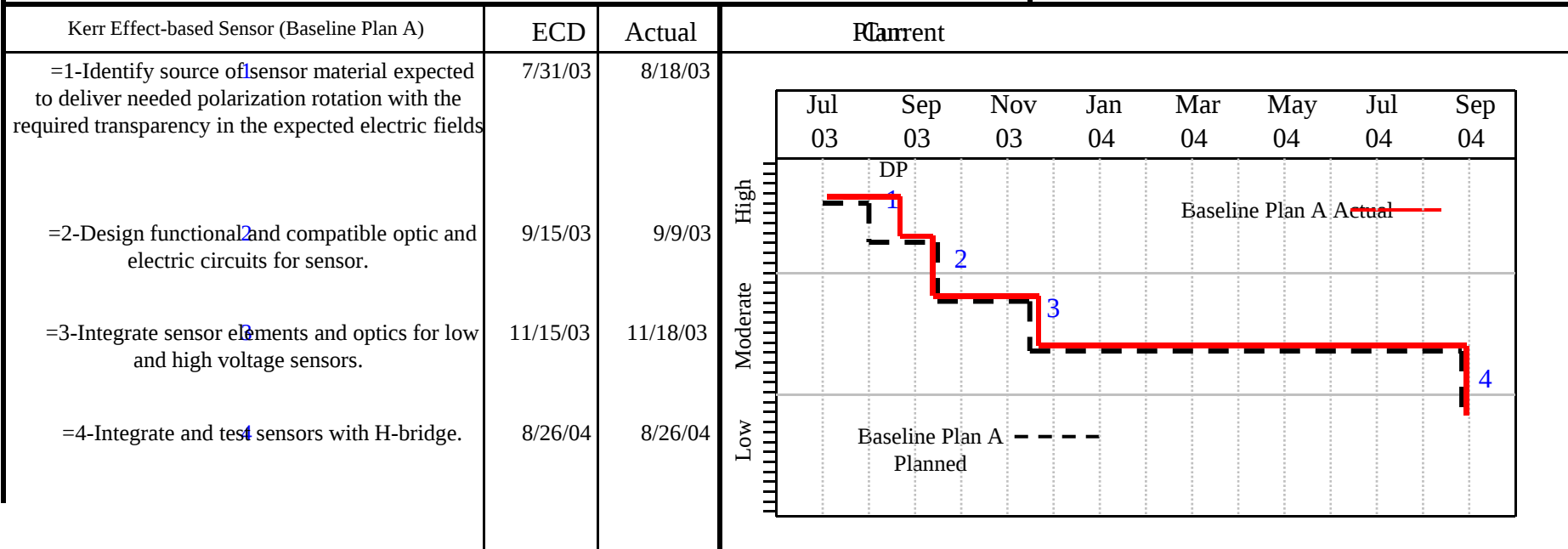
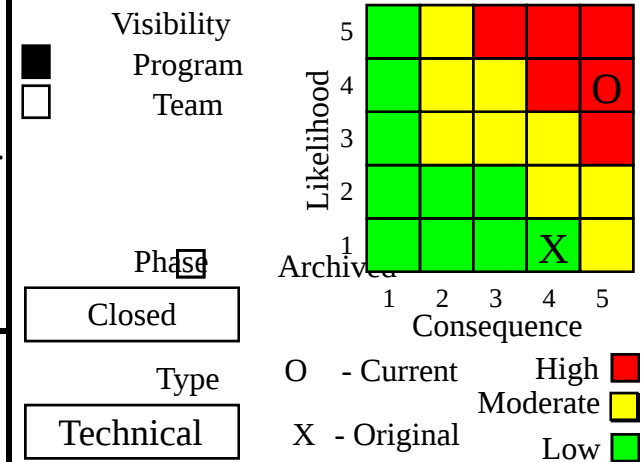
Example: Fly-By-Light Optical Voltage Sensor

Description: Photonic sensors for electric field that have the required time resolution and field sensitivity may not be developed successfully.

Likelihood Rationale: The physical effect in the sensor design is well known however, it has not been applied before to this purpose with such stringent performance requirements.

Consequence Rationale: The consequence of not successfully developing the planned sensor is the use of much less compact photonic technologies, with consequent difficulty of integration into the system.

Mitigation Plan Status: Some evidence of sensitivity to optical mode shifts. If so, address in H-Bridge design in the Validation Phase. Risk item is closed.



Aerospace R&D Management with TRL's

- **Features**

- Simple progress tracking framework
- Applicable from part level through system level
- Maturation still requires passing tests
- Simple framework for order and timing of tests

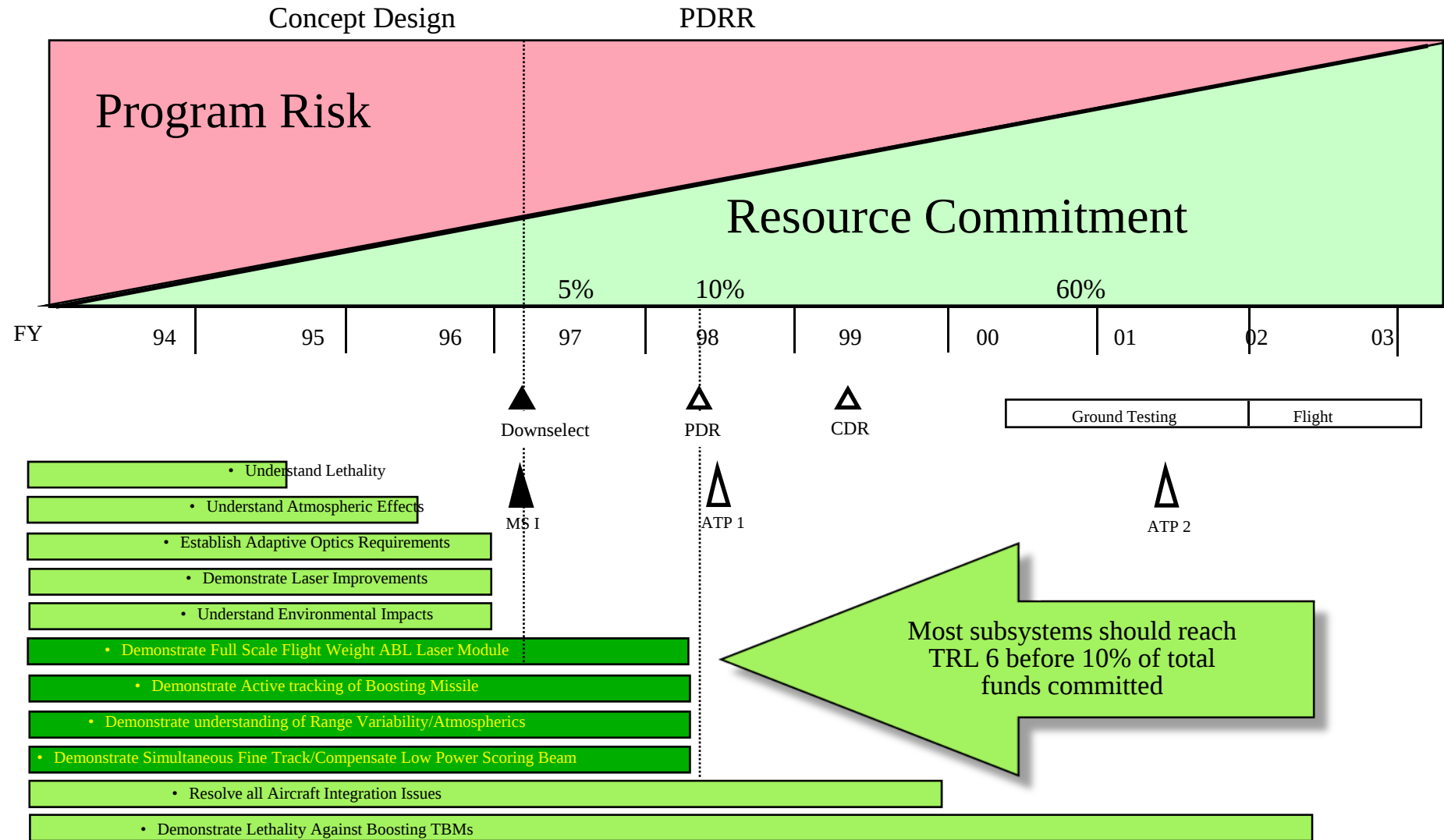
- **Benefits**

- Customers and suppliers understand requirements
- Change impacts easier to determine
- Facility needs easier to determine

- **Drawbacks**

- Effectiveness highly dependent on customer and supplier involvement.

Time for TRLs in Schedule



Aerospace Plans for TRLs

- **Being incorporated into proposal risk management procedures**
- **Being incorporated into program management procedures merging technology and application readiness**
 - **Procedure 5157 in Boeing**
- **Both incorporations include aspects of other readiness measures, e.g.**
 - **Manufacturing**
 - **Integration (not yet firmly defined)**
 - **System**
 - **Cost**

TRL Tailoring

- **TRL concept allows flexibility in definitions in the levels according to the needs of different agencies**
- **DoD definitions differ slightly from NASA definitions**
- **DoD tailored definitions for different technology areas**
 - **General**
 - **Software**
 - **Biomedical**
 - **Fissile Nuclear Fuel**
- **DoE - Incorporation of TRLs into Technical Business Practices at Sandia National Lab (proposed)**
- **2002 – TRLs adopted by British MoD for technology management within program and project management**

Conclusion

- **TRLs simplify aerospace R&D by providing a common language for understanding technology maturity and by providing a framework for assessing technology risk.**
- **Aerospace industry both adopted and expanded on TRL concept**

Summary by Les

- **FESAC, OFES and some ReNeW teams are embracing TRLs as a methodology with a metric to assess the technology maturity of fusion technologies and quantify remaining developmental gaps**
- **TRLs provide a framework for assessing technology risk.**
- **Aerospace industry provides the example and expertise to help implement and execute the TRL process**