UNCOVERING TEAM PERFORMANCE DYNAMICS WITH DATA & ANALYTICS

A research journey to explore teamwork and performance across boundaries

Big Data Tokyo

7 February 2017

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Tokyo Bryan R

GLOBAL TEAMWORK LAB

GPD Japan　池　大

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グローバルプロジェクトデザイン　dai.ike@gpdesign.com
ジャパン株式会社代表取締役

- 現在、GPD社の日本支社代表取締役。
- 以前は、アクセンチュアにてシステム運用方法論およびツールの日本国内での普及の責任者を務める。数千ページにおよぶ方法論と運用ツールの日本語化プロジェクトのPMとして従事。
- IT関連のプロジェクトにSEおよびコンサルタント、PMとして多数参加。
- 3,000名規模の企業ISO27000セキュリティ・マネジメント規格取得のPMを担当し、約半年でその当時最大規模の取得案件を成功させる。
- リスクマネジメント協会会員Certified Risk Manager.

GPD Japanは、東京大学大学院 新領域創成科学研究科をサポートしており、GTLの立ち上げ当時からパートナー企業として活動を支援しています。

New in 2015: *Global Teamwork Lab (GTL)*

GLOBAL TEAMWORK LAB

Kashiwa-no-ha Smart City　柏の葉

東京大学
THE UNIVERSITY OF TOKYO

Massachusetts Institute of Technology

- Global Teamwork Lab (GTL) promotes global capability and research on multidisciplinary teamwork for students, faculty and industry
- **Uncovering Dynamics of Complex Teamwork across Boundaries**

TofT on SofS

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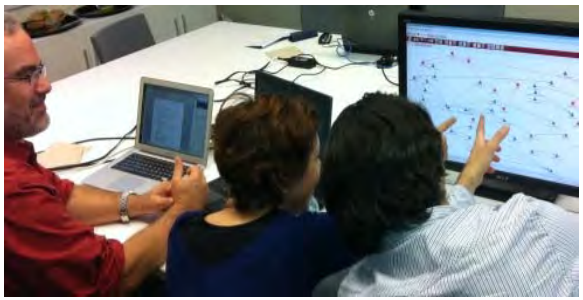
- **Teams of Teams** working on **Systems of Systems**
- **Performance** for Complex Problem Solving



- **システム**のシステムに関する作業を行う**チーム**のチーム
- 複雑な問題解決のための**パフォーマンス**

Projects are Socio-Technical Systems

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Socio = Project Teams in Organizations with values, behavior, skills, structure, priorities, capacities, skills, and costs

Technical = Projects Outcomes through product systems, with architecture, interfaces, materials, information, services, …

- Team behaviors and the demand for outcomes combine and constrain in often **surprising** ways

Socio = 価値、行動、スキル、構造、優先度、能力、スキル、コストを持つ組織のプロジェクトチーム

Technical =アーキテクチャー、インターフェース、マテリアル、情報、サービスなど、プロダクトシステムによる成果

- チームの挙動と結果の要求は、驚くほど

Trend: From Practices to Dynamics

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- Classic engineering projects were born through **practices and standards**, evolved over decades, and reflective of significant embedded know-how.
- The underlying dynamics – the drivers of performance -- are often assumed or hidden.
- *If our work and market environments are **stable**, and we **keep up** with change, practices and standards may be sufficient.*

- 伝統的なエンジニアリングプロジェクトは、何十年にもわたって進化してきたプラクティスと標準によって生まれ、重要な組み込みノウハウを反映しています。
- 基本的なダイナミクス（パフォーマンスの推進要因）は、しばしば仮定されるか隠されます。
- 私たちの仕事と市場環境が安定しており、変化に追いついているならば、実践と基準で十分かもしれません。

People, models, data, and analytics

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Design of Engineering Teamwork:

- Integrate systems view of product, process, and organization
- Forecast surprising, likely, and emergent outcomes
- Act as a Social Instrument
- Allows participants to explore the trade space.
- Connects to streams of signals (of evolving models and underlying actual performance)

技術系チームワークによるデザイン

- 成果物、プロセス、組織を俯瞰できる統合システム
- 想定外、予想通り、切迫したなどの結果を予測する
- ソーシャル機構として扱う
- チーム参加者がトレードスペースを検討できるようする
- お互いの連絡の流れをつなげる（進化するモデルと基礎となる実際の性能）

RESEARCH STRATEGY

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GTL Research

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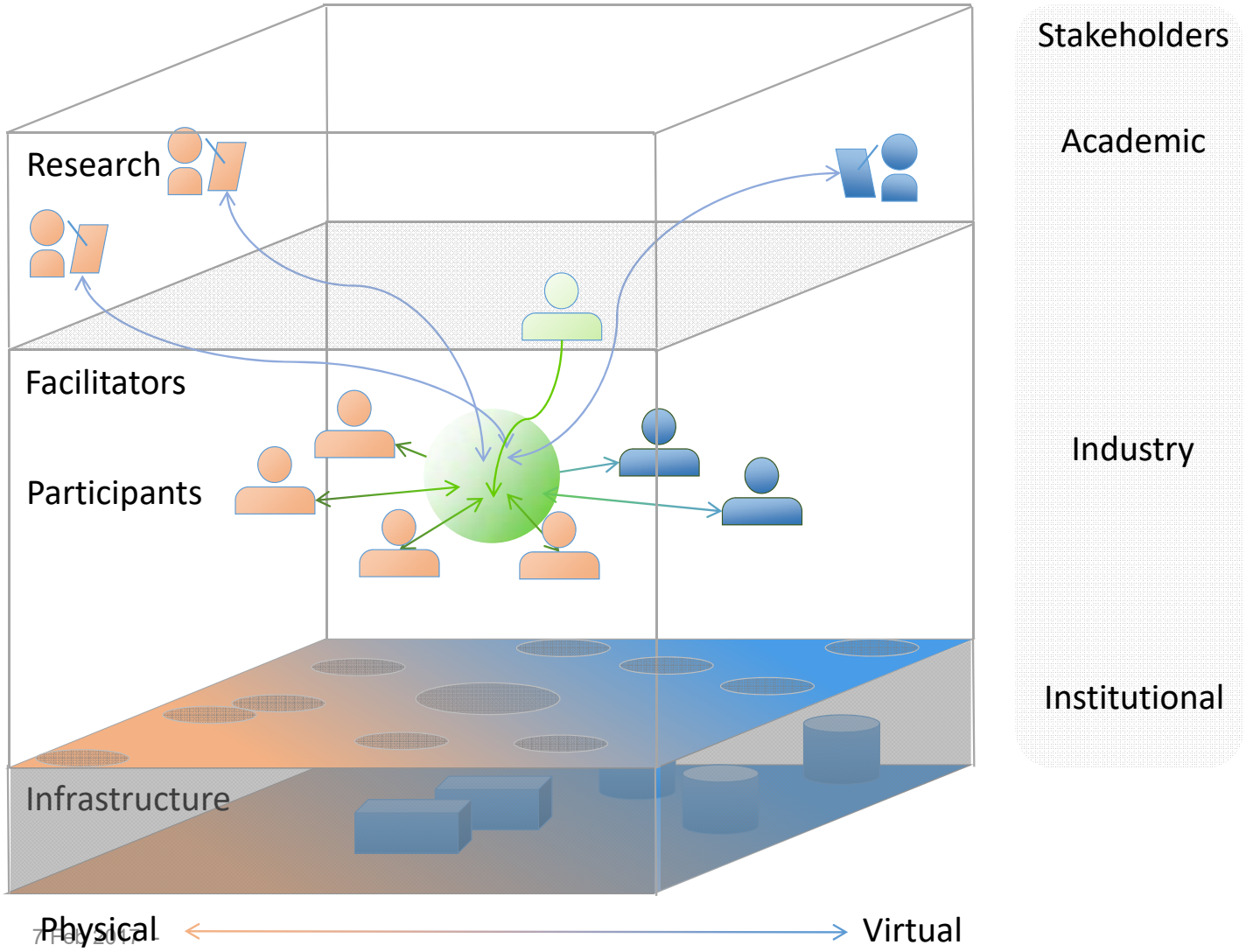
- Our research focuses on the underlying ***mechanisms and dynamics of performance under complexity***.
- **Teams, their problems, and their environment are instrumented** to reveal phenomena in real-time: demands, behaviors, activities, interactions, and outcomes across social and technical boundaries.
- **Data-driven experiments** are matched with modeling, simulation, systemic analytics, and interactive visualization.
- These methods are developed, tested, and deployed for **practical use by our joint industry-university teams**.

- 私共は、複雑化した環境において、チームとしての根本的な振舞いの理解し、ダイナミックな能力を発揮する方法を探求します。
- チームがどの様に行動するのか、その環境がどの様に変化するのかをリアルタイムで計測します。例えば、要求、作業、相互作用および成果などが随時記録されます。そして社会的かつ技術面の境界を越えた成果を生み出します。
- データを中心した研究は、モデリング、シミュレーション、系統的分析と視覚化された相互関係図によって統合されます。
- 開発、テストされたこれら方法論は、私共の産学協同チームの今後の実践に活かすために用いられます。


Stakeholders
Academic
Industry
Institutional
Research
Facilitators
Participants
Infrastructure
Physical
Virtual

Workshop-based Experiments

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- Pick a **dynamic of teamwork during** complex-problem solving.
- **Design an experiment** to observe these teamwork physics in real time.
- Use **platform to support complex problem-solving by teams of teams**
- Instrument for **repeatable and scalable experiments**.

- 複雑な問題解決の間にチームワークのダイナミックを選びなさい。
- これらのチームワークの物理をリアルタイムで観察するための実験を設計します。
- プラットフォームを使用して、チームのチームによる複雑な問題解決をサポートする
- 反復性とスケーラビリティのために、実験にセンサーを追加してください。

PROJECT DESIGN EXPERIMENTS

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Teamwork Experiment Examples

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- Engineering Project Planning
- Dependency Management
- New Service Concept Generation
- Infrastructure Scope and Contract Negotiation
- City Design with Walkability

- エンジニアリングプロジェクト計画
- 依存関係管理
- 新しいサービスコンセプトの生成
- インフラストラクチャスコープネゴシエーション
- 都市計画

An Engineering Plan is a Project Design

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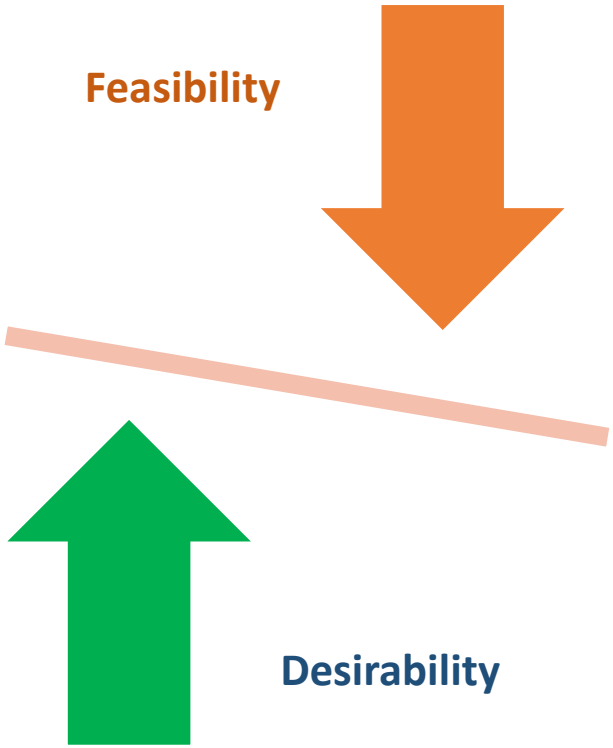
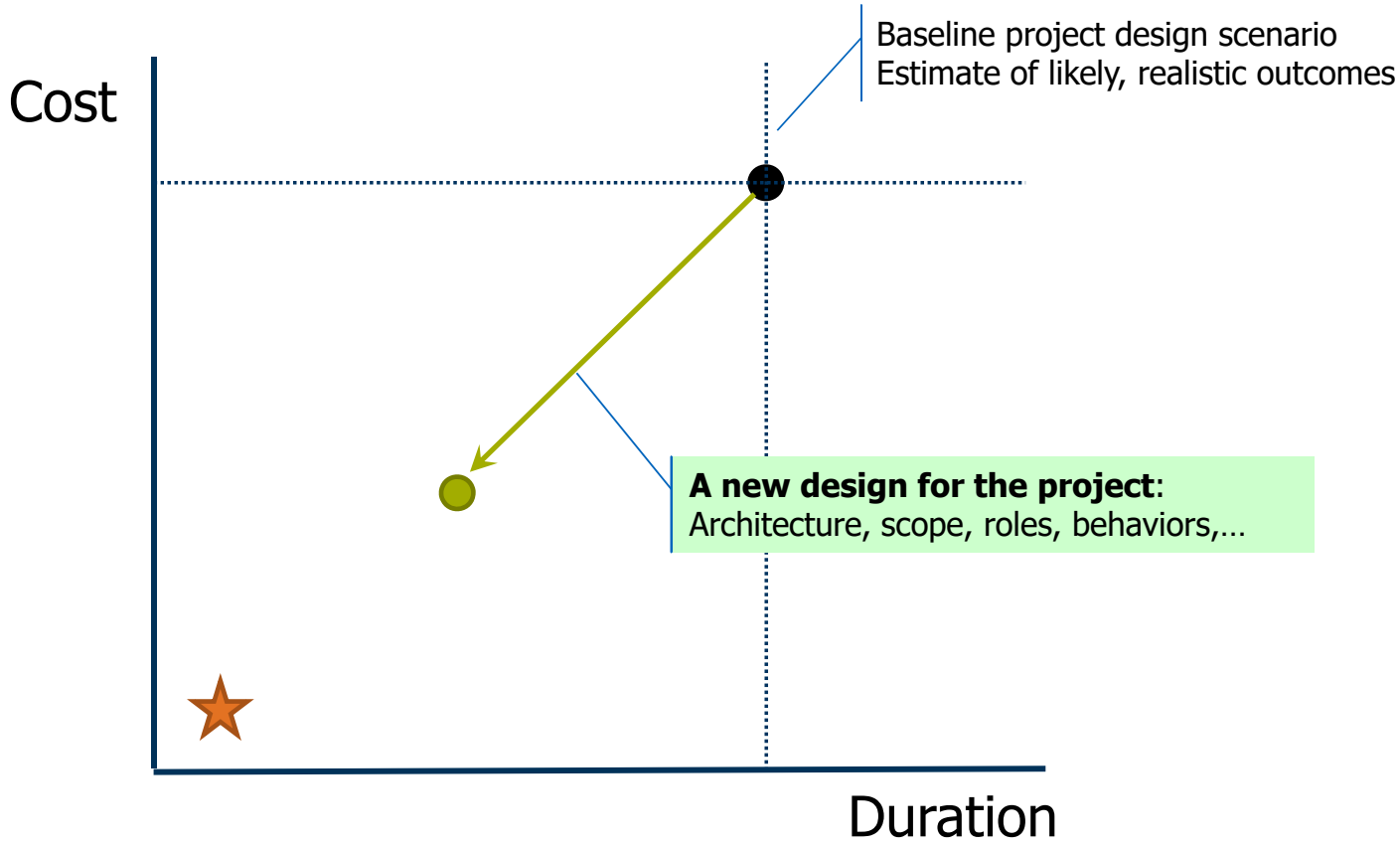
- The plan, or design, of a project…
  - … integrates a system of product, process, and organization
  - …is search and choice towards a desirable and feasible project
  - …predicts the likely Cost, Schedule, and Scope at some Risk

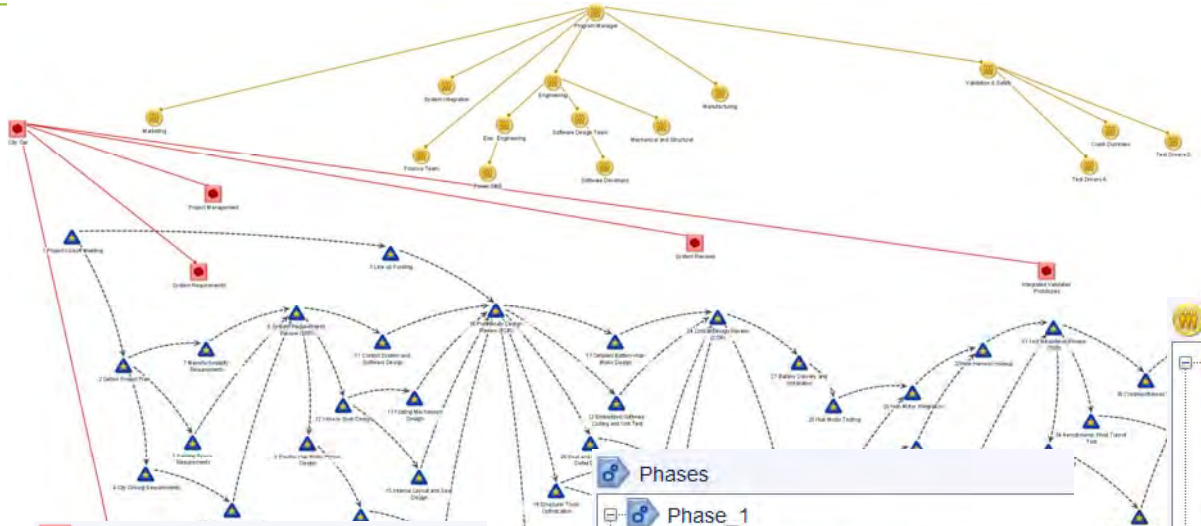


- プロジェクトの計画または設計…
  - …製品、プロセス、および組織
  - …望ましい、実現可能なプロジェクトへの探索と選択の
  - … スクで見込まれるコスト、スケジュール、および範囲を予測する

Project Design Tradespace & the “Design Walk”



Starting Point: City Car Project

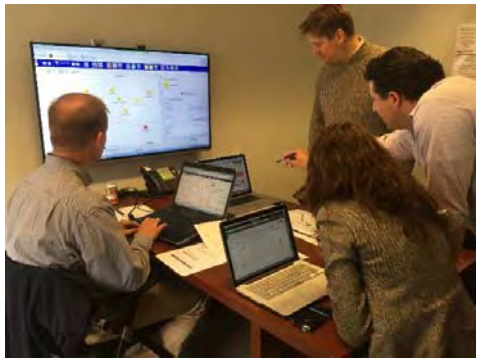


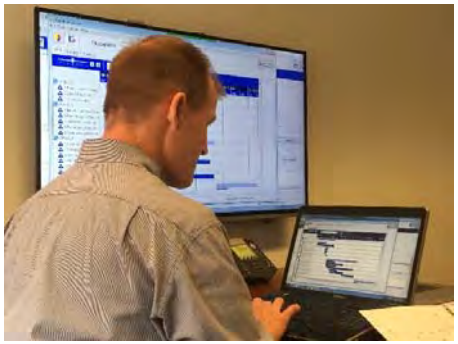
- Products
  - City Car
    - System Requirements
    - Project Management
    - System Reviews
    - Integrated Validated Prototypes
    - Subsystems
      - Body / Shell
      - Power
      - Interior
      - Chassis
      - Software / Controls

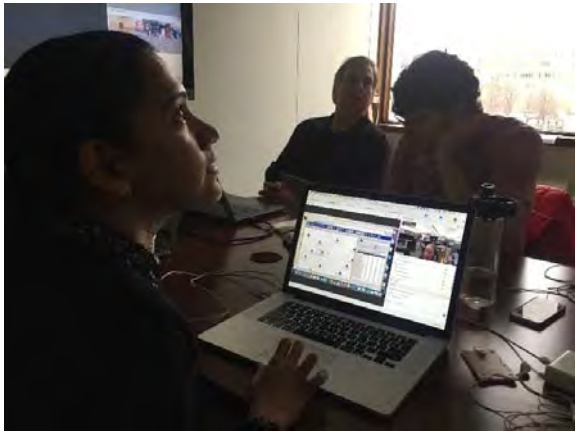
- Phases
  - Phase_1
    - 1 Project Kickoff Meeting
    - 2 Define Project Plan
    - 3 Line up Funding
  - Phase_2
    - 4 City Driving Requirements
    - 5 Parking Space Requirements
    - 6 Recharging Requirements
    - 7 Manufacturability Requirements
    - 8 System Requirements Review (SRR)
  - Phase_3
  - Phase_4
  - Phase_5
  - Phase_6
  - Phase_7

- Teams
  - Program Manager
    - Finance Team
    - System Integration
    - Marketing
    - Manufacturing
    - Engineering
      - Elec Engineering
        - Power SME
      - Software Design Team
        - Software Developrs
      - Mechanical and Structural
    - Validation & Safety
      - Test Drivers A
      - Test Drivers B
      - Crash Dummies
  - Supplier: Designer
  - Industrial Design
  - Seat Engineers
  - Supplier: Battery

Experiment in Process







1,482 simulations 316 Scenarios in 2 hours

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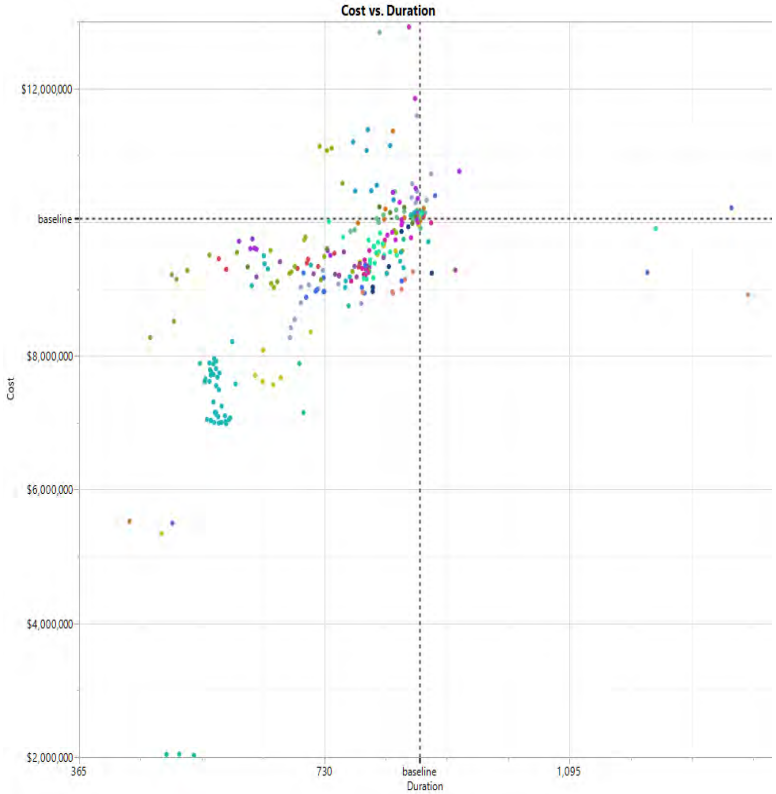
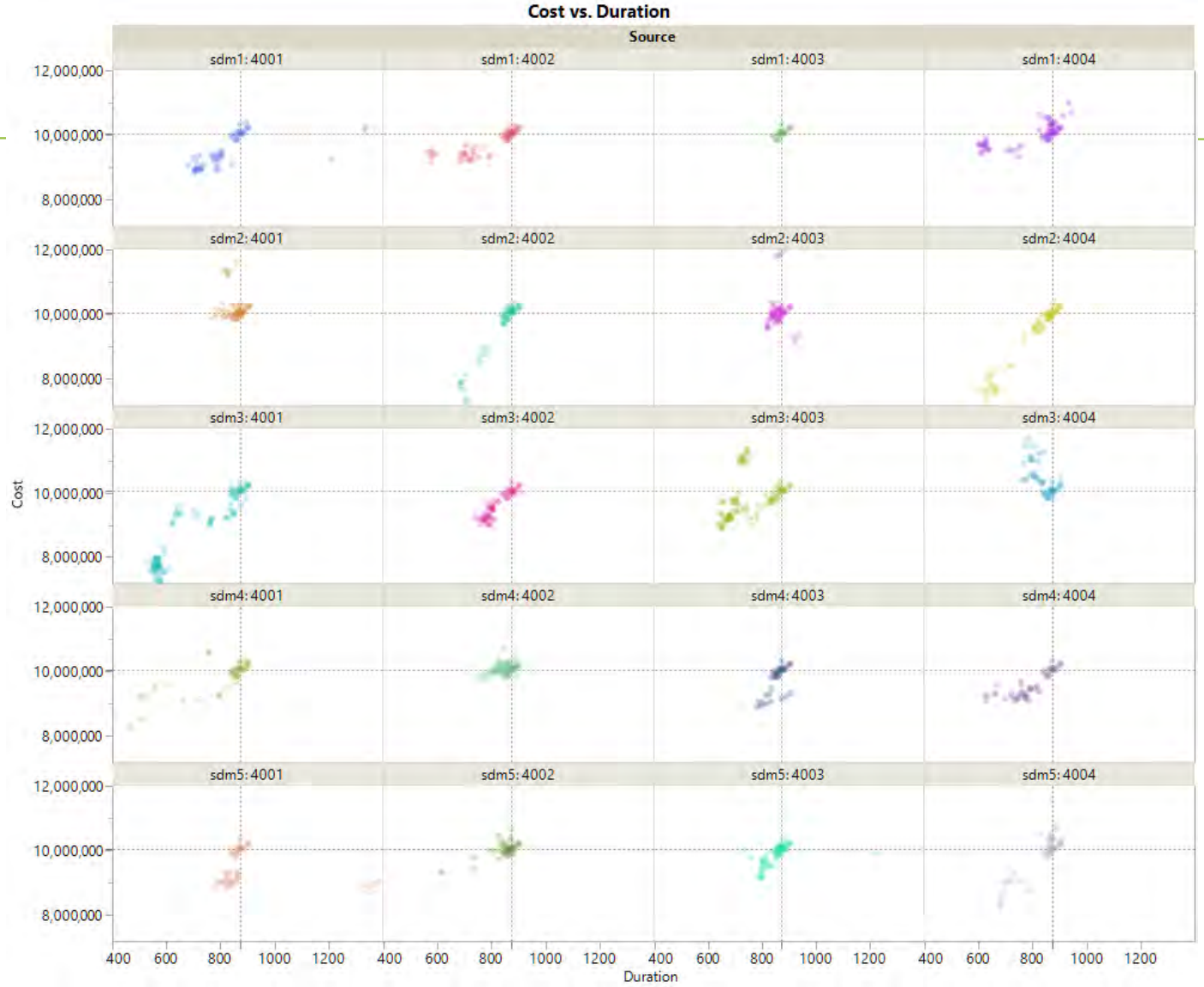
- Each dot is a feasible project scenario, yet perhaps not valuable
- Common starting point for 20 teams: $10.1M, 872 days
- Each change is an insight: which designs of the project as are acceptable and valuable?



- それぞれのドットは実現可能なプロジェクトシナリオですが、おそらく価値のないものです
- 20チーム共通の出発点：$10.1M、872日間
- それぞれの変化は洞察である：プロジェクトのどのデザインが受け入れられ、価値があるか？



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Selected Scenarios & Pathway Patterns

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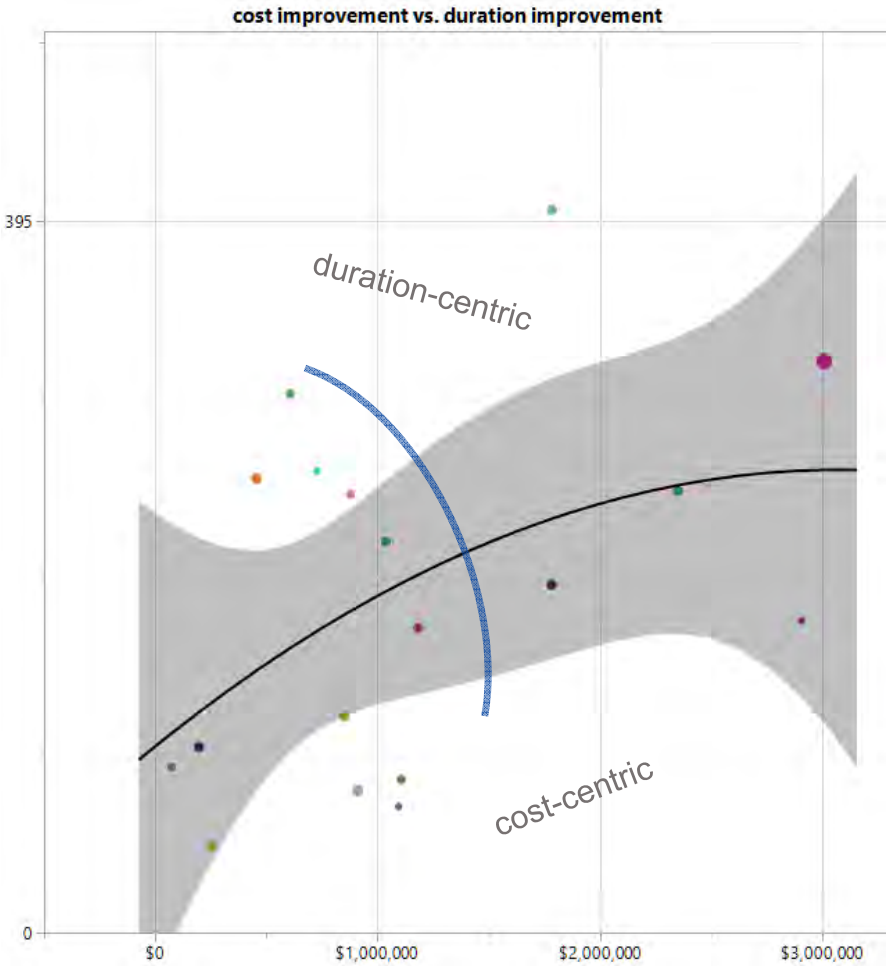
- Diagram shows improvement in preferred solution for each team.
- Some teams generated solutions better at duration; other teams preferred cost.
- Why do some teams keep attention on solutions along a sub-optimal pareto?



- 図は、各チームの優先ソリューションの改善を示しています。
- いくつかのチームは、期間中により良いソリューションを生み出しました。 他のチームはコストを優先しました。
- なぜ、最適ではないパレートに沿ったソリューションに注目を集めるチームはありますか？

CURRENT EXPERIMENT: ATTENTION AND AWARENESS OF DEPENDENCIES

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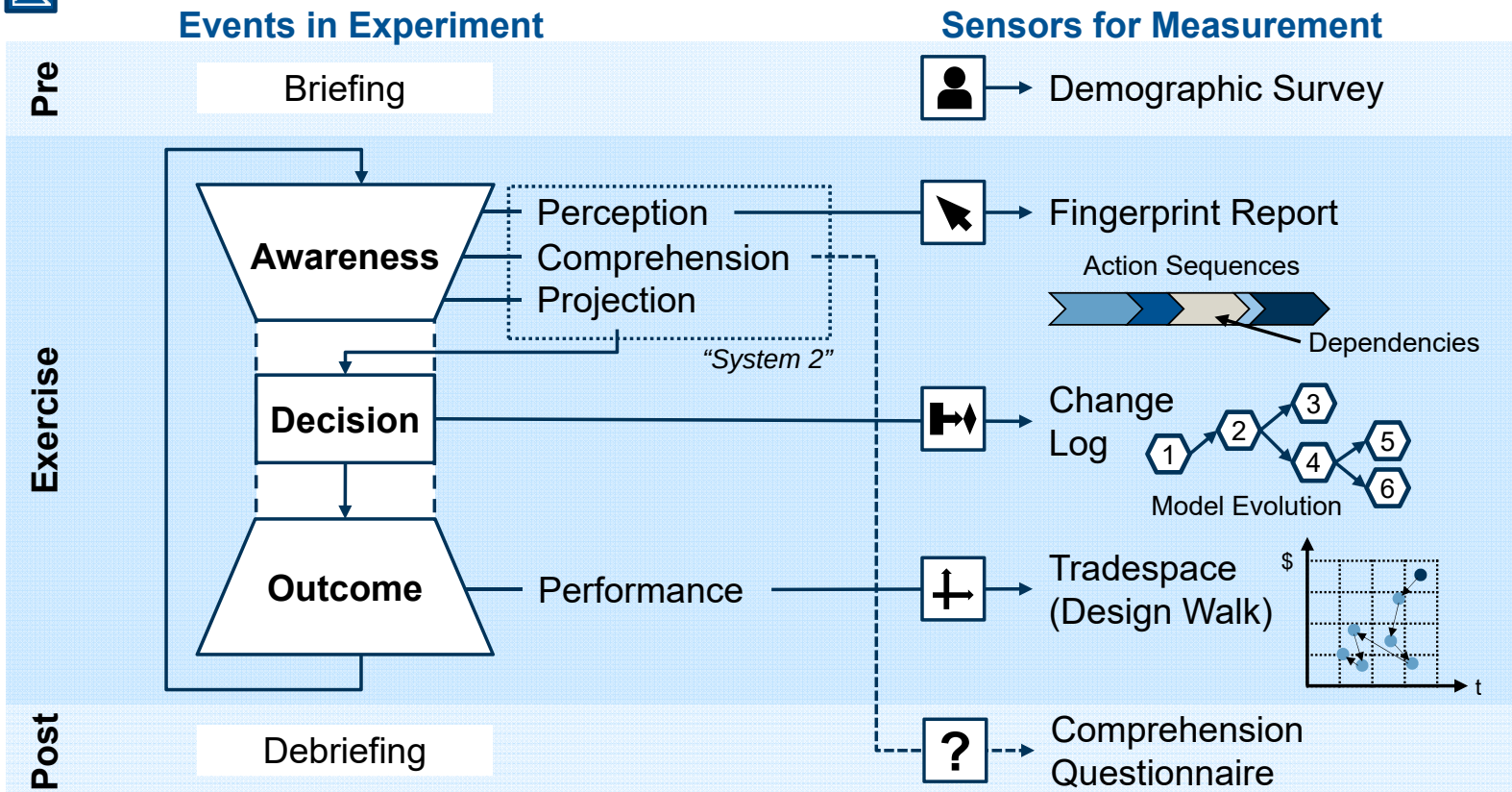
The experiment sensors are arranged around the developed awareness-decision theory



Kahneman, D. (2011). Thinking, Fast and Slow (1st ed.). New York: Farrar, Straus and Giroux. ISBN: 0-374-27563-1
Endsley, M. R. (1995). Toward a Theory of Situational Awareness in Dynamic Systems. *Human Factors*, 37(1), pp. 32-64.

What drives teams to better project design?

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COST

20 teams common starting point, 2 hours

DURATION

Experiment: attention allocation to dependencies
実験：依存関係への注意の割り当て

Research Questions

To which **elements** do **high performing** teams **allocate their attention**?

高性能チームはどの要素に注意を払うのか？

Does **attention allocation** towards **key dependencies** lead to **higher performance**?

主要な依存関係への注意の割り当てはより高いパフォーマンスにつながるか？

Does **focus on project model structure** improve the **designing performance** of teams?

プロジェクトモデル構造に焦点を当ててチームの設計パフォーマンスを向上させるか？

Through which **events** do project teams **become aware of activity dependencies**?

どのイベントを通じて、プロジェクトチームは活動の依存関係を認識しますか？

Which other **action patterns** are followed by **high performing** project teams?

他にどのような行動パターンが続いていますか？

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TEAMWORK DURING EARLY IDEATION AND CONCEPT GENERATION

U Tokyo i.School,
Prof. Hideyuki Horii

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Uniqueness of i.school

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- Prof. Horii focused on Innovation science
- Innovation workshop itself is the subject to study
- Cognitive science, Organizational behaviors, Knowledge engineering, Pedagogy
- Results of studies are utilized to design better innovation workshop

- 東京大学堀井教授によるイノベーションサイエンスに特化した機構
- イノベーションワークショップを取り入れた学習の場
- 認知科学、組織行動、知識工学、教育学
- 研究の結果は、ワークショップのより良いイノベーションワークショップにするために利用される

i school

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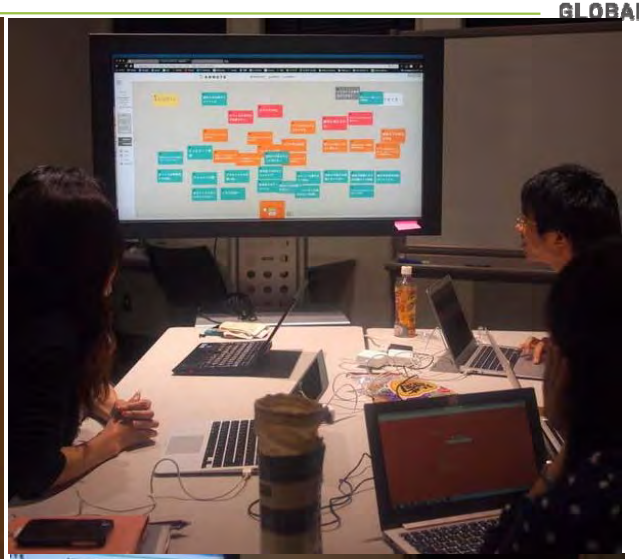
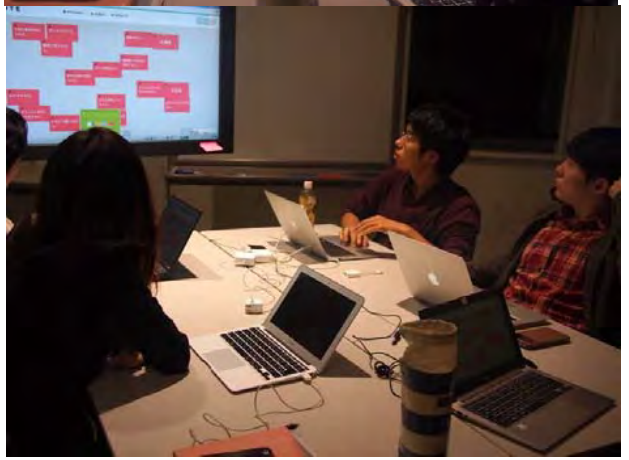
Massachusetts Institute of Technology

Teamwork for Concept Generation





Ideation & Knowledge Structuring

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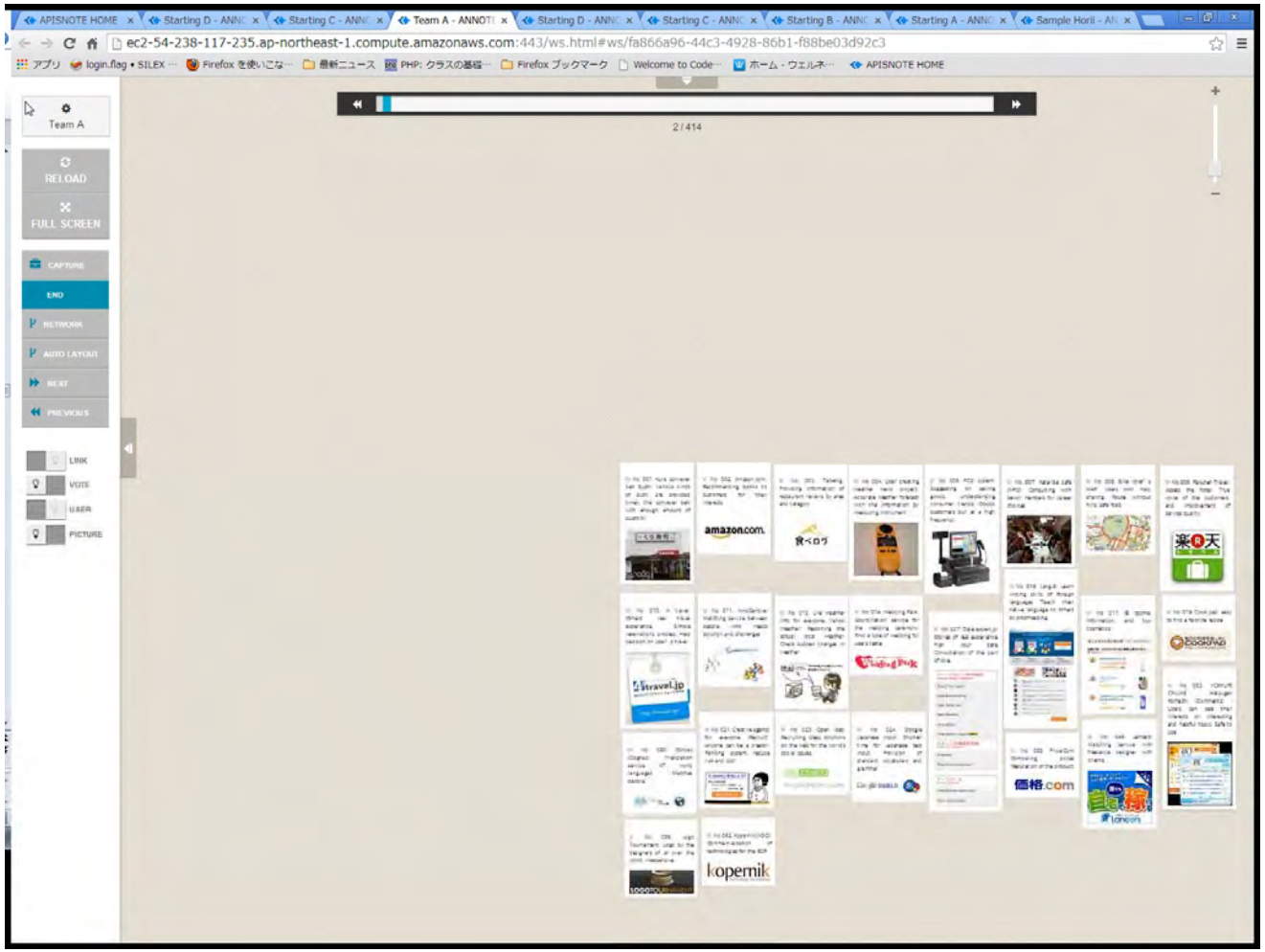

Our partners from the U Tokyo i.School run workshops for upstream concept generation

Courtesy U Tokyo i.School
Prof. Hideyuki Horii

Courtesy U Tokyo
i.School
Prof. Hideyuki Horii

Happiness Counter

Courtesy U Tokyo i.School
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EXPERIMENT DESIGN FOR INFRASTRUCTURE SCOPE & CONTRACT NEGOTIATION

Life-cycle performance of civil infrastructure Public-Private Partnerships

From Vivek Sakhrani MIT PhD

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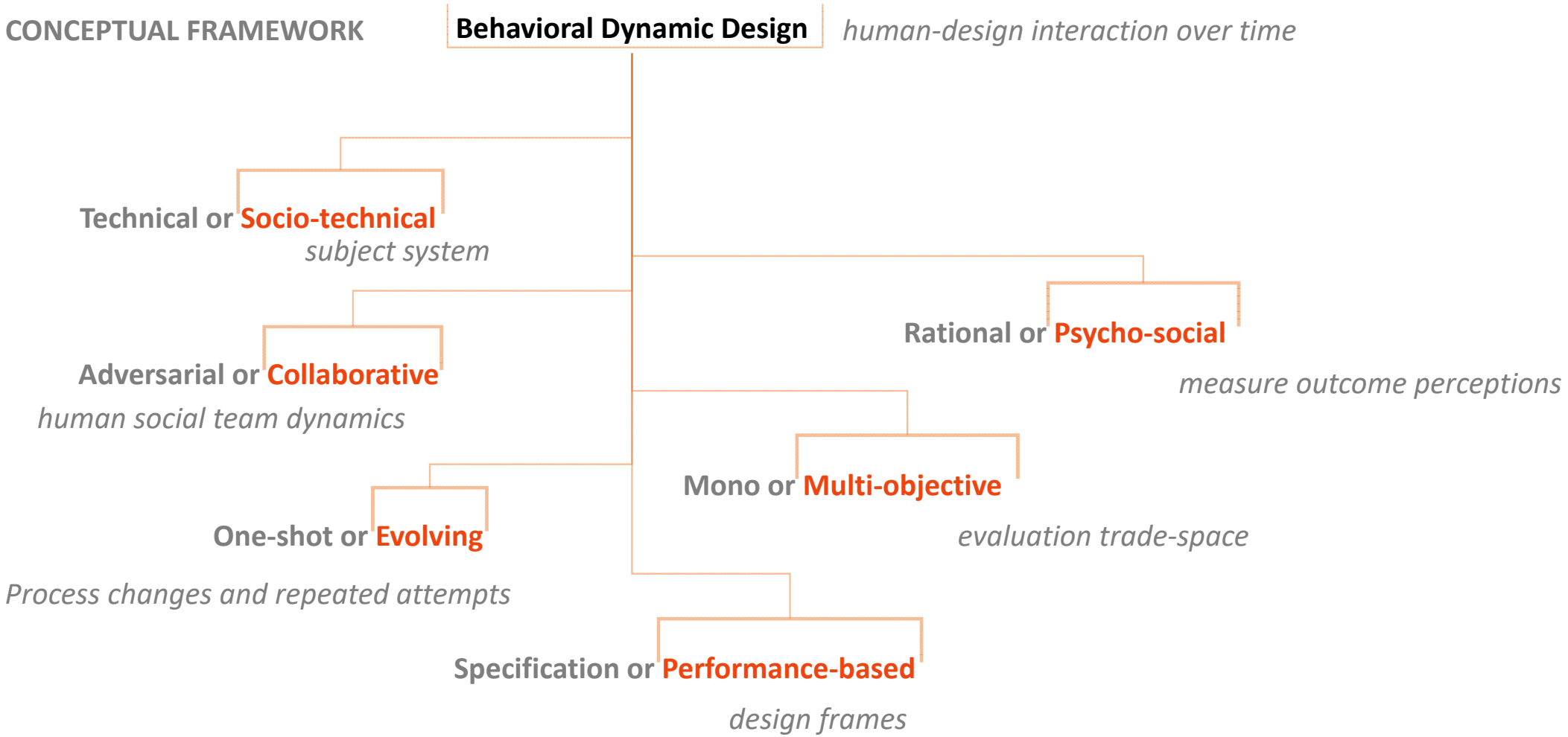
CONCEPTUAL FRAMEWORK



From Vivek Sakhrani MIT PhD; Senior Consultant, CPCS Transcom Inc

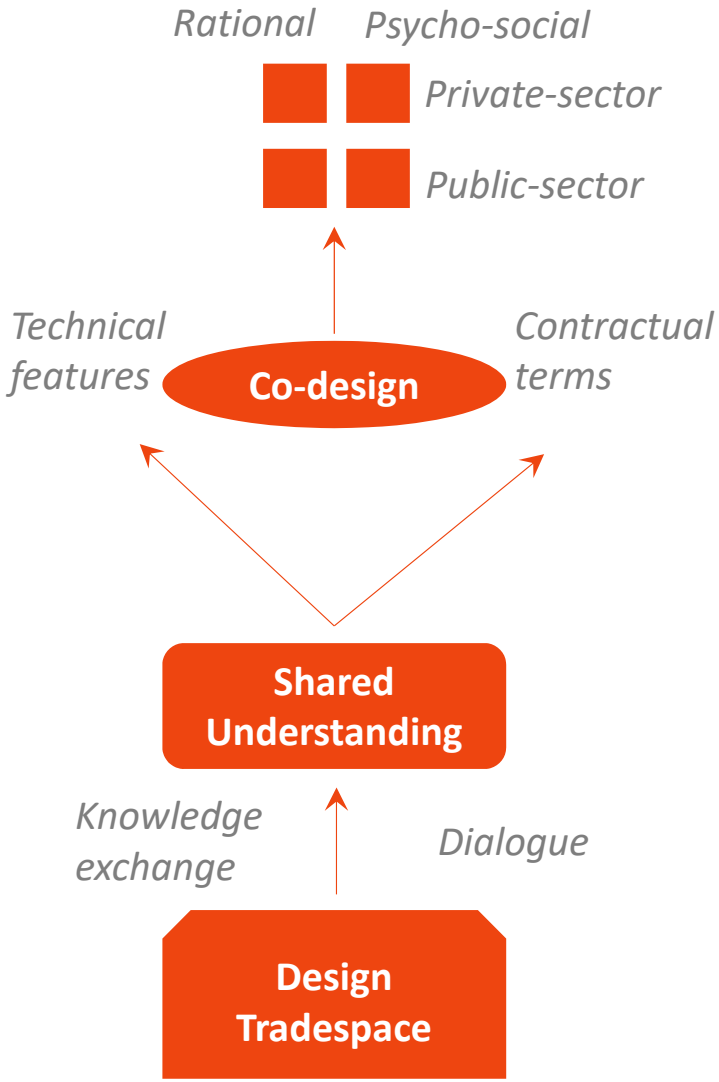
EXPERIMENT SUMMARY

Design Frame: explore multi-objective trade-space and choose designs through performance-based negotiations, with treatments and controls

Subject System: **life-cycle performance of civil infrastructure Public-Private Partnerships**

Main hypothesis: collaborative design results in innovation through learning and shared understanding

Sub hypotheses: effects of information asymmetry and dialogue (communication)



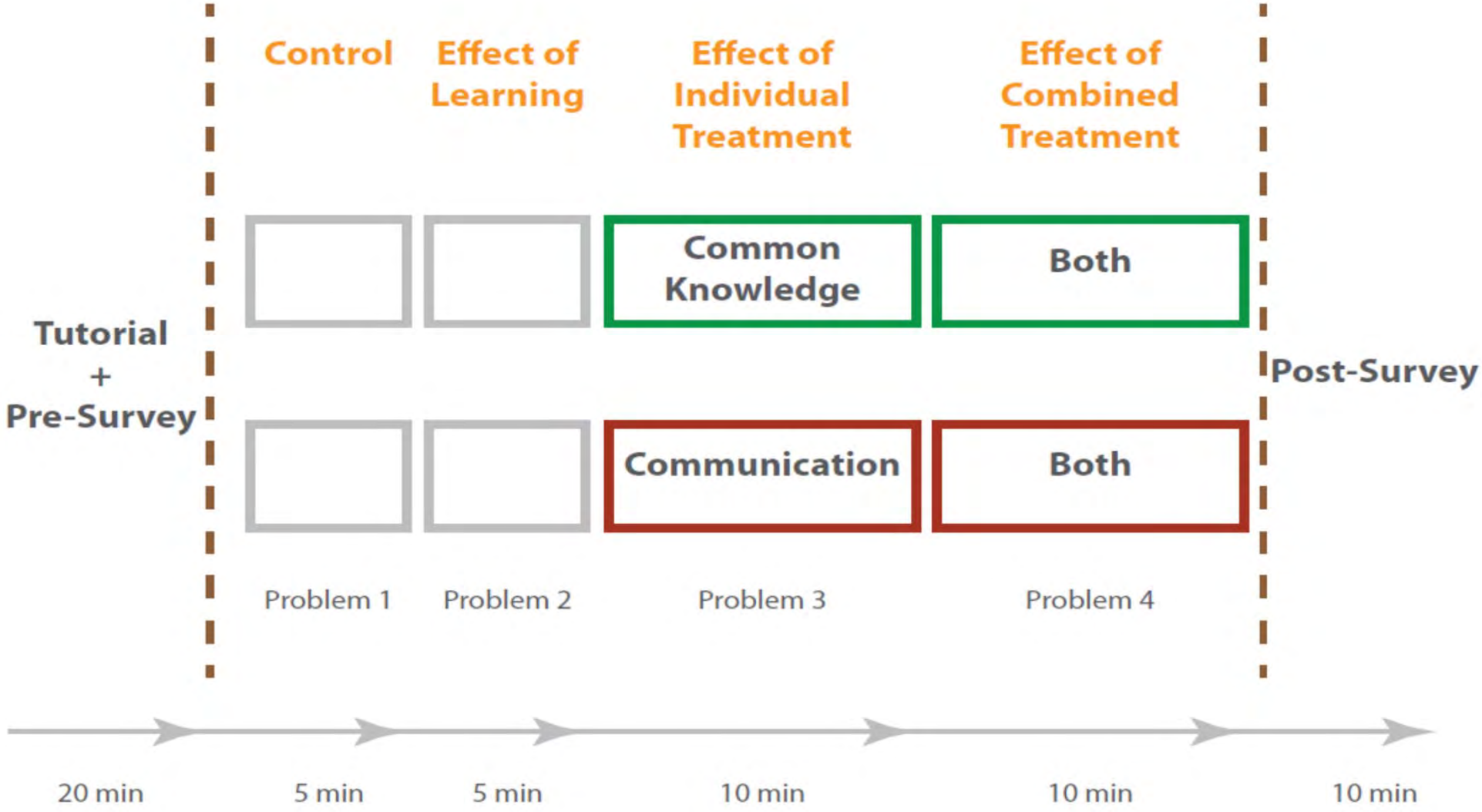
Evaluate both technical payoffs and psycho-social experience for collaborating actors

Nature of socio-technical system Implies multi-domain, i.e. co-design

Collaborative co-design is enabled through shared understanding of how design choices affect system performance

Joint tradespace exploration supports knowledge exchange and dialogue

From Vivek Sakhrani MIT PhD; Senior Consultant, CPCS Transcom Inc



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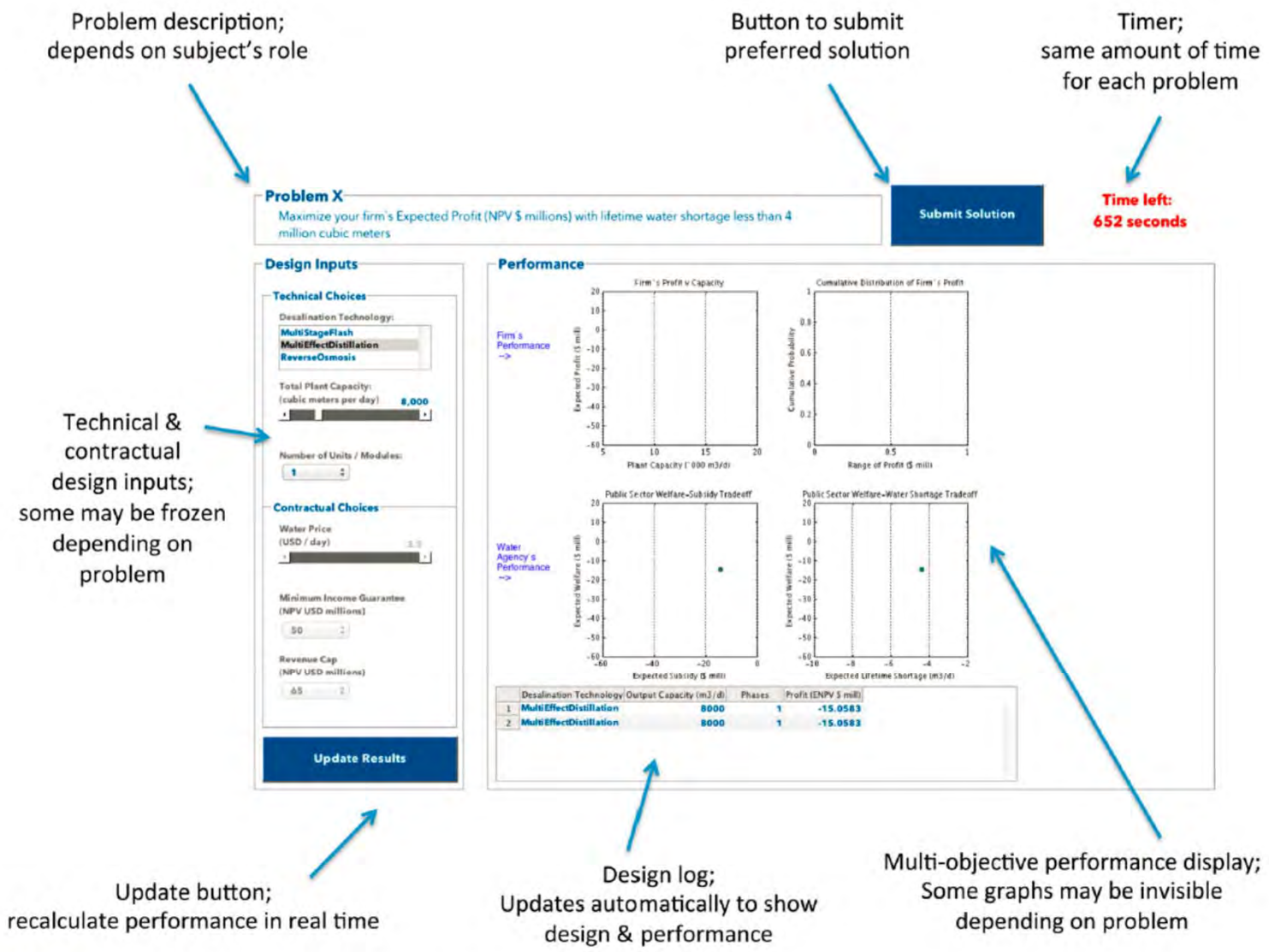
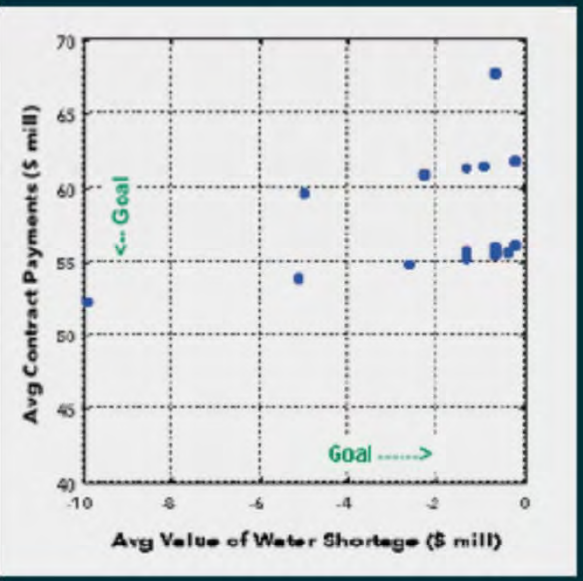


Figure 3. The user interface for the DesalDesign tradespace model.

From Vivek Sakhrani MIT PhD; Senior Consultant, CPCS Transcom Inc



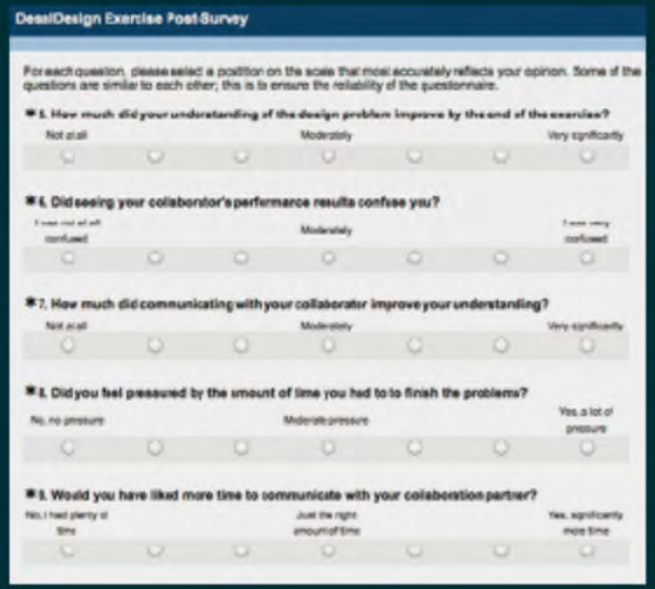
Design Iterations and Solutions submitted

- N = 112 participants
- 10,000 iterations
- 448 solutions

	ok
	not huge profit
	but it's alright
	and we minimize the water shortfall probability
	otherwise we need to put less plants
1207 ckcd-pv	i am taking away so much of your revenue uncertainty
	@ 60
	its max MIG
	water uncertainty shouldnt be a problem then
1205 ckcd-fv	yes but I'm putting a lot of capital down
1207 ckcd-pv	no?

Communication Dialogue Protocol

- N = 92 participants
- Transcripts


DesalDesign Exercise Post Survey

For each question, please select a position on the scale that most accurately reflects your opinion. Some of the questions are similar to each other; this is to ensure the reliability of the questionnaire.

*5. How much did your understanding of the design problem improve by the end of the exercise?
Not at all — Moderately — Very significantly

*6. Did seeing your collaborator's performance results confuse you?
Moderately

*7. How much did communicating with your collaborator improve your understanding?
Not at all — Moderately

*8. Did you feel pressured by the amount of time you had to to finish the problems?
No, no pressure — Moderate pressure

*9. Would you have liked more time to communicate with your collaboration partner?
Just the right amount of time

Pre- and Post-Experiment Survey Responses

- N = 92 participants
- SVI survey responses

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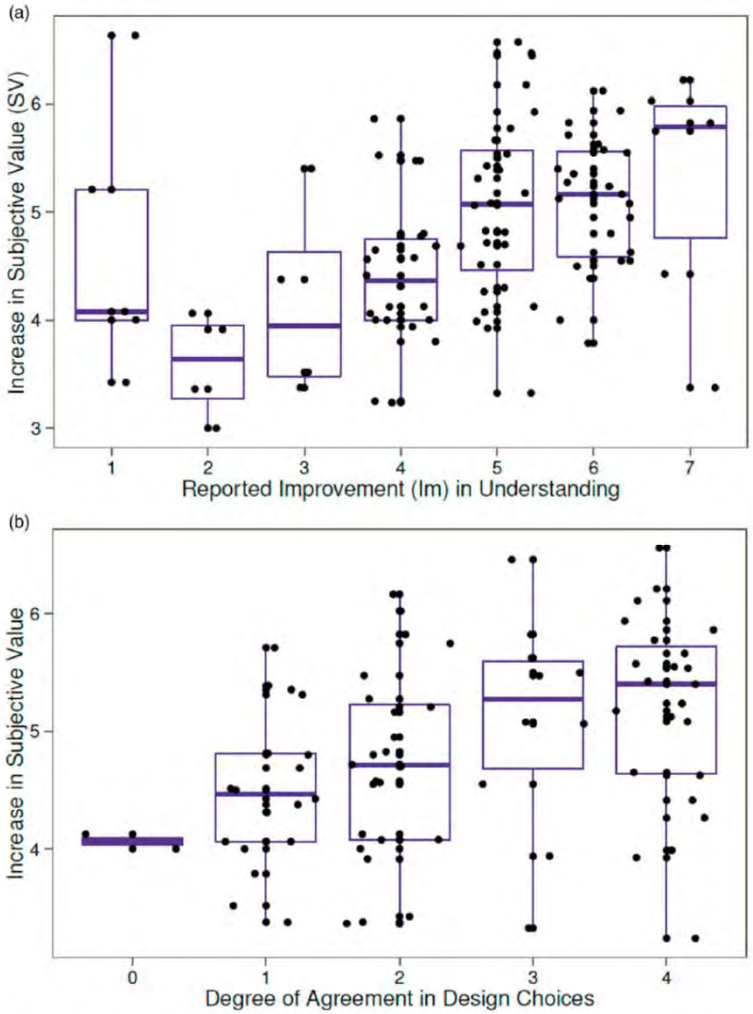

Figure 6. (a) Variation in the increase in SV through collaboration, controlling for the level of improvement in understanding and (b) variation in the increase in SV through collaboration, controlling for the degree of agreement in design choices (proxy for objective value outcomes).

From Vivek Sakhrani MIT PhD; Senior Consultant, CPCS Transcom Inc

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DESIGN OF A CITY WITH WALKABILITY

Ira Winder, MIT Media Lab & KACST

Tactile Matrix for Riyadh, Saudi Arabia

GLOBAL TEAMWORK LAB


Source: Ira Winder
Daylighting
41
Walkability
49
51

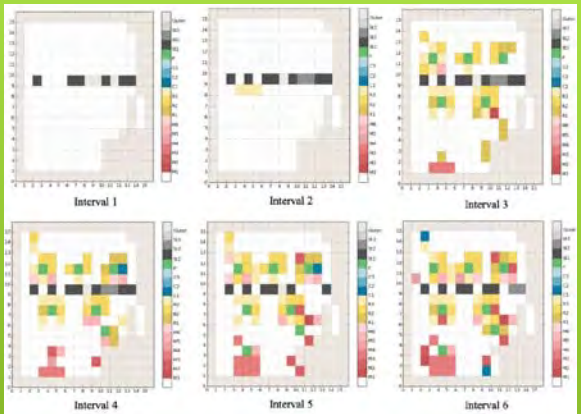

Figure 16. Recreated Snapshots of the grid at the end of each 5-minute interval for game session 2

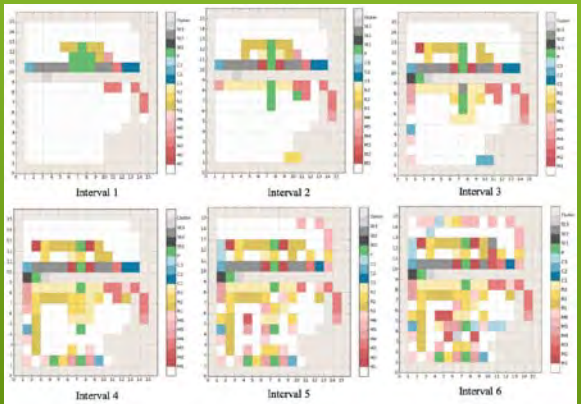

Figure 17. Recreated Snapshots of the grid at the end of each 5-minute interval for game session 3

Source: Tariq Alhindi, Tarfah Alrashed, Almaha Almalki, Faisal Aleissa, Cody Rose, Ira Winder, Anas Alfaris, Areej Al-Wabil

Source: Ira Winder

FUTURE RESEARCH

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Meso-Scale: 7 to 7x7x7 people

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- Much research exists at the "**micro-scale**" for teams, examining the interplay of individuals, their skills, personalities, and biases as part of a small team.
- Emerging research at the "**macro-scale**" is using "big data" to draw conclusions at the population level.
- Our work at **GTL focusses at the meso-scale**, the team of teams.
  - the most common scale of working teams in the field.

- 小規模なチームの一員として、個人、そのスキル、パーソナリティ、相互作用を検証する、「マイクロスケール」には多くの研究が存在します
- 「マクロスケール」での新たな研究は、人口レベルで結論を引き出すために「ビッグデータ」を使用することです。
- GTLでは「メソスケール（中規模）」のTeam of Teamsにフォーカスしている
  - 実際の一般的なプロジェクトのサイズを想定

Sub-atomic Particles of Tasks

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- If “tasks” are the atomic particle of classic project management…
- Seek the underlying characteristics of tasks, and how they interact dynamically with the environment
- To better understand and predict likely performance.
  - the nature of work (the task)
  - the nature of behaviors (teams and resources) and
  - how they interact (project architecture and dynamics)

- “タスク”が古典的なプロジェクト管理では、これ以上分解できない作業のとすると…
- タスクの基本的な特徴と、それらが環境と動的にやり取りする方法を探る
- 予想されるパフォーマンスをよりよく理解し予測する。
  - 仕事の性質（仕事）
  - 行動の性質（チームとリソース）と
  - 彼らがどのように相互作用するか（プロジェクトのアーキテクチャとダイナミクス）

Scale and Pace of Research

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- Traditional work has proceeded at the **pace of a social science PhD**
  - Deep ethnographic case studies
  - Survey-based self-report
  - “toy problems”
- Often limited in **repeatability** and **scalability**.
- GTL looks to build research as platform, to connect to teams, roll-out experiments, observe, towards ***10x rapid and 100x scalable experiments***.

- 伝統的な仕事は、社会科学博士のペースで進められてきた
  - 深い民族学のケーススタディ
  - アンケートに基づく自己申告
  - “おもちゃを使った実験"
- しばしば、再現性とスケーラビリティに制限があります。
- GTLは、プラットフォームとしての研究環境を構築し、チームの行動を観察し、10倍の速さと100倍のスケーラブルな実験を目指しています。

CONCLUSION

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By seeking the underlying mechanisms in meso-scale sociotechnical systems:

- We should see commonality across types of teams and domains
- The shadows from research at the micro and macro scales should make sense, if not inform, the meso-scale mechanisms.
- We will be able to **predict and provide teams with real-time adaptive tools and thinking leading to great performance**.

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Uncovering Team Performance Dynamics with Data & Analytics

GLOBAL TEAMWORK LAB

- This talk introduces a framework by the Global Teamwork Lab (GTL) at U Tokyo and MIT to uncover the nature of performance during complex projects. The most innovative and significant grand challenges for industry and society are marked by technical and social complexity, with teams working across boundaries. With recent capabilities to instrument demands and activities, we propose a new lense and inquiry into the performance of teams. Sensors on both the people and the problem are analyzed in real-time, so that the awareness, interaction, and actions by teams are enhanced. An integrated "meso-scale sociotechnical systems" approach requires integrated instrumentation, analytics, modeling, and visualization so that data is streamed, processed, considered, and acted upon in the cognitive sweet spot of human teams. We'll show some recent experiments from GTL and the new "Interactive Visualization Lab" at MIT.
- The technical system its elements and architecture is tied in real time to an organization system, with its own elements and architecture. Local behaviors and system dynamics. Performance is an emergent result. These complex sociotechnical systems have been studied by disparate academic fields.
- We are re-framing the discussion to include the use of multiple sensors for data in the teamwork environment, and the interplay of data as generated by models and analytics with real people making decisions collaboratively. The "Big Data" discussion is brought to down to the meso-scale level that is at the heart of performance in industry. At the meso-scale we have a level of granularity much closer to the means of performance change .. at a level where the levers and behaviors can be discerned with better causality than the black box analytics at the macro-scale.
- At the same time, the underlying trends: more sensors, heterogeneous and unstructured data, improved and multiple cognitive analytics… will transform our research on engineering projects and global teamwork.